RTI International Annual Report

State Fiscal Year 2013–2014 Report of Program Activities, Objectives and Accomplishments; and Itemized Expenditures and Fund Sources

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REPORT OVERVIEW

- For the 2013–2014 fiscal year (FY), RTI received a nonrecurring State appropriation of $500,000 to match U.S. Department of Energy research and development funds.
- RTI utilized the full $500,000 of the State's investment in this program, allowing RTI to attract $5,179,250 in federal energy research funds, along with additional private sector investment.
- As a result, for every $1 in State FY 2013-2014 funds utilized by RTI, North Carolina attracted $10.36 in corresponding federal investment to support its economy.

As provided in Session Law 2013-360, Section 15.25, RTI International is pleased to submit this report of State fiscal year program activities, objectives, and accomplishments and prior State fiscal year itemized expenditures and fund sources.

ABOUT RTI

Growing from a handful of scientists in central North Carolina in 1959 to a staff of more than 3,700 in more than 40 countries today, RTI is now one of the world's leading independent, nonprofit research and development (R&D) organizations and one of the largest employers in the Research Triangle region.

Our activities both mirror and support national priorities and policies as well as diverse commercial, industrial, and academic endeavors. For instance, as public and government interest in environmental protection grew in the 1960s, so did related programs at RTI, building on our expertise in statistical, physical, and life sciences.

As our mission affirms, we are dedicated to improving the human condition by turning knowledge into practice through cutting-edge study and analysis in advanced technology, energy and the environment, health and pharmaceuticals, education and training, surveys and statistics, international development, economic and social policy, and laboratory and chemistry services.

We are proud of our scientific stature and our reputation for innovation. By continuing to conduct impartial, reliable, multidisciplinary research and by helping to develop and broker new technologies for our clients, we seek to be the world's preferred resource for turning knowledge into practice.

ENERGY RESEARCH AT RTI

RTI develops advanced energy technologies to address today's significant energy challenges, such as energy security, energy efficiency, sustainability, climate change, and water conservation. Our research supports national and worldwide goals of reliable, sustainable, economically viable, and secure energy supplies. In a newly created program, RTI also addresses the water-energy-nexus through technology development that improves the energy efficiency of industrial water treatment.

RTI scientists and engineers conduct applied R&D for a variety of stakeholders in the power, chemical, and petroleum refining industries, as well as for the transportation sector. These stakeholders include the following:

- Process technology licensors
- Gas processing companies

- Oil refiners
- Chemical manufacturers
- Electric utilities
- Clean fuels developers
- Catalyst manufacturers
- Lighting companies.

In addition to these and other commercial clients, RTI also works with the U.S. Department of Energy (DOE), Department of Defense (DoD), and other government agencies to develop new energy technologies.

Our R&D programs are focused into six primary areas, all of which are important for the production and utilization of clean, secure, and safe domestic energy in our state and in our nation:

- Natural gas
- Biomass and biofuels
- Syngas/clean coal
- Carbon capture and utilization
- Industrial water treatment and recycle/reuse
- Solid-state lighting

