SCHOOL OF ENERGY RESOURCES

Annual Report of the Advanced Conversion Task Force to The Joint Minerals, Business, and Economic Development Interim Committee

September 30, 2016

UNIVERSITY OF WYOMING

This Page Left Blank

Annual Report of the Advanced Conversion Technologies Task Force to the Joint Minerals, Business, and Economic Development Interim Committee September 30, 2016

(W.S. 21-17-121c)

This report summarizes the activities of the Advanced Conversion Technologies Task Force (formerly known as the Clean Coal Task Force) for Fiscal Year 2016 (July 1, 2015 – June 30, 2016). For the purposes of this report, the Advanced Conversion Technologies Task Force will hereafter be referred to as the Task Force and the Advanced Conversion Technologies Research Account will be referred to as the Account.

Creation and Appropriations Background

In 2007, House Bill 301 created the Task Force consisting of the current voting members of the University of Wyoming (UW) Energy Resources Council (ERC). That legislation appropriated $2.5 million to the Account which could only be expended upon appropriation by the Legislature. The legislation also directed the Task Force to solicit proposals for research in clean coal technologies and required that the appropriation could not be disbursed unless the project demonstrated a dollar-for-dollar match from non-state funds.

The Account was created to stimulate research and development in the area of low-emissions and advanced conversion technologies. The objectives of the program were to:

- Enable and accelerate demonstration and early commercial deployment of conversion technologies that have the potential to enhance and improve the use of sub-bituminous coal at high altitudes, specifically in Wyoming.
- Generate and test new ideas for significant improvement and cost reductions in next-generation, low-emissions, and advanced conversion technologies.
- Support collaborative research and development (R&D) in accomplishing the above objectives.

The Account supported proposals addressing the following:

- Research and development of new or improved conversion technologies that reduce emissions
- Pilot-scale demonstration of emerging technologies
- Engineering scale-up of demonstrated technologies
- Integration and operation of carbon capture technologies

Chapter 57 of the Legislature of the State of Wyoming's 2009 General Session Law extended the sunset date for the Task Force from June 30, 2010 to June 30, 2013. Section 5(a) provided that the 2007 general fund appropriation of $2.5 million into the Account would not revert, would be interest bearing and could continue to be used for clean coal research for the duration of the program. Since 2007, four additional appropriations of funds, each with a reversion date, were made to the Account (Table 1).

Table 1: Funds Appropriated for Advanced Conversion Research

Appropriation	Amount	Reversion Date
2007 Appropriation	$2,500,000	No reversion date
2008 Appropriation	$3,800,000	June 30, 2012
2009 Appropriation	$10,613,047	June 30, 2012
2010 Appropriation	$14,000,000	June 30, 2014
2012 Appropriation	$10,000,000	June 30, 2016
Total	**$40,913,047**	---

In the 2012 budget session, SF15/SEA3 revised the sunset date of the Task Force from June 30, 2013 to June 30, 2017 to ensure the Task Force would have oversight of the program one year after the June 30, 2016 reversion date.

FY 2016 Task Force Funding Sources

Abandoned Mine Land (AML) Funds - Redirected

In the 2012 budget session, HB121/HEA25 provided for the submittal of grant applications by the Wyoming Department of Environmental Quality (DEQ) to the Federal Office of Surface Mining for future funds and redirection of prior Abandoned Mine Land (AML) fund authorizations. Redirected funds derived from several sources including the Account and the Wyoming Carbon Underground Storage Project (WYCUSP). A portion of these funds was appropriated to the UW School of Energy Resources (SER) to fund research projects under guidance of the Task Force (Table 2). The status of each of these programs is discussed in more detail below.

