Rocky Mountain Power

Clean Coal Technology Program

Sustainable Transportation and Energy Plan

Clean Coal Research Team

Sustainable Transportation Energy Plan (STEP)
Clean Coal Research Technology

1 Executive Summary

The Sustainable Transportation Energy Plan (STEP), a result of SB 115 codified in Utah statute in 2016, authorizes Rocky Mountain Power (the Company) to spend up an annual average of $1.0 million over a five year period "to investigate, analyze, and research clean coal technology" (Senate Bill 115, Section 54-20-104). "'Clean Coal technology' means a technology that may be researched, developed, or used for reducing emissions or the rate of emissions from a thermal electric generation plant that used coal as a fuel source" (Senate Bill 115, Section 54-2-1). To meet that objective, the Company proposes to allocate these funds across a number of projects that focus on the capture, reduction and sequestration of carbon dioxide (CO_2) and the reduction of nitrogen oxides (NOx). Funding will go towards specific projects that will be performed or assisted by Utah universities, Utah companies developing woody-waste biomass-based fuels, and a Utah company with a promising CO_2 capture technology that may result in lower capture costs in comparison to traditional methods.

The currently proposed program of Clean Coal Research projects are as follows:

1) a co-firing test of woody-waste (biomass) materials at the Company's Hunter Unit 3,
2) co-funding of a long term availability test of Sustainable Energy Solutions' cryogenic capture technology at either the Hunter or Huntington Plant,
3) co-funding of USTAR's Phase 1 effort to perform pre-feasibility study for commercial sequestration sites with co-funding by the United States Department of Energy,
4) a study to evaluate the potential for CO_2 to be used for regional enhanced coal bed methane recovery with sequestration,
5) a study to evaluate the performance and cost effectiveness of integrating solar thermal capture technologies at Hunter 3,
6) the application of an advanced neural network control system at Huntington Unit 2 for the reduction of NOx, and
7) implementation of a utility scale demonstration of alternative technologies that result in material decreases in NOx emissions without the use of Selective Catalytic Reduction (SCR).

2 Purpose and Necessity

The proposed projects and studies, which are further described in this document, were selected to meet the statutory requirements of the STEP legislation. These projects and studies were selected to address further reductions in NOx emissions from the Hunter and Huntington plants, reduce emissions from other sources and to further develop and evaluate technologies and processes for capturing and storing CO_2 which may be an element in an overall strategy to meet the state's goals

under the federal Clean Power Plan.

The proposed projects and studies were identified through an exhaustive process that solicited and incorporated input from the Clean Coal Research team (see Appendix G for a list of participants). This team consisted of engineering faculty from the University of Utah, Brigham Young University, Utah State University, the Utah Science Technology and Research (USTAR), Utah Governor's Office for Energy Development, Utah technology companies and the Company's plant, technical services and resource development groups. Selected areas of demonstration or study focused specifically on the following:

1) CO_2 capture,
2) CO_2 sequestration (i.e. long term geologic storage), and
3) CO_2 and NOx emissions reductions from targeted facilities.

Overall criteria in the selection process of projects were multi-faceted and are intended to include the following key objectives:

1) need for physical demonstrations, if applicable and practicable,
2) advance existing/emerging technologies, 3) actively involve Utah universities and companies to perform the work,
3) leveraging other funding, if available and applicable.

The proposed Clean Coal Research projects/studies, type of project and project category are identified in Table 1.

Table 1
Clean Coal Research Proposed Projects & Studies and Classifications

Project/Study	**Type of Project**	**Category**
Co-firing test of woody-waste (biomass) materials-Hunter 3	Demonstration	CO_2 reduction & particulate matter (PM) reduction associated with wildfires and avoided coal burn
Co-funding of a long term availability test of Sustainable Energy Solutions' Cryogenic Carbon Capture™ technology	Demonstration, co-funding	CO_2 capture
Co-funding of University of Utah's Phase 1 pre-feasibility study of commercial CO_2 sequestration sites in Utah	Study, co-funding	CO_2 sequestration
Evaluate the potential for CO_2 to be used for regional enhanced coal bed methane recovery	Study	CO_2 sequestration

Evaluate the feasibility of solar thermal integration on Hunter 3	Study	CO_2 reduction
Advanced neural network control system at Huntington 2	Demonstration	NOx reduction (and partial CO_2 reduction)
Utility scale demonstration of alternative NOx emissions controls	Demonstration/ Study	NOx reduction

The Key Research Objectives are summarized in Table 2.