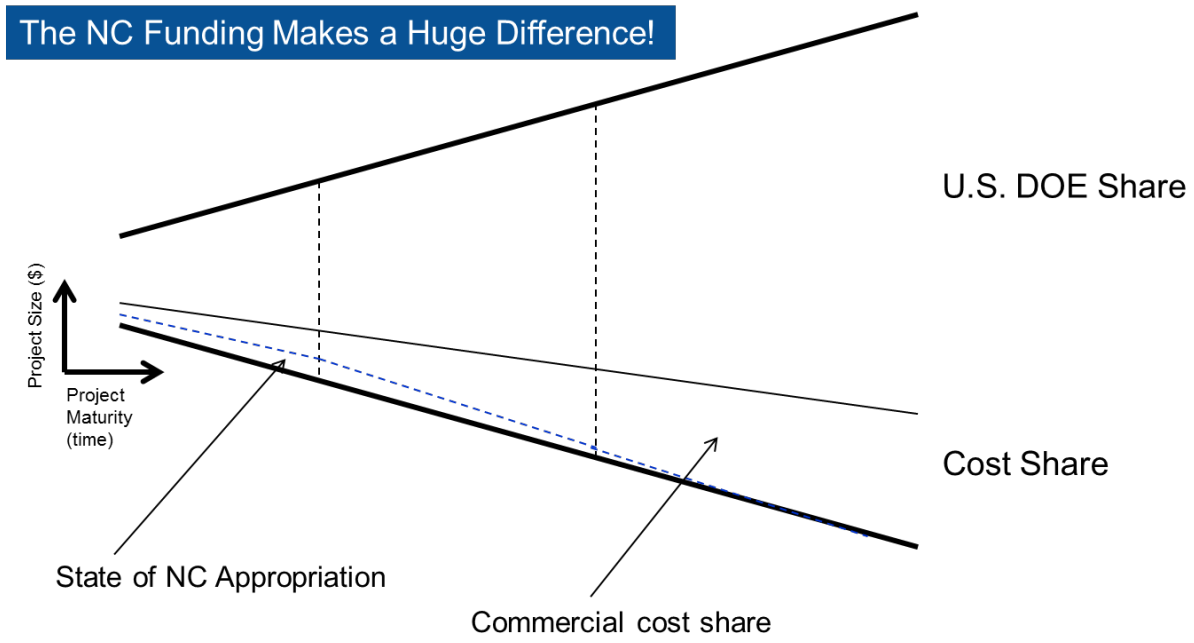
RTI develops advanced technologies for energy applications from concept to large scale demonstration, with a focus on applied research. We partner with the largest energy and chemical companies in the world and leverage our state support to enter new R&D areas and build new technology platforms and to build a technology base for future commercialization of new energy technologies. RTI is unique in North Carolina, with a world class reputation in the energy sector.

IMPORTANCE OF THE $500K GRANT APPROPRIATED TO RTI IN THE FY 2013–2014 STATE BUDGET

North Carolina State Funding as an Investment in Energy Technology Development

RTI develops advanced energy technologies mainly under the funding from the U.S. DOE. These federal research awards require a cost share or match from non-federal sources, typically 5% or 20%, depending on the funding program. RTI's first priority is to develop partnerships with industry that can attract this cost share match from the private sector, and RTI has a successful track record for building these industry alliances. However, the development of new technologies often makes it difficult to attract such cost share requirements until the technologies are sufficiently proven to attract private sector

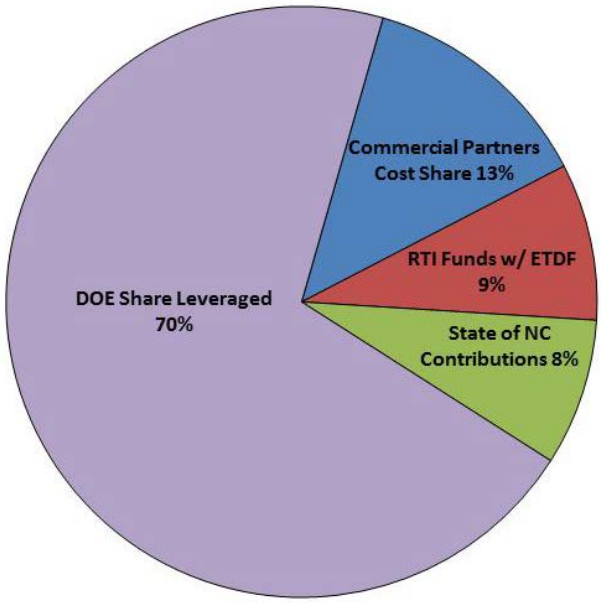
investment. State matching funds allow RTI to cover this early cost share gap and to demonstrate the viability of new technologies – and then attract private sector investment as they mature. As projects are further advanced, industry often picks up the full funding load for U.S. DOE cost share requirements.



The State Budget approved by the legislature for Fiscal Year (FY) 2013–2014 included a $500,000 grant to assist RTI in winning federal energy research grants that require cost share—or match. The goal of this grant is to help RTI advance energy research in North Carolina and create jobs in this important and growing part of the state's economy. The key points of how RTI utilizes the grant and the benefits to the State can be summarized as follows:

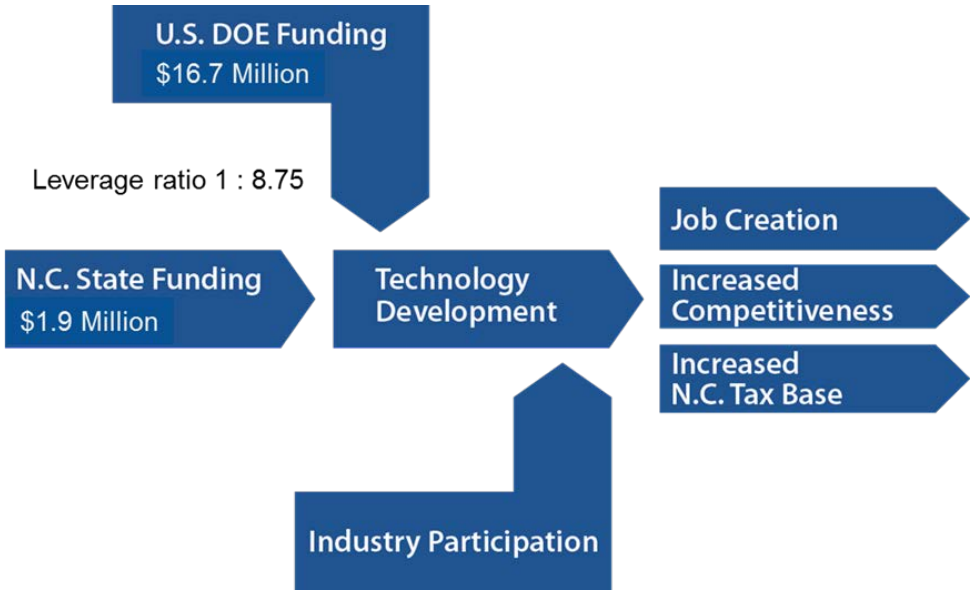
- North Carolina state funding helps RTI to initiate development of at least three to five additional energy technology concepts per year. This year, a total of six development projects have been benefitting from the state funding.
- This fiscal year RTI utilized the full $500,000 of the State's funding to attract $5,179,250 in federal energy research funds, along with additional private sector investment. As a result, for every $1 in State FY 2013-2014 funds utilized by RTI, North Carolina attracted $10.36 in federal investment to support its economy.
- Together with U.S. DOE funding and in partnerships with leading industrial companies RTI builds a pipeline of innovative technologies addressing the energy challenges of our state and of our nation.
- Since 2010, the State of North Carolina has invested ~$500,000 annually to help RTI attract federal and private funding for energy technology development in NC. While

the NC is the smallest investor in this effort, its funding to date has helped attract approximately $25 million in technology investment to NC's economy.



FY11-FY14 RTI Energy Funding Breakdown

- Commercialization of technologies leads to increased economic competitiveness. It creates high-paying jobs, typically attracting talent from outside of the state and resulting in significant economic input to the state of North Carolina.



Federal Leveraging of NC State Funding to RTI for FY11-FY14

STATE FISCAL YEAR 2013–2014 PROGRAM ACTIVITIES, OBJECTIVES, AND ACCOMPLISHMENTS

In this 2013-2014 state fiscal year, utilizing the full $500,000 of the State's funding has greatly assisted in further building RTI's technology development pipeline, attracting $5,179,250 in federal research dollars (10.36:1 federal leverage ratio) along with approximately $5 million in industry and other funding to the state, successfully retaining and creating jobs in the state of North Carolina. The table below shows the leveraging of Federal funds through State funding.

Leveraging of Federal Funds through State Funding

Federal Dollars Leveraged Through Use of State Funding		
Project / Proposal	**NC Funds Used ($)**	**Federal Dollars Leveraged ($)**
Internal Combustion Engine Reformer/Converter for Gas-to-liquids Conversion	106,993	2,032,867
Novel Dry Particle Thermal Transfer Fluids for Transformational Solar Energy Storage	104,957	1,994,183
Catalytic Upgrading of Biofuels	100,000	400,000
Advanced Gasification Technologies Development	66,234	264,936
Solid-State Lighting Luminaire Reliability Model	62,085	248,340
Novel Non-Aqueous Solvent-based Carbon Dioxide Capture Process	59,731	238,924
Total	**500,000**	**5,179,250**

Specific projects benefiting from State of NC funds and the goals of and accomplishments within those projects are highlighted below:

1. **Internal Combustion Engine Reformer/Converter for Gas-to-liquids Conversion.** RTI used $106,993 of its FY14 state funding to secure a new award of $2,032,867 from the U.S. DOE to demonstrate a novel approach that uses a modified internal combustion engine and gas-to-liquid technology developed by RTI to enable an economic, small-footprint modular process design for conversion of natural gas to liquid fuels and electric power. Such a small-footprint design would enable production of high-value chemicals and fuels directly on-site from stranded or associated natural gas (that is currently vented or burned at oil well sites) or on-site from shale gas wells. This project is being conducted in cooperation with MIT and Columbia University, but the testing will be performed at RTI here in NC.