Table 2: AML Funded Efforts Assigned to the Task Force and SER

Program Name	Appropriation	End Date or Fund Reversion Date	Project Status
Advanced Conversion Technology Research - 2012	$10,000,000	Reverted June 30, 2016	10 projects funded, all completed
Minerals to Value-Added Products Feasibility Study - 2012	$500,000	Study end date, September 30, 2012, Reverted June 30, 2014	2 projects funded, both completed
Commercial-Scale Minerals to Value-Added Products Facility - 2012	$9,000,000	Reverted June 30, 2016	No funding deployed, all funds reverted
Natural Resources to Manufacture Glass and Glass Products in Wyoming - 2012	$100,000	Reverted June 30, 2014	All funds repurposed to rare earth element research
Rare Earth Elements (Assigned to SER) - 2015	$316,764	Reverted June 30, 2016	3 projects funded, all completed

FY 2016 Program Updates

Advanced Conversion Technology Fund Research

All of the appropriations directed toward clean coal and advanced conversion technology research since 2007 were awarded to 52 different projects. Of the 52 projects originally funded, 46 have been completed, 3 projects were terminated prior to completion and 3 projects failed to negotiate a contract. All projects were completed by June 30, 2016. Because researchers seldom spend their budgets down to a zero balance and because a couple of projects were terminated early, all but $331,439 of the $41,526,133 appropriated to the Task Force was spent. A listing of all the projects funded by the Task Force is shown in Appendix A.

By legislation, the 2007 funds do not have a reversion date (Table 1). In addition, the 2007 funds were set up as an interest bearing account. The original 2007 appropriation of $2.5 million has been accumulating interest; however, over time the rate of interest growth has slowed as the 2007 funds have been spent on research projects. Since 2007, this account accumulated $613,066 in interest, a portion of which was deployed by the Task Force as supplemental funding to some clean coal projects. According to the State of Wyoming, Department of Administration and Information Accounting Office, the balance of interest on the 2007 account as of September 13, 2016 was $285,000. The overall budget for the Account from 2007-2016 is shown in Table 3.

From 2011 to 2015, SER hosted an annual research symposium to provide a forum for researchers funded through the Account to present the results of their work to the public. Researchers from each of the 46 projects that were completed presented their results in a public forum. Each symposium was well attended by a diverse audience of industry experts, academicians, government representatives, and the general public. In addition to publicly presenting research findings, each researcher submitted a final executive summary and final technical report of their work. The executive summaries for each of the funded and completed projects can be found on the SER website at: http://www.uwyo.edu/ser/research/advanced-conversion-research/final-executive-summary-reports.html.

Since completion of the advanced conversion research projects, SER staff has conducted two surveys - one in August 2015 and one in August 2016 - asking for information on continued research and steps toward pilot or commercial scale-up of the technologies funded by the Task Force. The survey also asked the researchers to identify any barriers they have encountered to scaling-up their technology.

The 2015 survey was sent to 25 researchers and the 2016 survey was sent to 21 researchers. Between 2015 and 2016, several of the researchers retired or changed jobs. The number of survey respondents in 2015 was 7 out of 25 and in 2016 the number of respondents was 9 out of 21. A couple of important outcomes of the survey were that eight of nine respondents in 2016 are continuing scale-up of their technology and four of them have reached pilot or commercial scale. One project is a 200 kW fluidized bed chemical looping combustion system for CO_2 capture that uses Wyoming Powder River Basin coal as one of its two target fuels. The system is the largest in North America and second largest in the world. A complete summary of the 2016 and 2015 survey is attached as an appendix to this report (Appendix B).

Table 3. Advanced Conversion Technology Account Balance

Appropriation	**Amount**
2007 Appropriation	$2,500,000
2008 Appropriation	$3,800,000
2009 Appropriation	$10,613,047
2010 Appropriation	$14,000,000
2012 Appropriation	$10,000,000
Interest generated on 2007 Funds, 7/1/2007 – 6/30/2016	$613,066
Subtotal	**$41,526,113**
Funds Awarded ***(includes use of interest funds)***	**Amount**
2007 Awards	($2,105,703)
2008 Awards	($2,661,573)
2009 & 2009a Awards *(From 2007 interest and 2008 and 2009 appropriations)*	($12,095,909)
2010 & 2011 Awards *(From 2010 appropriation)*	($13,055,026)
2012 Awards *(From 2010 and 2012 appropriations)*	($11,049,338)
Subtotal	**($41,242,685)**
Funds Returned to State	**Amount**
Unawarded research funds *(Appropriations – Awards)*	$283,428
Unspent research funds	$331,439
2007 Interest Funds Remaining*	$285,000
Total Funds Returned to State	**$899,867**

*Interest amount as of September 13, 2016 from State of Wyoming Department of Administration and Information.

