ROCKY MOUNTAIN POWER
A DIVISION OF PACIFICORP

1407 W North Temple, Suite 330
Salt Lake City, Utah 84114

March 3, 2021

VIA ELECTRONIC FILING

Utah Public Service Commission
Heber M. Wells Building, 4th Floor
160 East 300 South
Salt Lake City, UT 84114

Attention: Gary Widerburg
Commission Administrator

RE: Docket No. 16-035-36 - In the Matter of the Application of Rocky Mountain Power to Implement Program Authorized by the Sustainable Transportation and Energy Plan Act

Rocky Mountain Power hereby submits for filing its Application to Implement Program Authorized by the Sustainable Transportation and Energy Plan Act, signed into law March 29, 2016, requesting authorization to implement one additional innovative utility programs specifically, U.C.A. § 54-20-105(1)(h) and § 54-20-107.

Rocky Mountain Power respectfully requests that all formal correspondence and requests for additional information regarding this filing be addressed to the following:

By E-mail (preferred): datarequest@pacificorp.com
jana.saba@pacificorp.com
marie.durrant@pacificorp.com

By regular mail: Data Request Response Center
PacifiCorp
825 NE Multnomah, Suite 2000
Portland, OR 97232

Informal inquiries may be directed to Jana Saba at (801) 220-2823.

Sincerely,

Joelle Steward
Vice President, Regulation

CC: Service List 16-035-36

Marie Bradshaw Durrant
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Salt Lake City, Utah 84114
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Attorney for Rocky Mountain Power

BEFORE THE PUBLIC SERVICE COMMISSION OF UTAH

IN THE MATTER OF THE APPLICATION OF ROCKY MOUNTAIN POWER TO IMPLEMENT PROGRAM AUTHORIZED BY THE SUSTAINABLE TRANSPORTATION AND ENERGY ACT	))))	Docket No. 16-035-36

APPLICATION TO IMPLEMENT PROGRAM AUTHORIZED BY THE SUSTAINABLE TRANSPORTATION AND ENERGY ACT

Rocky Mountain Power, a division of PacifiCorp ("Company" or "Rocky Mountain Power"), hereby submits this application to the Public Service Commission of Utah ("Commission") pursuant to Utah Code Annotated ("U.C.A") § Section 54-20-101, *et seq*., also known as Senate Bill 115 – the Sustainable Transportation and Energy Plan Act ("STEP"), signed into law March 29, 2016, requesting authorization to implement an innovative utility program authorized by STEP, specifically, U.C.A. § 54-20-105(1)(h) and § 54-20-107.

The Company is seeking authorization from the Commission to use STEP funding to support a Utah State University study on Projecting the Impact of the Electrification of the Uinta Basin Oil and Gas Fields on Air Quality ("Uinta Basin Study"). In support of its Application, Rocky Mountain Power states as follows:

1. Rocky Mountain Power is a division of PacifiCorp, an Oregon corporation, which provides electric service to retail customers through its Rocky Mountain Power division in the states of Utah, Wyoming, and Idaho, and through its Pacific Power division in the states of Oregon, California, and Washington.

2. Rocky Mountain Power is a public utility in the state of Utah and is subject to the Commission's jurisdiction with respect to its prices and terms of electric service to retail customers in Utah. Rocky Mountain Power's principal place of business in Utah is 1407 West North Temple, Suite 310, Salt Lake City, Utah 84116.

3. Communications regarding this filing should be addressed to:

Jana Saba
Utah Regulatory Affairs Manager
Rocky Mountain Power
1407 West North Temple, Suite 330
Salt Lake City, Utah 84116
E-mail: jana.saba@pacificorp.com

Marie Bradshaw Durrant
Senior Attorney
Rocky Mountain Power
1407 West North Temple, Suite 320
Salt Lake City, Utah 84116
E-mail: marie.durrant@pacificorp.com

In addition, Rocky Mountain Power requests that all data requests regarding this application be sent in Microsoft Word or plain text format to the following:

By email (preferred): datarequest@pacificorp.com

By regular mail: Data Request Response Center
PacifiCorp
825 NE Multnomah, Suite 2000
Portland, Oregon 97232

Informal questions may be directed to Jana Saba, Utah Regulatory Affairs Manager at (801) 220-2823.

4. This Application is the sixth tranche of proposed STEP programs for which the Company is seeking authorization. Since receiving authorization from the Commission for the first set of innovative utility programs, the Company has continued to seek potential opportunities to partner with stakeholders on additional innovative utility programs that are in the interest of its customers.

5. Based on those efforts, the Company has identified the program described in this Application as providing a variety of benefits, including: (1) identifying ways electricity can facilitate reduction in the emissions contributing to high ozone events in the Uinta Basin area of Utah; (2) producing data on the role and potential benefits of increasing the supply of electricity to a rural area with high oil and gas production and associated high ozone levels.

Available STEP Funding

6. To date, approximately $48.4 million of the $50 million authorized by U.C.A. §54-20-105 for the STEP Pilot Program has been allocated to seventeen approved STEP projects. Most of the STEP projects are expected to spend close to their approved budgets, but a few of the projects, such as the Gadsby Emissions Curtailment and Commercial Line Extension projects, are currently expected to have funds remaining at the end of the pilot period. Thus, sufficient funds within the Innovative Utility Programs U.C.A. §54-20-105(1) are available. In this Application, the Company requests approval for a new project in this category—approximately $200,715 for the Uinta Basin Study. As shown in Table 1, even with this new project, the STEP Pilot Program is expected to have surplus funding at the end of the pilot period.