2. **Novel Dry Particle Thermal Transfer Fluids for Transformational Solar Energy Storage.** RTI used $104,957 of its state funding to secure a new DOE award for $1,994,183 to develop a high-quality concentrating solar thermal energy transport and storage system for use in light metals manufacturing. RTI has developed a specialized heat transfer fluid that can be heated to temperatures of over 1,000°C, much higher than conventional fluids. Because the heat transfer fluid can store thermal energy, metal manufacturing plants can continue to operate even when the sun is not shining. This technology will enable constant, high-temperature operation of a light metals production process with reduced carbon dioxide emissions.

3. **Catalytic Upgrading of Biofuels.** RTI used $100,000 of its state funding to secure an additional $400,000 from the U.S. DOE to develop, design and operate a small integrated pilot system for the catalytic upgrading of crude biofuels produced from a one ton per day biomass catalytic pyrolysis pilot plant located at RTI. The goal is to develop an upgraded biofuels product that can be utilized directly in conventional refineries for production of transportation fuels without need of subsidies.

4. **Advanced Gasification Technologies Development.** RTI used $66,234 of its state funding to secure $264,936 from the U.S. DOE to assess the potential to achieve a substantial reduction in the production cost of electric power, chemicals, and fuels made via gasification of coal with near-zero emissions. This project will assess the cumulative and synergistic improvements realized when multiple advanced technologies (including technologies developed by RTI) are incorporated into the overall process. Estimated cumulative effects of these technologies' benefits indicate that production costs may be reduced by as much as 20-25%, capital costs reduced by as much as 33-38%, and overall efficiencies increased by as much as 7-8%.

5. **Solid-State Lighting Luminaire Reliability Model.** RTI used $62,085 of its state funding to secure $248,340 from the U.S. DOE for the development of a reliability model for light fixtures utilizing energy efficient light emitting diode (LED) technologies. By testing LED light fixtures under high stress conditions designed to simulate years of field use, RTI demonstrated that LED light sources are extremely durable and can be expected to operate much longer than conventional light sources under normal operational conditions. This information provides the first publicly available LED lighting benchmarks for the industry and for potential users of LED lighting such as municipalities, businesses and consumers.

6. **Novel Non-Aqueous Solvent-based Carbon Dioxide Capture Process.** RTI used $59,731 of its state funding to secure $238,924 from the U.S. DOE to demonstrate at pilot-plant scale a novel non-aqueous solvent and process for carbon dioxide capture, developed by RTI, with regeneration energies approximately 40% lower than

conventional processes. This has potential to significantly lower the cost and energy penalties for capture of carbon dioxide from power plant flue gas streams.

STATE FISCAL YEAR 2013-2014 ITEMIZED EXPENDITURES AND FUND SOURCES

The $500,000 in appropriation funds used by RTI were applied to labor costs inclusive of indirect overhead charges. See **Appendix A** for detail.

OUTLOOK FOR STATE FISCAL YEAR 2014–2015

For the State fiscal year 2014-2015, RTI plans to continue to utilize State of NC funding to further strengthen its energy program. The funds will be used to leverage federal funds for the following technology development projects for which RTI has already received award notices and for which contract negotiations are under way:

- **Carbon, Hydrogen, and Separation Efficiencies in Bio-oil Conversion Pathways**. Researchers at RTI are further advancing RTI's process technology for the cost competitive production of transportation fuels from biomass under a $3.1 million award from the DOE. RTI has been developing a catalytic biomass pyrolysis process over the past several years and is now operating a one ton per day pilot plant at its Energy Technology Development Facility in Research Triangle Park to convert biomass into a "biocrude" that can be upgraded to transportation fuel using technology commonly used in petroleum refining. Effective hydrogen utilization is a major factor in increasing the cost competitiveness of bio-based fuels. Under this new project, RTI will develop a novel catalyst technology that will reduce the overall hydrogen demand and will also improve the carbon efficiency by recovering carbon that leaves the process in a waste water stream and returning it to beneficial use in the process. Veolia Water, a global leader in water treatment technologies with major offices in Cary, NC, will help RTI to optimize the overall process by recovering valuable carbon from process wastewater.