Integrated Test Center

In the 2014 legislative session, a $15 million appropriation was made under section 334(n) of the state budget bill to the Wyoming Governor's Office for design, construction and operation of an Integrated Test Center (ITC) to study the capture, sequestration and management of carbon emissions from a Wyoming coal-fired power plant. An additional $5 million commitment from private industry was required under the appropriation, which has since been secured from the Tri-State Generation and Transmission Association, with an additional $1 million pledged from the National Rural Electric Cooperative Association. Total funds for the ITC is currently $21 million.

The host site for the ITC is being provided by Basin Electric Power Cooperative (BEPC) at their Dry Fork Station (DFS) in Gillette, Wyoming. BEPC is providing additional in-kind contributions to the ITC project, including engineers and construction management services. The ITC will provide space for researchers to test carbon capture, utilization and sequestration (CCUS) technologies using up to 20 MW of coal-based flue gas from DFS. While many carbon capture technologies are being developed and studied in laboratory settings, the ITC will be one of the few research and testing facilities located at an operating coal-fired powered plant. Along with testing capture technologies, additional research will look at taking flue gas and turning it into marketable commodities.

Pre-construction engineering and design work for the ITC started in 2015. Installation of a flue gas damper and other equipment was completed in March 2016 while the DFS was undergoing a regularly scheduled maintenance shutdown. Additional engineering, site preparation and other construction work started in the spring of 2016. The ITC facility is scheduled to be completed in the summer of 2017.

Management of the ITC has been delegated by the Governor's Office to the Wyoming Infrastructure Authority (WIA). As such, the WIA has executed a series of agreements as follows:

- A site host agreement between the Wyoming Governor's Office and BEPC-DFS to establish terms and conditions to engineer the test bays and make available a coal-derived flue gas delivery system.
- A cooperative agreement between SER/Task Force and WIA establishing a cooperative effort for construction, management and operation of the ITC.
- A cooperative agreement between the WIA and Tri-State Generation and Transmission Association for their private investment of $5 million to the ITC.
- A memorandum of understanding (MOU) between the WIA and XPrize Foundation, Inc. to establish a framework for cooperation and coordination between the two entities that will result in development and construction of a test facility in a timely manner and successful completion of the XPrize competition.

Occupation of test bay space in the ITC will be determined through a competitive request for proposal (RFP) process. The RFP will seek applicants that can: 1) improve efficiency of carbon capture from a Wyoming coal-fired power plant; and 2) develop a beneficial use of CO_2 at utility scale. The RFP is being drafted by a technical advisory committee (TAC) appointed by the WIA consisting of experts from the utility industry. The TAC is working with the WIA, SER and the Wyoming Governor's Office to write and release the RFP and evaluate the proposals that are submitted. The TAC will then provide the Governor with a recommendation of tenant(s) for the test bay, giving the Governor the final decision for ITC occupancy.

The TAC hopes to have their recommendation for a tenant(s) to the Governor by February 1, 2017. The test bays should be ready for occupancy by the summer of 2017 and testing should begin by fall 2017.

Appendix A
Listing of Advanced Conversion Technology Fund Research Projects, 2007-2012

2007			End Date	Revised End Date	Final Report	Total Research Funds	Matching Funds	Total Award	Spent	Unspent	Percent Complete
Principal Investigator	**Proposal Title**	**Affiliation**									
KJ Reddy	Capture and Mineralization of Carbon Dioxide from Coal Combustion Fuel gas Emissions: Pilot Scale Studies	Renewable Resources	6/30/2010	8/30/2011 6/30/2011	Received	$ 972,115.00	$ 487,115.00	$ 485,000.00	$ 485,000.00	$ -	100%
Mac Radosz	Carbon Capture from Coal Flue gas on Carbonaceous Sorbents	Super Critical	6/30/2010	2/28/2011 12/31/2010	Received	$ 750,000.00	$ 375,000.00	$ 375,000.00	$ 375,000.00	$ -	100%
Benjamin Phillips	Novel Fixed-Bed Gasifier for Wyoming Coals	Emery Energy Company	6/30/2010	9/30/2012 12/31/2011	Received	$ 1,125,049.00	$ 562,549.00	$ 562,500.00	$ 562,500.00	$ -	100%
Alan Bland	Pre-Gasification Treatment of PRB Coals for improved Advanced Clean Coal Gasifier Design	Western Research Institute	6/30/2010	2/29/2012 12/31/2011	Received	$ 798,184.00	$ 399,981.00	$ 398,203.00	$ 398,203.00	$ -	100%
Benjamin Phillips	Novel Fixed-Bed Gasifier for Wyoming Coals	Emery Energy Company	6/30/2010	3/31/2013 12/31/2011	Received	$ 570,000.00	$ 285,000.00	$ 285,000.00	$ 285,000.00	$ -	100%
		Total				$ 4,215,348.00	$ 2,109,645.00	$ 2,105,703.00	$ 2,105,703.00	$ -	100%