Table 1:
STEP PILOT PROGRAM PROJECT

	Budget
EV Charging Infrastructure	$ 10,000,000
Clean Coal Technologies	
Woody Waste Co-Fire	1,538,980
Emerging CO2 Capture	1,587,521
Sequestration Site Characterization	150,000
CO2 Enhanced Coal Bed Methane Recovery	275,000
Solar Thermal Assessment	187,000
NOX Neural Net Implementation	1,007,449
Advanced NOX Control	157,415
Subtotal Clean Coal Technologies	4,903,365
Innovative Utility Programs	
Battery Storage - Solar	6,800,000
Substation Metering	1,100,000
Gadsby Emissions Curtailment	500,000
Line Extension	2,500,000
Other Innovative Technology: Microgrid	250,000
Other Innovative Technology: Smart Inverter	450,000
Other Innovative Technology: Power Demand Intermodal Hubs	2,000,000
Other Innovative Technology: Battery Demand Response	3,270,000
Uinta Basin Study (proposed)	**200,715**
Subtotal Innovative Utility Programs	17,070,715
Conservation, Efficiency And Other New Technology Programs: Advanced Resiliency Management System	16,520,000
Total STEP funds	$ 48,494,080

Uinta Basin Study Project

7. The Uinta Basin area of Utah has been designated as in non-attainment with federal ozone standards, mostly due to a unique combination of geography, meteorology and emissions from oil and gas activities in the area. Addressing the high winter-time ozone events is critical to protect the area's health, environmental and economic interests. Electrification has been identified as one of the most promising methods to dramatically reduce air emissions across the Uinta Basin.

8. Many pump jacks used by oil and gas wells in the Uinta Basin are powered by internal combustion engines. These pump jacks are a significant source of NOx emissions in the Basin. NOx is a key pollutant that contributes to formation of ozone. Part of this research and modeling project will help predict the extent to which electrification of these pump jacks will reduce NOx production from the oil and gas fields in the Uinta Basin.

9. Key research questions to be examined in this project are: 1) the extent to which controlling NOx emissions will have a bigger impact than controlling volatile organic compound ("VOC") emissions; 2) the extent to which electrification of the Basin oil and gas fields will permit a significant, irreversible reduction in NOx emissions and of winter ozone levels; 3) the extent to which the benefits of electrification will significantly offset other, reversible NOx emissions, such as drilling activities, and prevent a return to the very high ozone concentrations that occurred in the early 2010s; 4) evaluation of whether the logistics and economics of electrification will allow the oil and gas industry to continue operating.

10. As more fully described in the Appendix A accompanying this Application, the Company believes that the Uinta Basin Study, to be completed by the end of 2021, would provide necessary data and could lay the groundwork to support further electrification of the Uinta Basin if it is found to be both beneficial and feasible. The Uinta Basin Study would provide evidence

and the necessary starting point for the Company, oil and gas producers and state and federal regulators to work together to develop the infrastructure needed to optimize the availability of electricity to oil and gas sources in the area. The Company is requesting authorization to spend approximately $200,715 in STEP funds for the Uinta Basin Study pursuant to U.C.A. §54-20-105(1)(h) as a technology project that is in the interest of the Company's customers.

WHEREFORE, Rocky Mountain Power respectfully requests that the Commission approve this Application and the proposed programs, as filed, with an effective date of May 1, 2021.

DATED this 3rd day of March, 2021.

Respectfully submitted,

ROCKY MOUNTAIN POWER

/s/

Marie Bradshaw Durrant

Attorney for Rocky Mountain Power

Appendix A

Projecting the Impact of the Electrification of the
Uinta Basin Oil and Gas Fields on Air Quality

A Sustainable Transportation and Energy Plan (STEP) Project

Proposed by Utah State University

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I. Executive Summary

The Uinta Basin (the Basin) of Eastern Utah produces more natural gas and oil than any other part of the state and underpins the economy of the Basin. Unfortunately, the gas and oil industry also degrades the air quality of the Basin. The Basin is now designated to be in marginal non-attainment of the EPA ozone standard, and will probably transition to moderate non-attainment within the next year or two. Most regions of the oil and gas fields are not on the electric grid and a large proportion of the pumps used to lift oil to the surface are powered by natural gas-fueled internal combustion engines. Extending the electric grid to all regions of the oil and gas fields would permit electrified pumping, which should considerably improve air quality. Electrifying the Basin could be part of a solution to meet pending regulations that the State of Utah and the Environmental Protection Agency are known to be working on as a result of the nonattainment status of the Basin. Expanding the electric grid in the Basin could be a key piece of meeting regulatory requirements.

This is a proposal to Rocky Mountain Power and PacifiCorp for a project to obtain quantitative estimates of the air quality and economic impact that electrification of the oil and gas fields would have in the Basin. The work will be performed by personnel at Utah State University Uintah Basin and SLR International Corporation (SLR).

Ozone pollution forms in the atmosphere when ultraviolet light from the sun stimulates a chain reaction. Precursors for the reaction are two separate classes of compounds, designated nitrogen oxides (NOx) and volatile organic compounds (VOC). Compounds from both classes must be present in the air for ozone to form, and strategies for controlling ozone concentrations are always based on curtailing emissions of NOx and/or VOC. However, some ozone systems are more sensitive to NOx control, others to VOC control. Costly controls for VOC, say, when the system is more sensitive to NOx are counter-productive.