- **Low CO_2 Coal-to-Liquids**. The DOE and DoD selected RTI to develop a breakthrough hybrid coal-to-liquid process technology to produce jet fuel. The project will be led by RTI, in partnership with Aerojet Rocketdyne and the Gas Technology Institute. RTI and its partners will address key issues that hinder the use of coal to produce jet fuel, including high capital costs associated with the conversion process. Within the terms of the two-year, $4.4 million cooperative agreement funded by the DOE, RTI will develop a hybrid process technology that combines coal and natural gas to generate a syngas that is subsequently converted to jet fuel. RTI aims to rapidly progress this hybrid technology for potential commercial deployment

in the next five to ten years. The process integrates several advanced emerging technologies, including RTI's warm syngas cleanup and novel syngas-to-liquids technologies, and is anticipated to cost 25-30% less than conventional technologies.

- **Fouling-Resistant Membranes for Treating Concentrated Brines for Reuse in Advanced Energy Systems**. The complex range and high concentrations of salts, minerals, and metals that make up the total dissolved solids (TDS) found in concentrated brines generated throughout the fossil fuel lifecycle severely limit current treatment and disposal options. The high TDS levels in concentrated brines (often 8 times higher than that of seawater) make current approaches to water treatment untenable. In this project, funded by the DOE, RTI will develop and demonstrate bench-scale feasibility of a low-cost, novel water treatment process using electrically conductive membrane distillation (ECMD) for the reuse of concentrated brines. This project's goal is to develop a new class of advanced ECMD membranes that will mitigate the fouling issues that often occur during water treatment, paving the way for expanded water reuse and discharge options beyond what is currently feasible. Anticipated benefits/outcomes of the proposed technology will include at least 50% reuse of treated water, 35% to 90+% reduction in water treatment cost, and improvement in membrane fouling relative to existing membranes, RTI will collaborate with the University of California at Riverside as well as Veolia Water, a global leader in wastewater services with major offices in NC.

In addition to supporting these already defined projects, RTI anticipates utilizing the balance of state fiscal year 2014-2015 State of NC funding to support 1-2 additional federally-funded projects that are anticipated but yet to be finally awarded.

SUMMARY

All of the funds received by RTI have been used for the purposes for which they were granted. Financial data for all listed projects, inclusive of forecasts, have been provided for FY 2013-2014. The line item budget for the FY 2013-2014 use of funds is attached. We appreciate the State's support of the above projects and the continued opportunity to hire and retain jobs in the State of North Carolina. Please direct any questions to David L. Denton, Senior Director, Business Development, Energy Technology Division, RTI International, ddenton@rti.org or 919-485-2609.

APPENDIX A: STATE OF NORTH CAROLINA COST SHARE FUNDING, FY 2013-2014

Summary

State of NC Funding $500,000

Project/Proposal	Start Date	Total Cost	DOE Award	Cost Share Requirement	Use of NC Funds	Federal Dollars Leveraged
Internal Combustion Engine Reformer/Converter for Gas-to-liquids Conversion	5/28/2014	$ 3,500,000	$ 3,325,000	$ 175,000	$ 106,993	$ 2,032,867
Novel Dry Particle Thermal Transfer Fluids for Transformational Solar Energy Storage	2/6/2014	$ 3,285,684	$ 3,121,400	$ 164,284	$ 104,957	$ 1,994,183
Catalytic Upgrading of Biofuels – Thermochemical Add-on	5/1/2014	$ 449,928	$ 349,928	$ 100,000	$ 100,000	$ 400,000
Advanced Gasification Technologies Development	10/1/2013	$ 1,196,380	$ 896,704	$ 299,676	$ 66,234	$ 264,936
Solid-State Lighting Luminaire Reliability Model	10/1/2013	$ 706,327	$ 565,062	$ 141,265	$ 62,085	$ 248,340
Novel Non-Aqueous Solvent-based Carbon Dioxide Capture Process	10/1/2013	$ 1,512,691	$ 1,210,153	$ 302,538	$ 59,731	
			TOTAL	**$ 1,182,763**	**$ 500,000**	**$ 5,179,250**
				Unallocated Funding (return to state):	***$ 0***	
				DOE-to-State Funds Leverage Ratio:		***10.36***