2008			End Date	Revised End Date	Final Report	Total Research Funds	Matching Funds	Total Award	Spent	Unspent	Percent Complete
Principal Investigator	**Proposal Title**	**Affiliation**									
Maohong Fan	Development of a New Solid Sorbent for CO2 Separation	UW Chemical Engineering - Fan	6/30/2011	12/31/2011 6/30/2011	Received	$ 503,661.00	$ 253,394.00	$ 250,267.00	$ 250,267.00	$ -	100%
Mohammad Piri	Geologic Sequestration of CO2 in the Rock Springs Uplift (Southwest Wyoming): Experimentation and Modeling of	UW Chemical Engineering - Piri	6/30/2010	10/31/2011	Received	$ 999,572.00	$ 500,000.00	$ 499,572.00	$ 499,572.43	$ 32.57	100%
Alan Bland	A Novel Integrated Oxy-Combustion Flue Gas Purification Technology- A Near Zero Emissions Pathway	Western Research Institute	12/31/2010	11/30/2012 9/30/2012	Received	$ 2,909,104.00	$ 1,454,552.00	$ 1,454,552.00	$ 1,454,552.00	$ -	100%
Brandon Pavlish	Feasibility of Hydrothermal Dewatering for the Potential to Reduce CO2 Emissions and Upgrade Low Rank Coals	Energy & Environmental	6/30/2010		Received	$ 119,762.00	$ 59,881.00	$ 59,881.00	$ 59,881.22	$ -	100%
Gerri Botte	Coal Electrolysis for the Production of Hydrogen and Liquid Fuels	Ohio University	6/30/2010	6/30/2011	Received	$ 794,633.00	$ 397,332.00	$ 397,301.00	$ 397,301.00	$ -	100%
		Total				$ 5,326,733.00	$ 2,665,159.00	$ 2,661,573.00	$ 2,661,574.00	$ 32.57	100%

2009			End Date	Revised End Date	Final Report	Total Research Funds	Matching Funds	Total Award	Spent	Unspent	Percent Complete
Principal Investigator	**Proposal Title**	**Affiliation**									
Larry Baxter	Cryogenic Carbon Capture	Sustainable Energy Solutions	6/30/2012		Received	$ 2,811,456.00	$ 1,405,750.00	$ 1,405,706.00	$ 1,405,705.51	$ 38.49	100%
S. Elangovan	Removal of Synthesis Gas Pollutants & Liquid Fuel Synthesis- Part 2	Ceramatec, Inc/WRI	12/31/2011	6/30/2012	Received	$ 1,900,393.00	$ 950,393.00	$ 950,000.00	$ 950,000.00	$ -	100%
Joshua Stanislowski	Demonstration of Hydrogen Production From Wyoming Coal	Energy & Environmental	3/31/2011	5/31/2011	Received	$ 899,986.00	$ 600,000.00	$ 299,986.00	$ 299,985.85	$ 14.15	100%
Vijay Sethi	Development & Evaluation of Non-Carbon Sorbents	Western Research Institute -Sethi	9/30/2011	4/30/2012 1/31/2012	Received	$ 697,584.00	$ 350,000.00	$ 347,584.00	$ 347,583.89	$ 2,416.11	100%
Ben Phillips	Extended Operational Runs on Emery Hybrid Gasifier to Accelerate Commercial Adoption	Emery Energy Company	8/31/2011	10/31/2012	Received	$ 2,678,565.00	$ 1,340,650.00	$ 1,337,915.00	$ 1,337,914.72	$ 2,735.28	100%
KJ Reddy	Supplemental Budget for "Capture & Mineralization of carbon Dioxide from Coal Combustion Flue Gas Emissions:	Renewable Resources	6/30/2010		Received	$ 212,764.00	$ 106,382.00	$ 106,382.00	$ 106,382.00	$ -	100%
Ron Surdam	CO2 Sequestration in Depleted Compartmentalized Gas Fields -the Key to Deploying Clean Coal Technology in the	Wyoming State Geological Survey	12/31/2012	3/29/2012	Terminated contract early	$ 1,000,000.00	$ 500,000.00	$ 500,000.00	$ 291,934.16	$ 208,065.84	Remaining funds returned to state
Tom Barton	Hydrogen Separation for Clean Coal Applications	Western Research Institute -Barton	4/1/2012	12/31/2012	Received	$ 2,000,004.00	$ 1,000,004.00	$ 1,000,000.00	$ 1,000,000.00	$ -	100%
		Total				$ 11,884,203.00	$ 6,253,179.00	$ 5,631,024.00	$ 5,631,024.00	$ 213,269.87	100%