Table 2

Clean Coal Research - Proposed Projects & Key Research Objectives

Project/Study	**Key Research Objectives**
Co-firing test of woody-waste (biomass) materials-Hunter 3	1. Technical, economic and environmental assessment of biomass co-firing 2. Demonstration of co-firing capability with major changes to material handling equipment and processes 3. Identify processes that minimize cost of fuel processing without negative impacts on operations
Co-funding of a long term availability test of Sustainable Energy Solutions' CO_2 Cryogenic Capture™ technology	1. Demonstrate ability to achieve long term capture capability and operation 2. Economic assessment of utility-scale implementation of technology 3. Capture capabilities of other emissions
Co-funding of University of Utah's Phase 1 pre-feasibility study of commercial CO_2 sequestration sites in Utah	1. Team formation to address technical/non-technical (regulatory, legislative, technical, policy, commercial & financial) challenges 2. Plan development to address economic feasibility and public acceptance 3. High level technical evaluation of the geology of the sequestration sites
Evaluate the potential for CO_2 to be used for regional enhanced coal bed methane recovery	1. Determine if local coal beds are conducive to enhanced CH_4 recovery using CO_2 2. Evaluate the feasibility of permanent CO_2 sequestration used in enhanced coal bed methane recovery 3. Evaluate potential for reduced seismicity compared to deep saline well injection
Evaluate the feasibility of solar thermal integration - Hunter Plant	1. Determine performance and economic feasibility of solar thermal assisted steam generation

	2. Identify land requirements
Advanced neural network control system at Huntington 2	1. Deploy an open system artificial neural network software program targeting NOx emissions and net heat rate reductions 2. Document emissions reductions & heat rate improvements 3. Modify the neural network to accommodate changes in ramp rates and reduced load operating conditions.
Utility scale demonstration of alternative NOx emissions control technologies	1. Assess alternative options for implementation of one or more NOx reduction technologies that in combination achieve similar emissions rates expected from a Selective Catalytic Reduction system 2. Select one or more NOx emissions technologies that appear to be capable of meeting the primary objective and, where indicated and further testing is required, install a slip stream or full stream demonstration of the technology. 3. Assess the economic feasibility of full scale implementation of the technolog(ies) compared to other available options for these units.

The individual projects are summarized in the next section, Project Descriptions.

3 Project Descriptions

Co-firing Tests of Woody-waste (biomass) Materials in Hunter Unit 3

This proposed project consists of two 18-hour co-firing tests of processed woody waste (biomass) to be fired in the Hunter Unit 3 boiler. The target heat input from woody waste material is 10% of the required total fuel input of the Unit 3 boiler. The processed woody waste will come from Utah forests and will consist of pinion-juniper, fir, aspen and other woods that have been cut down or removed to reduce fire danger, improve or maintain avian habitats and watersheds, or to remove dead trees. Additional wood resources include scrap and waste material from logging operations. Two types of processed woody waste will be tested. The primary objective of these tests will be to determine whether these processed biomass fuels can effectively be used as "drop-in" replacements in lieu of burning coal. In addition to displacing coal and its attendant CO_2 and NOx emissions, using these processed woody waste materials will have the benefit of minimizing particulate matter emissions associated with either controlled or uncontrolled burns of collected forest materials. Performing these tests will also be used as a mechanism to further evaluate and demonstrate these Utah-based technologies.