Funding Breakout - by Project by Quarter						
7/1/13 - 6/30/14 = Actuals, 7/1/14-9/30/14 = Forecast	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Total**
	7/1/13 - 9/30/13	**10/1/13 - 12/31/13**	**1/1/14 - 3/31/14**	**4/1/14- 6/30/14**	**7/1/14- 9/30/14**	
Internal Combustion Engine Reformer/Converter for Gas-to-liquids Conversion ($107K in Cost Share)						
Labor (w/ Fringe)	$ -	$ -	$ -	$ -	$ 62,550	$ 62,550
Travel, Services, etc.	$ -	$ -	$ -	$ -	$ 1,000	$ 1,000
Equipment, Materials, Subcontractors	$ -	$ -	$ -	$ -	$ 2,750	$ 2,750
Overhead (Indirect) Costs	$ -	$ -	$ -	$ -	$ 82,682	$ 82,682
Total	**$ -**	**$ -**	**$ -**	**$ -**	**$ 148,982**	**$ 148,982**
Labor (fully loaded)	***$ -***	***$ -***	***$ -***	***$ -***	***$ 143,102***	**$ 143,102**
Labor (fully loaded) towards State Cost Share Funds	**$ -**	**$ -**	**$ -**	**$ -**	**$ 106,993**	**$ 106,993**

Funding Breakout - by Project by Quarter						
7/1/13 - 6/30/14 = Actuals, 7/1/14-9/30/14 = Forecast	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Total**
	7/1/13 - 9/30/13	**10/1/13 - 12/31/13**	**1/1/14 - 3/31/14**	**4/1/14- 6/30/14**	**7/1/14- 9/30/14**	
Novel Dry Particle Thermal Transfer Fluids for Transformational Solar Energy Storage ($104.9K in Cost Share)						
Labor (w/ Fringe)	$ -	$ -	$ 38,131	$ 56,738	$ 79,520	$ 174,388
Travel, Services, etc.	$ -	$ -	$ 2,294	$ 20,365	$ 9,800	$ 32,459
Equipment, Materials, Subcontractors	$ -	$ -	$ 1,066	$ 726	$ 80,000	$ 81,792
Overhead (Indirect) Costs	$ -	$ -	$ 49,593	$ 82,703	$ 109,685	$ 241,981
Total	**$ -**	**$ -**	**$ 91,084**	**$ 160,531**	**$ 279,005**	**$ 530,620**
Labor (fully loaded)	***$ -***	***$ -***	***$ 87,236***	***$ 129,804***	***$ 181,926***	**$ 398,966**
Labor (fully loaded) towards State Cost Share Funds	**$ -**	**$ -**	**$ 37,500**	**$ 67,457**	**$ -**	**$ 104,957**

Funding Breakout - by Project by Quarter						
7/1/13 - 6/30/14 = Actuals, 7/1/14-9/30/14 = Forecast	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Total**
	7/1/13 - 9/30/13	**10/1/13 - 12/31/13**	**1/1/14 - 3/31/14**	**4/1/14- 6/30/14**	**7/1/14- 9/30/14**	
Catalytic Upgrading of Biofuels – Thermochemical Add-on ($100K in Cost Share)						
Labor (w/ Fringe)	$ -	$ -	$ -	$ 58,909	$ 45,500	$ 104,409
Travel, Services, etc.	$ -	$ -	$ -	$ 29,693	$ 2,500	$ 32,193
Equipment, Materials, Subcontractors	$ -	$ -	$ -	$ 125,904	$ 1,500	$ 127,404
Overhead (Indirect) Costs	$ -	$ -	$ -	$ 83,580	$ 60,537	$ 144,117
Total	**$ -**	**$ -**	**$ -**	**$ 298,086**	**$ 110,037**	**$ 408,123**
Labor (fully loaded)	***$ -***	***$ -***	***$ -***	***$ 134,773***	***$ 104,095***	**$ 238,867**
Labor (fully loaded) towards State Cost Share Funds	**$ -**	**$ -**	**$ -**	**$ 74,319**	**$ 25,681**	**$ 100,000**