2009A			End Date	Revised End Date	Final Report	Total Research Funds	Matching Funds	Total Award	Spent	Unspent	Percent Complete
Principal Investigator	**Proposal Title**	**Affiliation**									
Mohammad Piri	Reactive Transport of Acidic Brine Resulting form CO2 Sequestration in the Rock Springs Uplift (SW Wyoming):	Chemical Engineering - Piri	6/30/2012		Received	$ 375,820.00	$ 188,500.00	$ 187,320.00	$ 187,320.23	$ 1,179.77	100%
Eddie Krule	Innovative Catalytic gasification Technology to Maximize the Value of Wyoming's Coal Resources	Great Point	6/30/2013		Received	$ 926,100.00	$ 463,050.00	$ 463,050.00	$ 463,050.00	$ -	100%
Alan Bland	WRI's Pre-Gasification Treatment of Low Rank Coals for Improved Clean Coal Gasifier Design: PhaseII: Pilot-Scale	Western Research Institute - Bland	4/30/2011	12/31/12 10/31/2012	Received	$ 1,957,022.00	$ 979,405.00	$ 977,617.00	$ 977,617.00	$ -	100%
Robert Downey	Proposal for Clean Coal Technology Research	Ciris Energy	6/30/2012	8/8/2011	Terminated contract early	$ 9,836,898.00	$ 5,000,000.00	$ 4,836,898.00	$ 586,744.00	$ 4,250,154.00	Remaining funds redirected to other projects
		Total				$ 4,432,459.00	$ 2,217,713.00	$ 6,464,885.00	$ 2,214,731.23	$ 4,251,333.77	100%