Preliminary evidence suggests that the ozone system of the Basin is under NOx control. Therefore, a greater impact will be seen from efforts to control NOx emissions. Internal combustion engines are a major source of NOx, and according to estimates by the Utah Division of Air Quality, natural gas and diesel engines used to pump oil are a large component of all NOx emissions.

Electrifying the Basin could also allow the use of control technologies such as vapor recovery units (VRUs) which also require electricity. It stands to reason, therefore, that conversion to electric pumping and the logistical availability of VRUs will have a significant impact on Uinta Basin air quality.

The focus of this research will be to evaluate logistical and economic aspects of electrification and obtain strong evidence to establish the following hypotheses:

1. The wintertime Uinta Basin ozone system is under NOx control, i.e., controlling NOx emissions will have a bigger impact than controlling VOC emissions.

2. Electrification of the Uinta Basin oil and gas fields will permit a significant, irreversible reduction in NOx emissions and of winter ozone levels.

3. The benefits of electrification will significantly offset other, reversible NOx emissions, such as drilling activities, and prevent a return to the very high ozone concentrations that occurred in the early 2010's.

4. The logistics and economics of electrification will allow the oil and gas industry to continue operating.

The project will involve data mining from sources such as the Utah Division of Oil, Gas and Mining; Utah Division of Air Quality; the Energy Information Administration; the Bureau of Land Management; the Environmental Protection Agency; satellite data from the Tropomi project; etc.

We will also develop and analyze computer models of ozone formation. These will be used to understand the impact of different emissions scenarios, e.g., electric vs. internal combustion pumping and other NOx sources.

II. Introduction

The Uinta Basin in Eastern Utah is the primary producer of oil and natural gas in the State of Utah, and the oil and gas industry sustains the economy of the Basin. Unfortunately, emissions from the industry also degrade Basin air quality. Because of high concentrations of ozone in the atmosphere, the Basin has been declared to be in the first or lowest category, "marginal", non-attainment for ozone, an official designation mandated by the US Clean Air Act. Every indication is that the Basin will enter the next step up in designation severity, "moderate" non-attainment, within a year or two. When that happens, the Utah Division of Air Quality, working in conjunction with the Environmental Protection Agency and the Ute Indian Tribe, will be required to develop plans and regulations that will reduce emissions. Uinta Basin crude oil is only marginally profitable, and there is concern that these regulations could significantly stifle the industry. Of course, poor air quality is deleterious to human health, but so is poverty. The Bingham Research Center at Utah State University Uintah Basin is committed to studying ways to promote healthy air quality without overburdening the economy.

The oil and gas fields in the remote southern part of the Basin are not on the electric grid, and many of the pump jacks in the Basin are powered by natural gas engines. The Bingham Research Center at Utah State University Uintah Basin is proposing to study the precise air quality impact and economics of electrification of the Uinta Basin oil and gas fields. We wish to investigate the hypothesis that conversion to electric pumps will mitigate many of the Basin's air quality problems. We also wish to examine the feasibility and economic impact of the power transmission grid development that would be required to replace the use of internal combustion engines. We will be joined in this effort by SLR International Corporation (SLR), a firm with extensive experience analyzing atmospheric emissions by the oil and gas industry and experience evaluating logistics and economics of energy development. Extending the electric grid into the southern part of the Basin will be very costly, but the direct benefit of improved air quality and the indirect benefit on the economy of the Basin need to be factored into the cost-benefit analysis. We are requesting that the Public Service Commission approve an expenditure of $200,715 of Sustainable Transportation and Energy Plan (STEP) funds to the Bingham Research Center, Utah State University Uintah Basin, for us to perform this study. Our goal will be to evaluate the logistics and economics of electrification and substantiate the following hypotheses:

1. The wintertime Uinta Basin ozone system is under NOx control, i.e., controlling NOx emissions will have a bigger impact than controlling VOC emissions.

2. Electrification of the Uinta Basin oil and gas fields will permit a significant, irreversible reduction in NOx emissions and of winter ozone levels.

3. The benefits of electrification will significantly offset other, reversible NOx emissions, such as drilling activities, and prevent a return to the very high ozone concentrations that occurred in the early 2010's.

4. The logistics and economics of electrification will allow the oil and gas industry to continue operating.

In Sections III and IV below, we present preliminary evidence that reductions in emissions from non-electric pump jacks could significantly improve air quality in the Basin. Details of the proposed study are presented in Sections V through X.

Unless otherwise mentioned, all reports and publications are available at this link: https://binghamresearch.usu.edu/reports

III. Ozone Formation in the Uinta Basin

Ozone is an unstable form of oxygen. The stratospheric ozone layer at an altitude of about 10 to 20 miles above sea level is essential to life on Earth: It blocks most of the harmful ultraviolet radiation from the sun. However, ozone at ground level in the air we breathe is harmful to human health and is regulated by the EPA. Ozone is a "secondary" pollutant, meaning that it is not directly emitted by pollution sources. Rather it gets "cooked" in chemical reactions in the atmosphere involving other primary pollutants.