Amaron Energy (www.amaronenergy.com) and AEG Coalswitch (www.active-energy.com/aeg-

coalswitch) are two Utah companies that have developed technologies to process/upgrade woody waste materials into biomass products that have properties that are similar to coal. The two companies use processes that are fundamentally different to create their biomass products. Independent 18-hour co-firing tests will be performed on each of the two biomass products at the Hunter Plant to determine how they perform as replacement fuels for coal.

The Amaron process consists of a torrefaction process in which the material is ground, sorted and heated in a low-oxygen environment to approximately 400-600 degrees Fahrenheit in a "torrefier" (fundamentally an indirect-fired rotating kiln). This produces a "coal like" material with a heating value of approximately 8,500-10,000 British thermal units per pound; this material can be pelletized which will enhance transportation and handling characteristics. Further testing will be required to determine if pelletization, which also adds cost, is needed.

The AEG Coalswitch process consists of a "steam explosion" process in which the woody waste material is ground, sorted, washed and heated by being exposed to high pressure steam (400-550 pounds per square inch) for approximately 15 minutes. The steam pressure is then released in a very short period of time (milliseconds); as a consequence, the woody material is deconstructed with high lignin content. This material is then rinsed, compressed and dried. This process also produces a "coal like" material with a heating value of approximately 8,500-10,000 British thermal units per pound. This material, too, can be pelletized. Further testing will be required to determine if the additional pelletization step is needed.

The testing process will include a complete analysis of the biomass fuel. Testing will be performed to assess the material's handling characteristics to ensure that it can be reliably handled by the existing boiler's coal handling, milling and conveying systems. Testing will be performed to ensure that co-combustion of the material does not have a deleterious effect on the boiler operation (undue slagging, fouling or coating of fabric filter bags).

To facilitate the proposed woody waste co-firing project, the University of Utah has been commissioned by Rocky Mountain Power to evaluate milling characteristics of these two processed fuels; this work is ongoing and is being performed at the University of Utah's combustion facility. This milling study is not being funded by STEP. For the performance of the co-firing test itself, Rocky Mountain Power will enter into separate contracts with Amaron and AEG Coalswitch for the supply and delivery of the processed material.

The University of Utah, together with Rocky Mountain Power will develop the test protocol, monitor and record the test, evaluate emissions, and perform specific fuel and ash analyses. The University of Utah will prepare summary final reports on these potential fuels to both reduce coal consumption and to provide a mechanism within the State of Utah where woody waste material can be periodically put to beneficial use without the particulate emissions associated with open burning.

For more information on the planned scope of work, refer to Appendix A, "Biomass Co-firing Proposal – University of Utah", which is a copy of the proposal submitted by the University of Utah with participation by Brigham Young University.

Co-funding of a Long Term Availability Test of Sustainable Energy Solutions' CO_2 Cryogenic Carbon Capture™ Technology

The proposed joint project uses the existing skid-scale version of Sustainable Energy Solutions' (SES) Cryogenic Carbon Capture™ (CCC) technology and supporting facilities to improve operational issues based on experience in a recent series of field tests, including preliminary short term field tests that were performed at Rocky Mountain Power's Dave Johnston plant in 2014. Rocky Mountain Power did not materially contribute to these short term tests at the Dave Johnston Plant other than to provide space and small amounts of electric energy and cooling water and making the field connections. The proposed STEP project (Phase I) will consist of modifying the test skid and performing a series of long term operational tests. This will be followed by the design, construction, and operation of a pilot facility based on the same scaled up technology (Phase II). The Phase I field tests will occur at either the Hunter or Huntington plants. Phase II will be a separate funding effort outside of the STEP program and is anticipated to be materially supported by the United States Department of Energy.