Funding Breakout - by Project by Quarter						
7/1/13 - 6/30/14 = Actuals, 7/1/14-9/30/14 = Forecast	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Total**
	7/1/13 - 9/30/13	**10/1/13 - 12/31/13**	**1/1/14 - 3/31/14**	**4/1/14- 6/30/14**	**7/1/14- 9/30/14**	
Advanced Gasification Technologies Development ($66.2K in Cost Share)						
Labor (w/ Fringe)	$ -	$ 2,399	$ 30,047	$ 60,154	$ 68,569	$ 161,170
Travel, Services, etc.	$ -	$ -	$ 517	$ 7,812	$ 7,470	$ 15,799
Equipment, Materials, Subcontractors	$ -	$ -	$ -	$ 150,660	$ 125,001	$ 275,661
Overhead (Indirect) Costs	$ -	$ 3,161	$ 30,711	$ 71,588	$ 96,258	$ 201,718
Total	**$ -**	**$ 5,561**	**$ 61,275**	**$ 290,214**	**$ 297,298**	**$ 654,348**
Labor (fully loaded)	***$ -***	***$ 5,489***	***$ 44,800***	***$ 137,621***	***$ 156,872***	**$ 344,781**
Labor (fully loaded) towards State Cost Share Funds	**$ -**	**$ 1,112**	**$ 19,700**	**$ 45,422**	**$ -**	**$ 66,234**

Funding Breakout - by Project by Quarter						
7/1/13 - 6/30/14 = Actuals, 7/1/14-9/30/14 = Forecast	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Total**
	7/1/13 - 9/30/13	**10/1/13 - 12/31/13**	**1/1/14 - 3/31/14**	**4/1/14- 6/30/14**	**7/1/14- 9/30/14**	
Solid-State Lighting Luminaire Reliability Model ($62.1K in Cost Share)						
Labor (w/ Fringe)	$ -	$ 52,480	$ 53,019	$ 65,479	$ 47,745	$ 218,724
Travel, Services, etc.	$ -	$ 2,167	$ 4,852	$ 1,514	$ 1,050	$ 9,583
Equipment, Materials, Subcontractors	$ -	$ 1,550	$ 39,647	$ 16,630	$ 4,500	$ 62,327
Overhead (Indirect) Costs	$ -	$ 64,511	$ 65,182	$ 107,279	$ 63,259	$ 300,232
Total	**$ -**	**$ 120,708**	**$ 162,701**	**$ 190,903**	**$ 116,554**	**$ 590,865**
Labor (fully loaded)	***$ 0***	***$ 115,114***	***$ 93,076***	***$ 112,051***	***$ 109,231***	**$ 429,472**
Labor (fully loaded) towards State Cost Share Funds	**$ -**	**$ 62,085**	**$ -**	**$ -**	**$ -**	**$ 62,085**

Funding Breakout - by Project by Quarter										
7/1/13 - 6/30/14 = Actuals, 7/1/14-9/30/14 = Forecast	**Q1**		**Q2**		**Q3**		**Q4**		**Q1**	**Total**
	7/1/13 - 9/30/13		**10/1/13 - 12/31/13**		**1/1/14 - 3/31/14**		**4/1/14- 6/30/14**		**7/1/14- 9/30/14**	
Novel Non-Aqueous Solvent-based Carbon Dioxide Capture Process ($59.7K in Cost Share)										
Labor (w/ Fringe)	$	-	$ 4,890	$	34,619	$	67,035	$	106,040	$ 212,584
Travel, Services, etc.	$	-	$ -	$	2,857	$	8,055	$	3,300	$ 14,213
Equipment, Materials, Subcontractors	$	-	$ -	$	-	$	28,675	$	54,107	$ 82,782
Overhead (Indirect) Costs	$	-	$ 6,443	$	46,270	$	91,293	$	142,221	$ 286,226
Total	**$**	**-**	**$ 11,333**	**$**	**83,746**	**$**	**195,058**	**$**	**305,668**	**$ 595,805**
Labor (fully loaded)	***$***	***-***	***$ 11,187***	***$***	***79,202***	***$***	***153,362***	***$***	***242,598***	**$ 486,349**
Labor (fully loaded) towards State Cost Share Funds	**$**	**-**	**$ 8,582**	**$**	**10,675**	**$**	**40,474**	**$**	**-**	**$ 59,731**