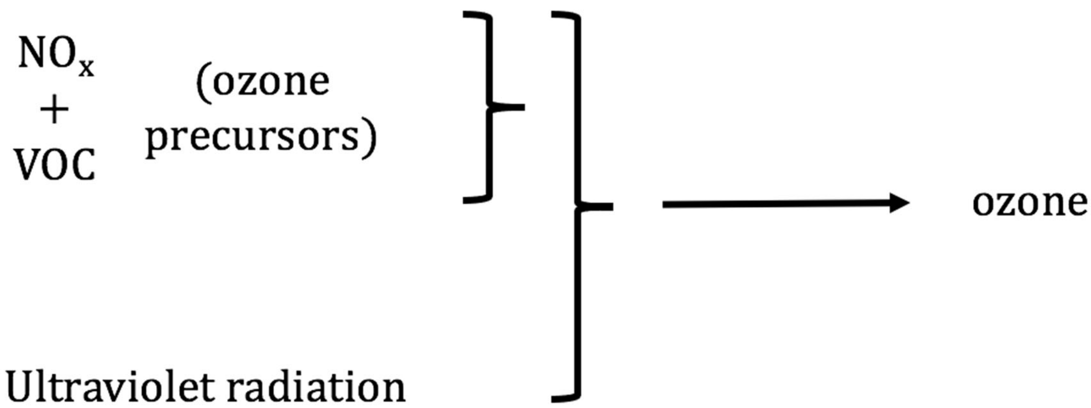

Figure 1. Ozone forms in the atmosphere when two classes of compounds, abbreviated as NO_x and VOC, are both present and are illuminated by ultraviolet radiation from the sun. To control ozone concentrations, we must regulate emissions of NO_x or VOC or both.

The basic “recipe” for “cooking” ozone is summarized in Figure 1. The symbols “NO_x” and “VOC” represent different classes of compounds. The NO_x class is comprised of two different compounds, nitric oxide (NO) and nitrogen dioxide (NO_2). NO_x is emitted to the atmosphere when nitrogen and oxygen in the air are heated, such as happens in an internal combustion engine. The VOC (volatile organic compounds) class are volatile organics including lighter hydrocarbons like ethane, propane, benzene, etc.; simple alcohols like methanol and ethanol; aldehydes such as formaldehyde and acetaldehyde, etc. Essentially, they any organic molecules light enough to escape readily into the atmosphere. Ozone is very reactive, so it usually converts rapidly to ordinary oxygen after sundown. Typically, ozone concentrations peak each day in mid-afternoon.

Ozone pollution has been recognized as an urban summertime problem since the 1960’s. Cities generate adequate amounts of NOx and VOC and the summer sun is intense enough that ozone forms readily. In contrast, in the Uinta Basin, high ozone concentrations typically occur in winter. (Winter ozone is very rare, only two regions worldwide are currently known to produce it.) NOx and VOC compounds are emitted in the summer, but the atmosphere is well mixed, and they get diluted rapidly. On the other hand, wintertime inversions lead to a surface layer of stagnant air; NOx and VOC levels are able to build up, reaching concentrations at which the process in Figure 1 is initiated. Uinta Basin ozone formation also requires snow cover: Without snow cover to reflect incoming solar radiation, the winter sun would be too weak. For example, see “Uinta Basin Ozone Study Annual Report 2011.”

Figure 1 grossly oversimplifies the chemical processes involved in ozone formation. When NOx and VOC compounds are both present, ultraviolet light triggers a complex cascade of chemical reactions involving many different molecular species. Computer models have been developed that capture the details of this chemical cascade. Urban summertime ozone and Uinta Basin wintertime ozone are both cooked up by the process shown in Figure 1, and can both be studied by these models, but there are important differences in the chemistry. The VOC mix is entirely different, the winter air has lower absolute humidity and is colder. Because of these and other differences, the models have struggled in the past to predict Uinta Basin ozone levels. However, Bingham Research Center personnel have recently succeeded in developing models that do predict ozone levels of past ozone events. These models will be applied in the proposed study.

IV. Several Lines of Evidence Suggest that Internal Combustion Engines Contribute Significantly to Ozone Production in the Uinta Basin

IV.A. VOC vs. NOx controls. What is the best way to mitigate ozone production?

NOx and VOC compounds are both necessary ingredients for ozone formation. However, the ozone system in any given airshed may be more sensitive to reductions of NOx than of VOC, or vice versa. We say that the ozone system is under either "VOC control" or "NOx control," or that it is "VOC sensitive" or "NOx sensitive." The question of NO_x vs. VOC control is very important, because it allows regulators to make informed decisions about effective control measures. For example, if an ozone system is VOC insensitive, then control measures need to focus on NOx, and vice versa.

IV.B. The Uinta Basin appears to be under NOx control.

The balance between NOx and VOC control is usually difficult to determine for any given ozone system, and there are no completely definitive results for the Uinta Basin. However, three pieces of evidence suggest that the winter ozone system is more sensitive to NO_x than to VOC:

1. Analysis of existing data. We have applied an analysis technique developed by Wood et al. ["A case study of ozone production, nitrogen oxides, and the radical budget in Mexico City," Atmospheric Chemistry and Physics, 9, 2499-2516, 2009, https://acp.copernicus.org/articles/9/2499/2009/] that estimates NOx sensitivity directly. The analysis indicates a relatively strong sensitivity to NO_x. The analysis gives no information on VOC sensitivity, so we still cannot say anything about the relative sensitivity of the two precursor classes. Results of this analysis are presented in Section 4.5 of the Bingham Center's 2018 Annual Report.

2. Computer models. A model developed by Edwards et al. ["High winter ozone pollution from carbonyl photolysis in an oil and gas basin," Nature, 514, 351-354, 2014, https://www.nature.com/articles/nature13767] indicates that the basin is probably under NO_x control, but with some sensitivity to VOC.