SES is a Utah company dedicated to the development of a low-cost CO_2 capture technology with an emphasis on retrofit potential (www.sesinnovation.com). The United States Department of Energy and State of Wyoming sponsored projects have shown the potential for the CCC process to cost half of current post-combustion technologies. The technology has demonstrated very high CO_2 removal efficiencies as well as the capability of removing criteria pollutants such as mercury and oxides of nitrogen and sulfur during recent field tests. These tests indicated several aspects of CCC that could be modified and optimized to improve longer-term reliability and efficiency. These modifications will be tested at the SES facility, after which the test skid will be deployed at the Hunter or Huntington plants to perform multiple long term tests (at least one greater than 500 continuous hours of run time with many more cumulative hours of run time) over a period of up to nine-months. Reliability is a critical requirement for Phase II of the technology development, which scales up this promising technology to 5-10 megawatts-electric equivalent. Phase I will be also co-funded by the US Department of Energy, Tri-State Generation and Transmission and the Electric Power Research Institute. The total project value of Phase I will be up to six million dollars of which Rocky Mountain Power will provide funding of approximately one million dollars. The US DOE indicates that demonstrated reliability and availability testing during Phase I will be a key factor in their consideration to fund a scale up of the technology (Phase II).

Expenditures made towards Phase I would be applied towards modifying the existing test skid, SES salaries and expenses during the testing phase, on-site consumables and insurances at Rocky Mountain Power's plant. Rocky Mountain Power would engage the services of a third party

engineering firm to provide an assessment of the costs for implementing the technology on a retrofit basis on a utility scale (i.e. a nominal 450 megawatt-electric coal-fired facility).

SES is negotiating with the US DOE for Phase I of this project. As part of that proposal to the US DOE, SES has indicated cost sharing and participation by the following entities:

1) Tri-State Generation and Transmission Association - Tri-state is a rural electric power producer in the Midwest that has demonstrated keen interest in SES's. Tri-State provides advisory roles, financial support and dedicates a portion of their staff to SES Phase 2 program.
2) National Rural Electric Cooperative Association (NRECA) - NRECA represents the rural cooperatives and is highly supportive of this work in an effort to evaluate and mature this technology.
3) Rocky Mountain Power –Rocky Mountain Power, as part of the STEP program, has committed to host a pilot-scale facility and financially support the development of this technology.
4) Electric Power Research Institute (EPRI) - EPRI is involved in a technical and economic evaluation of cryogenic capture and is providing cost share to SES's Phase 2 program.
5) Brigham Young University (BYU) - BYU provides fundamental science and engineering support, including Aspen modeling and laboratory experiments, to this project. BYU also provides cost share to SES's Phase 2 program.

For more detailed information, please refer to Appendix B, "Cryogenic CO_2 Capture Testing Proposal – Sustainable Energy Solutions" which has a copy of the proposal and budget submitted by Sustainable Energy Solutions.

Co-funding of University of Utah Phase 1 Pre-feasibility Study of Commercial CO_2 Sequestration Sites in Utah

For this project, Rocky Mountain Power proposes to co-fund and participate in the University of Utah's pre-feasibility study to evaluate the development of commercial scale carbon capture and sequestration (CCS) storage in Utah. This pre-feasibility study is being pursued in response to a Funding Opportunity Announcement (FOA Number DE-FOA-00001584) issued on June 23, 2016 also known as the Carbon Storage Assurance Facility Enterprise (CarbonSAFE). If selected by the US DOE, the University of Utah, and its co-participants, would receive up to $1.2 million to perform the pre-feasibility study. The ability to identify locations that are suitable for commercial scale CO_2 geologic sequestration is a critical issue that must be addressed to reduce the carbon footprint of coal-fired generating stations. The University of Utah and the other participating entities would contribute at least another $150,000 in direct funding or cost share, thereby meeting

the 20% minimum participation required by the USDOE to receive funding. This project's objectives, significant leveraged co-funding, and relatively small cost are consistent with the objectives of STEP. This Phase I effort is the first of a series of FOAs the US DOE intends to issue. The US DOE has planned for four phases which are as follows: a) Phase I-Integrated CCS Prefeasibility (this STEP project with an expected duration of 18 months), b) Phase II-Storage Complex Feasibility (expected duration of two years), c) Phase III-Site Characterization (expected duration of two years) and d) Phase IV-Permitting and Construction (with an expected duration of 3.5 years).