2010			End Date	Revised End Date	Final Report	Total Research Funds	Matching Funds	Total Award	Spent	Unspent	Percent Complete
Principal Investigator	**Proposal Title**	**Affiliation**									
Tom Barton	The Engineering Scale Up of Hydrogen Separation Facilities	Western Research Institute - Barton	6/30/2012	6/30/2013	Received	$ 2,619,998.00	$ 1,519,998.00	$ 1,100,000.00	$ 1,100,000.00	$ -	100%
Christopher Martin	Testing of an Advanced Dry Cooling Technology for Power Plants in Arid Climates	Energy & Environmental	1/31/2013	9/30/2013	Received	$ 1,099,192.00	$ 600,000.00	$ 499,192.00	$ 499,192.45	$ 807.55	100%
Brandon Pavlish	Evaluation of Novel Technologies for CO2 Capture: Neustream-C System	Energy & Environmental	6/30/2012	10/31/2012	Received	$ 1,977,334.00	$ 1,697,683.00	$ 279,651.00	$ 279,651.36	$ 504.64	100%
Dennis Laudal	Pilot-Scale Testing Evaluations the Effects of Bromine Addition on CMMs at Low Mercury Concentrations	Energy & Environmental	1/31/2012	5/31/2012	Received	$ 371,186.00	$ 226,156.00	$ 145,030.00	$ 145,030.49	$ 4,969.51	100%
Steven Paglieri	Efficient Coal to Hydrogen System	TDA Research, Inc	1/31/2012	9/30/2012	Received	$ 679,957.00	$ 340,000.00	$ 339,957.00	$ 339,957.37	$ 42.63	100%
Yulong Zhang	Development of Compact Heat Exchange Reactor for F-T Synthesis	WRI	6/30/2012	12/31/2013 6/20/2013	Received	$ 1,050,200.00	$ 600,200.00	$ 450,000.00	$ 450,000.00	$ -	100%
S. Elangovan	Modular Fischer Tropsch for Wyoming Coal to Liquid Fuels	Ceramatec	4/30/2012	3/31/2013 10/31/2012	Received	$ 1,192,208.00	$ 596,105.00	$ 596,103.00	$ 596,103.01	$ 1.99	100%
Dave Camp	Use of Historic Wyoming Field Test Data to Validate & Calibrate a Comprehensive Underground Coal Gasification	LLNL	-		Could not negotiate contract	$ 1,000,000.00	$ 500,000.00	$ 500,000.00	$ -	$ 500,000	Funds redirected to other projects
Thomas Wolery	Conceptual Design of a System for Treating Formation Waters Produced as Part of Geologic CO2 Sequestration	LLNL	-		Could not negotiate contract	$ 1,000,000.00	$ 500,000.00	$ 500,000.00	$ -	$ 500,000	Funds redirected to other projects
Jost Wendt	Retrofit Impacts of Oxy-coal Combustion of PRB Coal on Deposit Formation& & Mercury Speciation	University of Utah	6/30/2013	12/31/2013	Received	$ 1,081,382.00	$ 540,691.00	$ 540,691.00	$ 540,691.00	$ -	100%
Morris Argyle	Low Cost Route to Commercial Iron FT Catalysts for CTL & BTL	BYU	6/30/2013	12/31/2013	Received	$ 840,013.00	$ 420,009.00	$ 420,004.00	$ 420,004.00	$ -	100%
		Total				$ 13,155,299.00	$ 8,784,669.00	$ 4,370,628.00	$ 4,370,630.00	$ 1,006,326.32	100%

2011			End Date	Revised End Date	Final Report	Total Research Funds	Matching Funds	Total Award	Spent	Unspent	Percent Complete
Principal Investigator	**Proposal Title**	**Affiliation**									
Hufton, Jeffrey	Advanced Technology for Cleaning Sour Syngas with Capture of CO2	Air Products and Chemicals, Inc.	-	2/28/2014	Could not negotiate contract	$ 1,463,968.00	$ 731,984.00	$ 731,984.00	$ -	$ 731,984.00	Funds redirected to other projects
Whitty, Kevin	Advancement of Chemical Looping Combustion with Oxygen Uncoupling	University of Utah	6/30/2013	3/31/2014	Received	$ 888,396.00	$ 446,292.00	$ 442,104.00	$ 442,103.90	$ 3,918.10	100%
King, Dave	Coal-derived Warm Syngas Purification and CO2 Capture-assisted Methane Production	Pacific Northwest National Laboratory	6/30/2014		Received	$ 2,411,192.00	$ 1,205,596.00	$ 1,205,596.00	$ 1,205,595.96	$ 0.04	100%
Wailia, Daman	Pilot Scale Demonstration of MicGAS Coal Biotechnology for In Situ Biological Gasification of Unmieable Wyoming	ARCTECH	8/31/2013	6/30/2014	Received	$ 999,924.00	$ 500,000.00	$ 499,924.00	$ 499,924.00	$ -	100%
Piri, Mohammad	Pore-to-Core-to-Reservoir Modeling of Geologic Storage of Supercritical CO2 in Deep Fractured Saline Aquifers	University of WY	6/30/2014	12/31/2014	Received	$ 2,781,985.00	$ 1,407,934.00	$ 1,374,051.00	$ 1,374,050.57	$ 19,244.80	100%
Sethi, VJ	Multi-stage Processing of WY Coals to Liquid Fuels	Thermosolv	6/30/2012	6/30/2014 6/30/2013	Received	$ 1,000,000.00	$ 500,000.00	$ 500,000.00	$ 500,000.00	$ -	100%
Drinnan, Nicholas	Development of a Novel Helical Channel Reactor for Syngas Conversion	AmbreEnergy	2/1/2014	5/15/2014 3/31/2014	Received	$ 1,417,106.00	$ 740,000.00	$ 677,106.00	$ 677,106.14	$ 42,983.86	100%
Lui, Kunlei	Novel Carbon Capture Technology Development for Power Generation Using Wyoming Coal	University of Kentucky	6/30/2013	12/31/2013	Received	$ 1,485,396.00	$ 745,000.00	$ 740,396.00	$ 740,396.28	$ 4,383.72	100%
Baxter, Larry	Skid-Scale, Cryogenic Carbon Capture	Sustainable Energy Solutions	8/31/2013	8/31/2014 5/31/2014	Received	$ 5,026,474.00	$ 2,513,237.00	$ 2,513,237.00	$ 2,513,237.00	$ -	100%
		Total				$ 16,742,457.00	$ 8,790,043.00	$ 8,684,398.00	$ 7,952,414.00	$ 802,514.52	100%