3. Correlations between NO_x, VOC, and ozone concentrations. Historical ozone concentrations appear to be more strongly correlated with NOx concentrations than with VOC. Time-series plots of the residues relative to long-term trends of seasonal average ozone and NOx concentrations are seen to zig and zag more or less synchronously, Figure 2. (However, some correlation between NOx and ozone concentrations is expected in any case: NOx can be generated secondarily under the same conditions that produce secondary ozone.) On the other hand, seasonal average VOC concentrations have shown a significant upturn from 2018 to 2020, while a corresponding upturn in ozone concentrations was not seen. For details, see our peer-reviewed paper. [Mansfield & Lyman, "Winter Ozone Pollution in Utah's Uinta Basin is Attenuating," Atmosphere 12, 4, 2021]

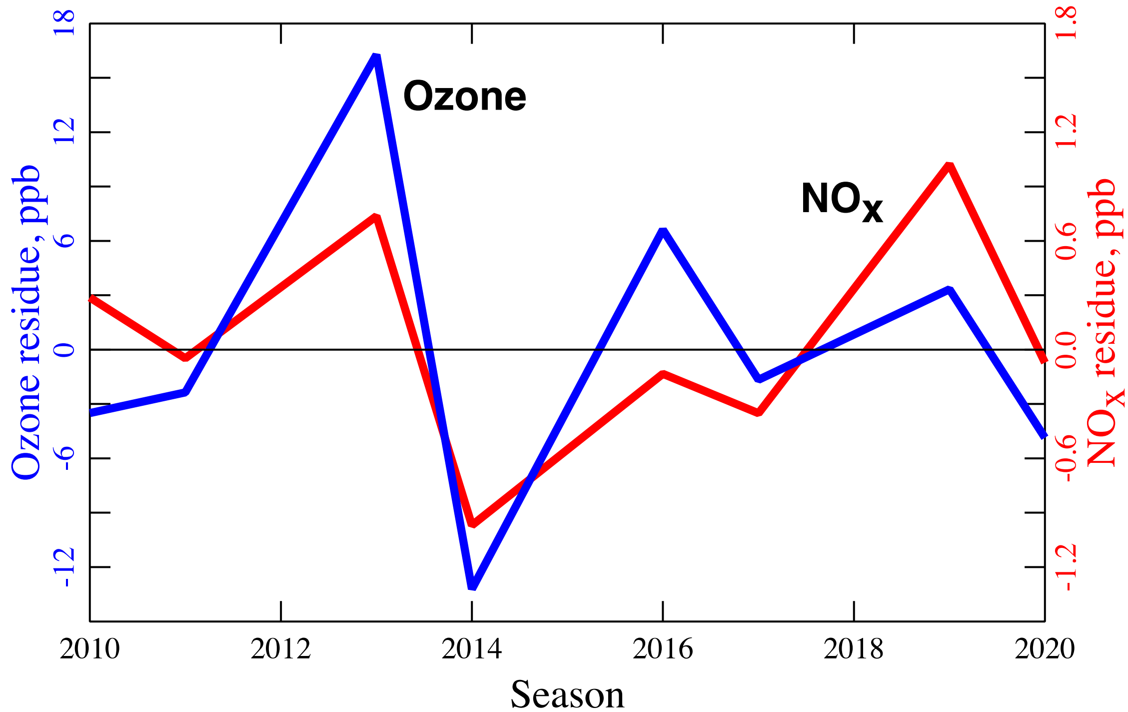

Figure 2. Plots of the residues in ozone and NOx seasonal average concentrations relative to long-term trends. The two traces zig and zag synchronously.

IV.C. Pump jacks powered by internal combustion engines are probably the largest NOx source.

The Utah Division of Air Quality has conducted two extensive inventories of NOx and VOC emissions from oil and gas operations in the Uinta Basin, covering, respectively, the years 2014 and 2017. Figure 3 summarizes the results for NOx. Total annual NOx emissions were estimated at 13,400 and 12,300 tons per year, respectively. These inventories are subject to uncertainty and should not be regarded as highly accurate, but they are the only emissions estimates available.