For Phase I of this overall program, the US DOE intends to fund up to 12 pre-feasibility studies across the US, with up to $1.2 million per study. In the event the University of Utah proposal is not selected, the $150,000 earmarked for this study would be re-allocated to the NOx feasibility/demonstration project.

Other participants in the study effort with the University of Utah and Rocky Mountain Power include: University of Utah Law School, Utah Geological Survey, Sandia National Labs, Utah Department of Environmental Quality, Schlumberger Carbon Services, Los Alamos National Lab and New Mexico Tech.

The following are excerpts from the US DOE Funding Opportunity Announcement DE-FOA-0001584 that more fully describes the objectives and requirements of the prefeasibility study effort:

> "One of the key gaps in the critical path toward Carbon Capture and Sequestration (CCS) deployment is the development of commercial-scale (50+ million metric tons CO_2) geologic storage sites for CO_2 from industrial sources. There has been relatively little effort by the private sector to identify and certify (i.e., regulatory permit) geologic storage sites that are capable of storing commercial-scale volumes of CO_2, primarily because of the lack of immediate economic incentives. As a result, commercial-scale CO_2 sources that want to develop CCS projects face the risk of not finding a suitable saline storage site for their captured CO_2.
>
> CarbonSAFE is an effort to develop an integrated CCS storage complex constructed and permitted for operation in the 2025 timeframe over a series of sequential phases of development: Integrated CCS Pre-Feasibility, Storage Complex Feasibility, Site Characterization, and Permitting and Construction. Subject to availability of funds, a series of FOAs are planned to accomplish this mission. This FOA, DE-FOA-0001584 - Integrated CCS Pre-Feasibility, is the first in a series of planned FOAs and focuses on the initial phase of development of the commercial-scale CO_2 storage site.
>
> The overall purpose of this FOA is to conduct pre-feasibility for a commercial-scale

CO_2 geological storage complex and demonstrate that the storage sites within the complex have the potential to store CO_2 emissions safely, permanently and economically. Successful applicants to this FOA will identify and perform a pre-feasibility study on a storage complex capable of storing 50+ million metric tons of industrially-sourced CO_2. This FOA will provide funding for the initial stages of development of the commercial-scale CO_2 geological storage, which will include the following activities:

- Formation of a CCS coordination team capable of addressing any regulatory, legislative, technical, public policy, commercial, financial, etc. challenges specific to commercial-scale deployment of the CO_2 storage project.
- Develop a plan for the storage complex and storage site(s) that address the challenges including but not limited to a strategy that would enable an integrated capture and storage project to be economically feasible and publicly acceptable.
- Perform a high-level technical sub-basinal evaluation to identify a potential storage complex with storage site(s), including a description of the geology and risks associated with the potential storage site. Identify and evaluate potential CO_2 sources."

This particular research project was not part of the original list of projects under consideration by the Clean Coal Research group. This item was added after reviewing the Funding Opportunity Announcement from the United States Department of Energy that was issued on June 23, 2016.

For more information on the University of Utah's plan, refer to Appendix C, "CarbonSAFE Proposal – University of Utah."

Evaluate the Potential for CO_2 for Regional Enhanced Coal Bed Methane Recovery

This project would perform a feasibility study to evaluate opportunities to use CO_2 for beneficial use for enhanced natural gas recovery from coal seams, specifically coal seams in the Emery County area. As part of this study, an assessment will be made of the capability of local coal seams to concurrently sequester CO_2.

CO_2 has the potential to be used for enhancing natural gas recovery from coal beds ("coal bed methane") in much the same way it is currently used for enhanced oil recovery. Significant research effort has been undertaken across the United States to identify cost effective CO_2 capture technologies. SaskPower's Boundary Dam project and Petra Nova's WA Parrish project are large utility scale projects that have been constructed or are under construction to use CO_2 injections for enhanced oil recovery.