2012			End Date	Revised End Date	Final Report	Total Research Funds	Matching Funds	Total Award	Spent	Unspent	Percent Complete
Principal Investigator	**Proposal Title**	**Affiliation**									
Joe Remias	Advanced solvent for CO2 Capture and Separation Technology for CO2 Sequestration to Enhance Utilization	University of Kentucky	9/30/2014		Received	$ 600,000.00	$ 300,000.00	$ 300,000.00	$ 300,000.00	$ -	100%
Joshua Stanislowski	Demonstration of Pilot-Scale Hydrogen and CO2 Separation Membrane Technlology on Wyoming Coal-	EERC	9/30/2014	11/30/2015 9/30/2015	Received	$ 1,765,000.00	$ 1,315,000.00	$ 450,000.00	$ 438,144.43	$ 11,855.57	100%
S. "Elango" Elangovan	Demonstration of a Modular Fischer Tropsch for Wyoming Coal to Liquid Fuels	Ceramatec	9/30/2014	3/31/2015	Received	$ 4,983,422.00	$ 2,491,712.00	$ 2,491,710.00	$ 2,491,693.98	$ 16.02	100%
Larry Baxter	Energy Storing Cryogenic Carbon Capture	Sustainable Energy Solutions	10/31/2015	4/30/2016	Received	$ 6,000,000.00	$ 3,000,000.00	$ 3,000,000.00	$ 2,997,439.23	$ -	100%
Maohong Fan	Pilot-Scale Demonstration of Catalytic Wyoming Coal Gasification and Syngas Processing (Diesel Production)	University of Wyoming	5/31/2016	3/31/2016	Terminated early	$ 2,000,000.00	$ 1,000,000.00	$ 1,000,000.00	$ 826,281.22	$ 173,718.78	Remaining funds returned to state
Ben Phillips	Testing and Feasibility Study of an Indirectly Heated Coal Gasifier	Emery Energy	12/31/2013	3/31/2014	Received	$ 773,990.00	$ 387,481.00	$ 386,509.00	$ 386,509.00	$ -	100%
Richard Axelbaum	Evaluation of Staged Oxyfuel Combustion for CO2 Capture	Washington University, St. Louis	11/30/2015		Received	$ 959,308.00	$ 479,657.00	$ 479,651.00	$ 461,459.83	$ 18,191.17	100%
JoAnn Lighty	Validation, Modeling & Scale-up of Chemical Looping with Oxygen Uncoupling	University of Utah	11/30/2014	5/31/2015	Received	$ 367,332.00	$ 184,000.00	$ 183,332.00	$ 182,347.49	$ 984.51	100%
Matthew Targett	Advanced Polygeneration Platform: Optimizing an Oxy-Combustion Burner for Utilizing PRB & GRB Coals	LP Amina	5/31/2015		Received	$ 3,540,000.00	$ 1,770,000.00	$ 1,770,000.00	$ 1,762,816.34	$ 7,183.66	100%
Burt Davis	Fischer-Tropsch Conversion of Wyoming Coal-Derived Syngas Using a Small Channel Reactor for Improving	University of Kentucky	9/30/2015		Received	$ 1,977,458.00	$ 989,322.00	$ 988,136.00	$ 951,919.38	$ 36,216.62	100%
		Total				$ 22,966,510.00	$ 11,917,172.00	$ 11,049,338.00	$ 10,798,611.00	$ 248,166.33	100%