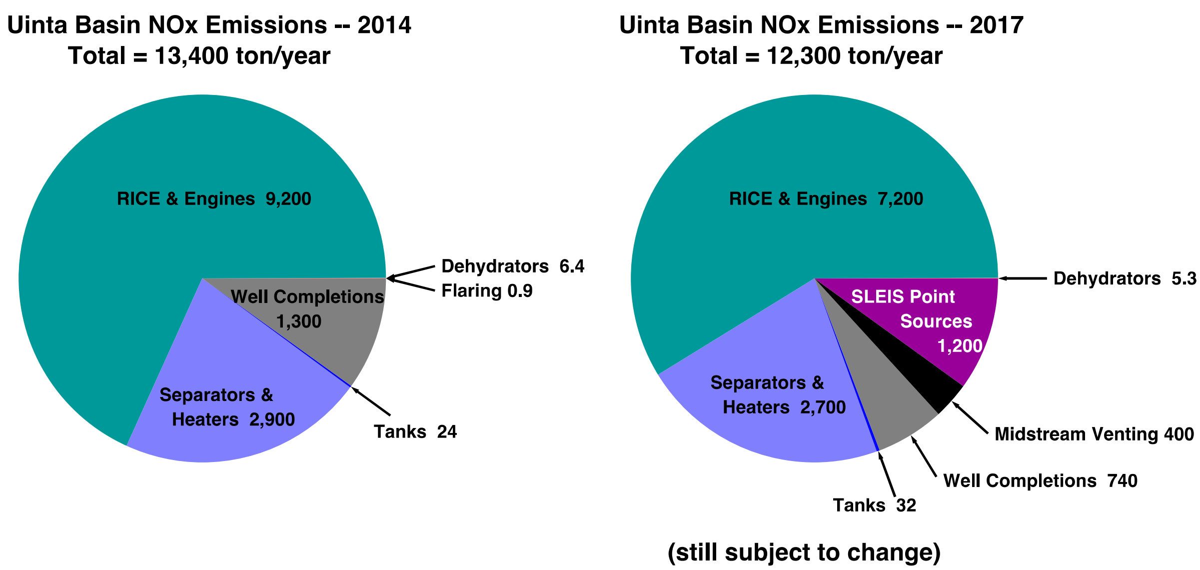

Figure 3. Results of the Utah DAQ emissions inventories for NO_x. All units are ton/year. Emissions from mobile sources, e.g., vehicles, are not included. The 2017 inventory is still open and subject to change. The 2017 inventory added several new emissions categories, midstream venting and State and Local Emissions Inventory System (SLEIS) point sources.

As mentioned above, NOx emissions are generated when nitrogen and oxygen in the air are heated, for example, by engines or flames. The inventories indicate that three categories are the most significant NOx sources in the Basin:

1. *Reciprocal internal combustion engines (RICE) and other engines*. These account for approximately 7,000 to 9,000 tons of NOx emissions annually. A large fraction of these are the pump jacks used to lift oil to the surface.

2. *Separators and heaters.* This category includes a number of different devices requiring external heating, and accounts for nearly 3,000 tons annually.

3. *Well completions.* This category includes all activities required to create a new well, from the moment the drill bit first enters the ground to when the well is ready to start producing. Large internal combustion engines are used to power the drill rigs. NOx contributions from this category are estimated to have fallen from 1,300 to 740 tons per year between 2014 and 2017, consistent with the decline in new well drilling that occurred over the same period.

The coal-fired Bonanza Power Plant, operated by the Deseret Power Electrical Cooperative about 50 miles south of Vernal, emits about 7,000 tons of NOx per year. Because it is a non-oil-or-gas source, it is not included in the UDAQ inventories. The plant has a 600-foot stack, meaning that during wintertime thermal inversions, its NOx is injected above the inversion layer and gets blown out of the Basin. Models indicate that it does not contribute significantly to Uinta Basin ozone. See, for example: Tran, Tran, Mansfield, and Shorthill, "Bonanza Power Plant Emissions Model."

Winter ozone concentrations have been measured in the Uinta Basin since 2010. As discussed in our paper, [Mansfield & Lyman, "Winter Ozone Pollution in Utah's Uinta Basin is Attenuating," Atmosphere 12, 4, 2021] ozone concentrations have shown a statistically significant downward trend since then. Causes of the ozone decline are still speculative, so we do not currently know whether the decline has been irreversible or if the ozone levels of the early 2010's will return. Because of the evidence about NOx control presented above, the following two causes are very plausible:

1. Shift towards electrified pump jacks. Over the past five or six years, new well development by certain operators has occurred in regions with electricity. Today, a larger proportion of oil is being pumped by electrical power than previously.

2. Decline in drilling operations. During the winters from 2010 to 2014, there were an average of about 30 drilling rigs operating in the Basin. Primarily because of the decline in global natural gas prices, the average dropped below 10 in the 2016-2020 period.

Of these two causes, #1 is irreversible while #2 is not. Figure 3 suggests that the shift towards electric pumps may have accounted for an approximate 2,000-ton reduction in NOx production between 2014 and 2017, whereas the decline in drilling operations has been responsible for a reduction of only about 600 tons. If these estimates are accurate, then of these two causes, #1 has probably had the greater impact.

Some large proportion of the 7,200 tons coming from engines in 2017 has been contributed by non-electric pumps. Therefore, by electrifying all pump jacks in the basin, we might conceivably remove 4,000 to 5,000 tons per year of NOx. Another emissions estimate ["Development of Baseline 2006 Emissions from Oil and Gas Activity in the Uinta Basin," https://www.wrapair2.org/PhaseIII.aspx] for 2006 puts the contribution from drilling operations at 4,300 tons/year. If all these estimates are valid, then by electrifying all pumps, which is not currently feasible because the oil and gas fields are not on the electric grid, we can perhaps offset the NOx increases that will occur when drilling operations return to historic levels.

IV.D. Working Hypotheses

Based on the discussion above, we have arrived at the following hypotheses. The proposed project will be directed towards establishing them more firmly.

1. The wintertime Uinta Basin ozone system is under NOx control, i.e., controlling NOx emissions will have a bigger impact than controlling VOC emissions.

2. Electrification of the Uinta Basin oil and gas fields will permit a significant, irreversible reduction in NOx emissions and of winter ozone levels.

3. The benefits of electrification will significantly offset other, reversible NOx emissions, such as drilling activities, and prevent a return to the very high ozone concentrations that occurred in the early 2010's.

4. The logistics and economics of electrification will allow the oil and gas industry to continue operating.

Of course, our primary objective will be to achieve quantitative results whenever possible.

V. Scope of Work -- Overview

This will represent a joint project between the Bingham Research Center at Utah State University Uinta Basin and SLR. As already mentioned, an important goal of the project will be to analyze the impact of electrification of the oil and gas fields, specifically the extent to which significant reductions of natural gas-powered pump jacks as a NOx source will improve air quality. But we cannot understand the contribution of one source relative to all others without studying them as well. Therefore, we will examine all the significant NOx contributors as established by Figure 3.