This proposed project will focus on the potential for recovering coal bed methane in the areas surrounding the Hunter and Huntington power plants which have abundant coal bed methane resources. The project will study options to use CO_2 for enhanced recovery of coal bed methane and the geologic sequestration capacity of the coal seams in the region. The proposed study objectives are:

1) Provide a technical, economic and environmental study on the costs and benefits of this technology, including transportation of CO_2 from a specific source to a specific coal bed methane sequestration area.
2) Determine whether local coal beds are conducive to enhanced CO_2 methane recovery.
3) Propose new technologies for improving CO_2 injection efficiency.

This study concept was developed and defined by the Clean Coal Research team during the development and research area identification phase.

The proposed study would be performed by the University of Utah and the University's Energy & Geoscience Institute. For more detailed information, please refer to Appendix D, "Application/Feasibility for Regional/Commercial Use of CO_2 for Enhanced Coal Bed Methane Recovery," which is a copy of the proposal submitted by the University of Utah - Energy & Geoscience Institute.

Feasibility Assessment of Solar Thermal Integration - Hunter Plant

This proposed project would investigate the potential of integrating solar thermal collection to provide steam and/or feedwater heating into the Hunter 3 boiler/feedwater cycle. Integration of a solar thermal collection system would have the benefit of minimizing coal consumption and the attendant emissions associated with reduced coal use. The study would focus on the application of parabolic solar troughs and would also consider power tower collection systems.

Factors that will be evaluated in the study are:

- Site specific costs and benefits of solar thermal integration at the Hunter Plant
- Steam/feedwater injection points in the boiler feedwater cycle and those impacts on performance,
- Impact on coal consumption and associated emissions,
- Land requirements

The study would be specific to the Hunter Plant, taking into account the solar insolation at that location.

For more information, refer to the proposal in Appendix E, "Solar Thermal Integration, Hunter Plant - Brigham Young University."

Advanced Neural Network Control System at Huntington 2

For this Clean Coal research project it is proposed to install and evaluate a neural network software system on Huntington Unit 2. The project would consist of installing and enhancing third party neural optimization software. The initial objective would be to target combustions with a primary objective of reducing NOx emissions followed by a reduction in the other emissions associated with combustion and then balancing those reductions with unit efficiency improvement. Along with combustion optimization there are other plant processes that may benefit from neural network optimization. This study will explore neural network optimization of those processes as well. Initial combustion study results are anticipated within the first year of the project and additional process objectives will be added during the long-term study of the neural network over the course of the five year STEP program.

For this project, the University of Utah will partner with Rocky Mountain Power and the software provider to install, demonstrate and fundamentally research artificial intelligence technology to improve emissions of coal-fired power systems. The computer software is based on artificial neural networks. Artificial neural networks are data-driven modeling techniques used to mathematically describe complex processes, such as coal combustion for power generation. Artificial neural networks are used to "learn" a specific process, particularly the relationships between inputs (e.g., flow rates, damper positions, etc.) and critical outputs (e.g., NOx emissions, boiler efficiency, etc.), through a mathematical model-fitting routine. Using this model of a process, optimization routines can be used to determine the optimal combination of inputs to give a desired output (e.g., finding the conditions that minimize NOx emissions, maximize efficiency, or a combination of both). Because the process is continually changing as conditions change, the software is used to continuously update the model and re-solve for optimum conditions.

The proposed project has a number of advantages that increase its likelihood of success: 1) the technology has been successfully demonstrated elsewhere, 2) there are a number of research opportunities to improve the technology, specifically as they may apply dynamic optimization due to fast ramping of the plant, 3) the project is relatively low cost, 4) the technology is scalable to other similar units, and 5) the proposed primary research team members are experienced in neural networks and process optimization and are local to Emery County.

Rocky Mountain Power would contract with the University of Utah for setup and implementation of the model, periodic upkeep of the model and assistance in periodic training of plant operators. Rocky Mountain Power would acquire the initial license from the software vendor and will likely renew the annual license fees over the duration of the five-year STEP program provided satisfactory and repeatable improvement is demonstrated.