Appendix B
Advanced Conversion Technology Fund Research
2016 Survey Results
As of August 18, 2016

2016 Survey:

- Survey was sent out on August 1, 2016 to 21 principal investigators; 10 responses have been received.
- 2016 Survey asked 5 questions - identical to the August 2015 survey:
    - PI name, affiliation, project name, year
    - Research topic
    - Since project completion, have you pursued further research and commercialization efforts on that topic/technology?
    - If so, has the technology reached pilot or commercial scale? (Please provide a description of that process)
    - If not, what have been the biggest hurdles to scale-up and what policies might assist in overcoming those challenges

2016 Survey Responses:

- PI's who responded to the 2016 survey indicated they are working on the following research topics:
    - 40.0% - combustion and gasification design technologies
    - 26.6% - carbon capture and use technologies
    - 26.6% - coal-to-liquids/coal-to-natural gas/coal-to-hydrogen technologies
    - 0.06% - economic analysis
- 91% of respondents answered "yes" – they have continued to pursue scale-up of their technology
    - Four received further funding from DOE
    - One received follow-up funding from ARPA-E but lost the project's industry partner due to an unfavorable economic outlook
    - National Energy Technology Laboratory (awarded) and National Science Foundation (pursued) are other funding entities
    - Funding was awarded to one project by the Illinois Clean Coal Institute (ICCI), but was rescinded when the ICCI program was dissolved to help recover Illinois' state budget
- 50% of respondents have reached pilot or commercial scale
    - One project is a 200 kW fluidized bed chemical looping combustion system for CO_2 capture that uses Wyoming Powder River Basin coal as one of its two target fuels. The system is the largest in North America and second largest in the world.
    - One project on CO_2 capture has advanced to pilot scale at 0.7 MWe.

    - Completion of construction and testing at pilot scale is expected in 2017 for another project.
    - A small pilot scale demonstration in China is planned for 2017 for a Fischer-Tropsch catalyst project.
- Current challenges for further scale-up:
    - Policy hurdles – little incentive to capture CO_2.
    - Market uncertainty and current permitting policies related to cooling systems selection.
    - Lack of incentive to further research given uncertainty in the CO_2 regulatory framework.
    - Lack of funding and slow growth in Fischer-Tropsch synthesis in the U.S.
    - The combined collapse of oil prices and lack of funding to incentivize coal-to-liquids Fischer-Tropsch processes has made the technology not economically efficient.
    - Market and regulatory (pollution control) factors, bankruptcies among coal companies, public opposition to coal export projects.

Advanced Conversion Technology Fund Research
2016 Survey Results
August 2015

2015 Survey:

- Survey was sent out to 25 principal investigators; 7 responses have been received.
- Survey asked 5 questions:
    - PI name, affiliation, project name, year
    - Research topic
    - Since project completion, have you pursued further research and commercialization efforts on that topic/technology?
    - If so, has the technology reached pilot or commercial scale? Please provide a description of that process.
    - If not, what have been the biggest hurdles to scale-up and what policies might assist in overcoming those challenges?

Responses:

- 100% of respondents answered "yes" – they have continued to pursue scale-up of their technology
- 29% of respondents have reached pilot or commercial scale:
    - Two received further funding from DOE
    - One received follow-up funding from ARPA-E and is now working to define a product offering with a commercial partner
    - One has gone on to 3 new awards from DOE and the State of Kentucky and has scaled up to a 25 kW chemical looping combustor and gasifier
- Indicated challenges for further scale-up:
    - One cited data constraints
    - Finding a market entry point since full-scale is so large
    - Coal is not considered a "clean technology," and interest in gasification systems has waned
    - Acceptance of small channel reactors as a significant benefit is needed in the policy arena

Other Comments:

- "We recently received a large DOE-funded program on chemical looping combustion. We never would have been able to receive that without the resources that were built under our University of Wyoming project."