This project will address four broad goals:

Goal A. Historical characterization of NO_x sources, emissions, and concentrations over the previous decade. Although the primary focus of the work is NOx emissions by pump jacks, establishing relative contributions of all significant sources will be important. The Utah DAQ emissions inventories for 2014 and 2017 will be the starting point for this goal. We will also apply a fuel-based technique for estimating NO_x emissions [Negron et al. , "Development of a Fuel-Based Oil and Gas Inventory of Nitrogen Oxides Emissions," Environmental Science and Technology, 52, 10175-10185, 2018, https://pubs.acs.org/doi/full/10.1021/acs.est.8b02245] and emissions estimates from permits submitted to the Bureau of Land Management (BLM). UDOGM data on well and engine locations will aid in this development. Further, USU is currently engaged in a project to directly measure emissions from natural gas-fueled engines in the Uinta Basin (https://deq.utah.gov/air-quality/emissions-of-reactive-organics-from-natural-gas-fueled-engines) and the data from that study will be available for this work. Modeling requires emissions estimates, but ozone concentrations also correlate with precursor concentrations, so we will also construct the history of NO_x concentrations, using measurements by UDAQ and USU, and satellite NO_2 column measurements from the TROPOMI and EMI projects. [http://www.tropomi.eu; Cheng et al., "NO2 Retrieval from the Environmental Trace Gases Monitoring Instrument (EMI): Preliminary Results and Intercomparison with OMI and TROPOMI," Remote Sensing, 11, 3017, 2019]

Goal B. Modeling the impact of electrification of oil and gas fields and the issue of NO_x control. As mentioned above, the question of NO_x and VOC control is important, and electrification of the oil and gas fields should produce lower NO_x emissions. We will build and study computer models that address both questions.

Goal C. Economic and Logistic Evaluation of Additional Power Transmission Development. We will look at logistics and timing of electrifying the basin which would include evaluating regulatory requirements. The capital costs and financial impact to the local oil and gas industry, and subsequently the working population, will be examined.

Goal D. Data analysis and synthesis, preparation of reports. Statistical data analysis and synthesis will be used to quantify the correlations between NO_x emissions and concentrations, and ozone concentrations. All results will be summarized in a report at the end of the project.

VI. Scope of Work -- Technical Approach

Goal A has been divided into three tasks, and Goals B and C into two each, and Goal D into one task.

Task A1. Pad-by-pad reconstruction of the history of NO_x sources. Well completions (new drilling and completions) are a source of NO_x primarily from the engines used to drill and frac wells. We will develop a historical database reporting the date, location, and distance of each completion, and develop information on the engine type and fuel type used. Historical numbers and types of heaters and separators will also be tabulated. Utah Division of Oil Gas and Mining (UDOGM) maintains detailed records of the timing and location of all drilling events, as well as historical well depth and production data. We can estimate the power output by any pump jack from the number of barrels lifted from a given depth, which in turn will correlate with the NO_x emission. We will use information from State of Utah emission inventories in conjunction with DOGM well location information to determine which wells appear to operate pumping units using electric powered pumps. We will supplement information on electric powered pumps, as opposed to engine powered pumps, by gathering information from the electric power providers and from operators. An objective approach will be developed to fill in any missing information. These may include representative stack parameters, average drilling/completion times by well type or formation. We will develop a historical database reporting these data. Task A1 will be completed primarily by SLR personnel with some assistance from USU as well.

Task A2. Pad-by-pad history of NO_x emissions. Using appropriate emissions factors, the historical data obtained from Task A1 will be used to generate a picture of NO_x emissions over the past decade with as much temporal and spatial resolution as possible. NO_x emissions estimates from new well permits submitted to BLM will also be accessed. As a check on the results, a fuel-based calculation of NO_x emissions pioneered by personnel from CIRES and NOAA [Negron et al. 2018, Environmental Science and Technology, 52, 10175-10185, , https://pubs.acs.org/doi/full/10.1021/acs.est.8b02245] will also be performed. Task A2 will be the responsibility of the USU group with assistance from SLR.

Task A3. Reconstruction of the history of NO_x concentrations. Modeling ozone concentrations requires data on NO_x emissions. But understanding NO_x concentrations is also important: Ozone concentrations are correlated with NO_x concentrations, and an ability to predict NO_x as well as ozone concentrations is a useful test of the modeling framework. Direct measurements of NO_x concentrations obtained either by USU or UDAQ exist over most of the past decade. Satellite data on NO_2 concentrations are also available. Therefore, we will combine the direct measurements along with the satellite data to generate a historical database reporting surface concentrations of NO_x. This task will be directed by the USU group with support from SLR.

Goal B: Modeling to determine the impact of electrification and to address the question of NO_x control.

Modelers at USU's Bingham Research Center have recently developed several techniques in photochemical 3D grid modeling that have produced much improved prediction of winter ozone concentrations in the Uinta Basin. This modeling platform will be used to determine winter ozone concentrations using the refined NO_x inventory described in Tasks A1 and A2.

Task B1. Source apportionment modeling of the impacts of electrification. Source apportionment modeling refers techniques that determine the contributions of different sources to overall air quality. Such techniques with photochemical grid models using inputs from Goal A will be applied to estimate the impacts of electrification of the oil and gas fields on NO_x emissions and ozone and NO_x concentrations. Personnel at USU and SLR will both contribute to Task B1.