This project was initiated by Rocky Mountain Power's technical services team and endorsed by

the Clean Coal Research team during the development and research area identification phase.

For more information, refer to Appendix F, "Advanced Neural Net Controls - University of Utah," which is a copy of the proposal submitted by the University of Utah with participation by Brigham Young University.

Utility Scale Demonstration of Alternative NOx Emissions Control Technologies

This particular Clean Coal research project is proposed to perform one or more slip stream or full scale demonstration tests of one or more NOx emissions control technologies at the Huntington Plant. The objective of this test program will be to determine if there are one or more emerging NOx control technologies either on a standalone or combined basis that could be installed at the plant that could achieve NOx emissions rates similar to those expected with selective catalytic reduction system (SCR) and at significantly lower cost than an SCR system. The United States Environmental Protection Agency (US EPA) has mandated that PacifiCorp install SCR systems on Hunter Units 1&2 and Huntington Units 1&2 within five years. These four units are fundamentally similar; it is expected that this process would help inform a NOx reduction implementation strategy for these affected units. The targeted NOx emissions rate with an SCR system is 0.07 pounds of NOx per million British thermal units.

STEP Clean Coal research monies will be used to fund all or a portion of these NOx emission control tests. In order to identify which technologies will be tested, a Request for Proposal (RFP) process will be conducted in 2017. Criteria that will be used to select technologies include: 1) an assessment of whether the technology can be installed at full scale, 2) previous operational experience, which includes scale, duration and performance, 3) permitting impacts, 4) expected capital and operating and maintenance costs, 5) an assessment of the long term reliability of the technology and ability to achieve the target emissions rate and 6) the ability of the underlying technology company to provide commercially viable performance warrantees/guarantees. Prior to distribution of the RFP, a Request for Information (RFI) would be issued to determine interest, identify any technology consolidation or partnering opportunities and prepare a short list of potential technology providers for the RFP.

Prior to issuing the RFP for NOx control technologies, it will be necessary to prepare a thorough inventory of one of the four boilers and the backend environmental control equipment. This inventory will need to include all major boiler process conditions including flows, pressures, typical operating states, temperatures, concentrations, materials of construction and fuel composition. A complete and accurate set of detailed drawings of the boiler and environmental control equipment would need to be compiled. As part of that inventory effort, a computation fluid dynamic model may need to be prepared, especially for applications of SNCR technologies.

A number of prospective technologies are currently under consideration; others will be reviewed through the end of 2016. Individual technologies that are currently being considered include: advanced combustion controls, SNCR systems (both with and without chemical enhancers such as hydrogen peroxide), ozone injection and catalytically treated fabric filter bags.

4 Benefits, Public Interest Justification and Compliance with SB115

Seven Clean Coal Research studies and projects have been identified and budgets proposed. These projects and studies were reviewed and prioritized by the Clean Coal Research team during the development and research identification phase. These selected projects meet SB115's definition of Clean Coal technology and its objective "to investigate, analyze, and research clean coal technology" (Senate Bill 115, Section 54-20-104). The benefits of each project are identified in the individual project descriptions found in the previous section.

The selected projects are intended to meet multiple objectives, and include:

1) demonstration projects that will result in measurable reduced emissions,
2) investment in promising technologies and applications that may advance technologies that when fully developed and applied in utility scale that will allow for coal-fired generation resources to operate with reduced carbon emissions,
3) funding and providing opportunities for industry-targeted areas of research that can be performed by Utah's universities, and
4) promotion of Utah's clean energy technology companies.

5 Alternatives Considered

Alternative technologies/studies/projects that were also considered as being potential areas of research under the Clean Coal Research program (but were eliminated from consideration due to their speculative nature or lack of direct tie to the clean coal research legislative intent) are as follows:

- Plant demand side management (VFDs, high efficiency motor retrofits, lighting upgrades, partial turbine upgrades)
- Site specific CO_2 capture studies with conventional amine-based technologiesCO_2 injection characterization studies
- Reduced load operation and enhanced ramping studies
- Solid-supported amines
  Development of catalysts for converting CO_2 into products (beneficial use)

6 Major Project Milestones

The major project milestones for each project can be found in Appendix H.

7 Program Closure, Retirement and Removal Information

In 2021, at the end of the 5-year period, the Company will report back to the Utah Public Service Commission regarding the actual expenditures made for each project, provide a report summarizing the overall study objectives, work performed, findings and results, lessons learned and recommendations for future action. In cases where a project is completed earlier than 2021 (i.e. the Woody Waste Co-firing demonstration at Hunter 3), a report will be prepared and submitted within 120 days of the completion of the project. If the Commission determines that additional reporting would be beneficial, the Company will comply with those requirements.

8 Planned Budgeted Costs

Table 3 identifies the proposed annual expenditures for each of the Clean Coal Research projects. Some minor adjustments in year-to-year spending for each project may occur. Any available excess funds that become available because actual costs are lower than currently forecast will be allocated to the Advanced NOx Controls Technology project.

Table 3

Clean Coal Research – Proposed Project – Estimated Annual Expenditures

	2017	2018	2019	2020	2021	Total
Woody Waste Co-firing	$612,841	$177,032	$ -	$ -	$ -	$789,873
CO_2-Capture (CCC)	$381,557	$668,301	$125,000	$ -	$ -	$1,174,857
US DOE Sequestration Site Characterization - Phase 1	$150,000	$ -	$ -	$ -	$ -	$150,000
CO_2-Enhanced Coal Bed Methane	$ -	$62,500	$75,000	$62,500	$75,000	$275,000
Solar Thermal Assessment	$ -	$ -	$65,083	$83,083	$38,833	$187,000
Neural Net Implementation	$547,806	$178,924	$216,719	$32,000	$32,000	$1,007,449
Advanced NOx Controls	$100,000	$320,411	$775,000	$220,411	$ -	$1,415,821
	$1,792,204	**$1,407,167**	**$1,256,802**	**$397,994**	**$145,833**	**$5,000,000**

9 Accounting

Costs for each individual project will be monitored and tracked separately. The individual projects will roll up to the Clean Coal Research project created by the company's accounting group under

the Sustainable Transportation and Energy Plan. Only costs spent on outside contracted goods and services will be covered by the Clean Coal Research funding. Internal Rocky Mountain Power labor costs will be funded through normal operations.

10 Procurement and Project Delivery Strategy

The Clean Coal STEP initiative is fundamentally a series of research projects in which the proposed plan is to work directly with universities and technology developers and suppliers that provide unique products and services. As such, this directed research program is not conducive to using typical competitive bidding practices. It is expected that the work for each project will be clearly defined and costs for that work negotiated with the entity that will perform the work. With the exception of the Advanced NOx Controls Technologies project, where the potential technologies and/or providers have not yet been identified, it is proposed to award the work to the entity (or entities) stated in the individual project definitions (See Appendices A-F). Typical Rocky Mountain Power contractual commercial terms and conditions will be applied to the extent possible. Applicable engineering specification and design standards will be applied as well as the Company's plant specific health, safety and environmental requirements.

Each project will have its own Rocky Mountain Power project manager.

APPENDICES

- Appendix A - Biomass Co-firing Proposal - University of Utah
- Appendix B - Cryogenic CO_2 Capture Testing Proposal - Sustainable Energy Solutions
- Appendix C - CarbonSAFE Proposal - University of Utah
- Appendix D - Application/Feasibility for Regional/Commercial Use of CO_2 for Enhanced Coal Bed Methane Recovery – University of Utah Earth Geosciences Institute
- Appendix E - Solar Thermal Integration, Hunter Plant - Brigham Young University
- Appendix F - Advanced Neural Net Controls - University of Utah
- Appendix G – Clean Coal Research Team
- Appendix H - Major Project Milestones