Task B2. Modeling to address questions of NO_x control. Faster-running box models will be used to explore questions of NOx control at low resolution in NOx/VOC space. Results of the most interesting box models will then be tested by 3D grid models. Personnel at USU will perform this task.

Goal C. Economic and Logistic Evaluation of Additional Power Transmission Development. Data will be gathered from similar studies, including recent Uintah Basin transmission line evaluations and information from similar studies in other Western oil and gas regions. Information will be developed to evaluate the process that would likely have to be followed to complete the type of electrification of the Basin that might be feasible. This would include a look at logistics, timing, and the effect of regulatory requirements. Costs would be evaluated in terms of the permitting and capital costs and potential financial impact to the local oil and gas industry, and subsequently the working population.

Goal D. Data analysis and synthesis; preparation of the final report.

Task D1. Data analysis and synthesis. An important task will be to analyze and synthesize the data generated in the previous tasks. We will look for temporal and spatial correlations between NO_x emissions, NO_x concentrations, and ozone concentrations, including gathering more evidence on the question of NO_x control. We will also quantify the expected air-quality benefits of electrification of the oil and gas fields. Task C1 will be the responsibility of the USU group.

Task D2. Preparation of a final report. Both teams will work together to prepare a final report at the end of the project summarizing all important findings.

VII. Expected Outputs and Outcomes

Outputs and outcomes expected from this project are:

- Quantitative predictions about the impacts of electrification of the oil and gas fields on Uinta Basin air quality,
- A better understanding of whether the basin ozone system is under NO_x or VOC control.
- A better understanding of the environmental and economic impacts of the potential electrification of the Basin.

VIII. Schedule

We are tentatively planning a ten-month project, running from March to December 2021. We have planned about five months for most tasks, with staggered starts. The anticipated schedule is shown in this Gantt chart.

TASK	MONTH									
	1	2	3	4	5	6	7	8	9	10
A1. History of NO_x sources	■	■	■	■	■					
A2. History of NO_x emissions			■	■	■	■	■			
A3. History of NO_x concentrations		■	■	■	■	■				
B1. Electrification modeling				■	■	■	■	■		
B2. NO_x control modeling					■	■	■	■	■	
C Power Transmission Development			■	■	■	■	■			
D1. Data analysis					■	■	■	■	■	
D2. Preparing report									■	■

IX. Proposed budget

	Hourly Rate	Projected Hours	Total	
USU personnel				
Mansfield	$73.00	147	$10,731	
David	$45.00	286	$12,870	
Lyman	$60.00	30	$1,800	
			$25,401	**USU total salaries**
			$11,811	**USU fringe benefits**
SLR personnel				
Hammer	$190.00	89	$16,910	
Reed	$180.00	26	$4,680	
Senior Planning Engineer	$190.00	120	$22,800	
Qiu	$169.00	59	$9,971	
Senior staff	$117.00	223	$26,091	
Junior staff	$78.00	254	$19,812	
			$100,264	**Total consultancy fees**
			$137,476	**Total direct costs**
			$63,239	**Total indirect costs**
			$200,715	**TOTAL**

Explanations.
1. USU fringe benefits are calculated as 46.5% of salaries.
2. Benefits and overhead for SLR are bundled into the hourly rates.
3. Total direct costs are the sum of USU salaries and fringe benefits and SLR consultancy fees.
3. Indirect costs (facilities and administration) are calculated as 46% of direct costs.
4. We are requesting funds to cover labor and indirect costs (facilities and administration). Other costs, computer facilities, for example, will not be charged to this grant.

X. Personnel Roles and Responsibilities

The project will be performed by personnel at the Bingham Research Center, Utah State University Uintah Basin, and at SLR International Corporation. The personnel assigned to the project possess the necessary skills to perform the work and will commit the time required to accomplish all tasks.

Marc Mansfield, Ph.D., Research Professor, USU, has experience as a physical chemist and with statistical analysis, including statistical analysis of air quality and air emissions data. He will serve as Principal Investigator on the project; will contribute to data analysis, acquisition, and interpretation; box modeling; and report writing.

Liji David, Ph.D., Senior Researcher, USU, has experience with chemical-transport modeling including ozone and $PM_{2.5}$; managing, interpreting, and curating large datasets and field data; satellite-data retrieval; and field campaigns. She will perform 3D grid modeling; data analysis, acquisition, and interpretation; and report writing.

Seth Lyman, Ph.D., Director of the Bingham Research Center and Associate Research Professor, USU, has experience in air quality measurements and analysis. He will contribute to data analysis, report writing, deliverable development, and database curation.

Robert Hammer, Project Manager, SLR, has many years' experience in environmental issues related to the oil and gas industry, both with operators and as a consultant. He will act as project manager over the SLR team and contribute to building the NO_x source historical database.

Jason Reed, CCM, Air Quality Modeling Team Leader, SLR, has extensive experience in all aspects of air quality modeling for the oil and gas industry. He will also assist in developing the NO_x source historical database and direct the SMOKE analysis and 3D grid modeling work.

Xin Qiu, Ph.D., ACM, EP, P. Met, Principal, Technical Director, Climate Change and Air Quality, SLR, oversees air quality modeling at SLR's Ontario, CN facility. He will also assist in developing the NO_x source historical database and direct SMOKE analysis and 3D grid modeling.

CERTIFICATE OF SERVICE

I hereby certify that on March 3, 2021, a true and correct copy of the foregoing was served by electronic mail on the following:

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