EVOLUTION OF THE UTAH ENERGY RESEARCH TRIANGLE:

A CONTEMPORARY CASE STUDY IN THE NEXUS OF

APPLIED RESEARCH AND PUBLIC POLICY

by

Alan John Walker

A thesis submitted to the faculty of
The University of Utah
in partial fulfillment of the requirements for the degree of

Master of Science

in

Petroleum Engineering

Department of Chemical Engineering

The University of Utah

May 2015

The University of Utah Graduate School

STATEMENT OF THESIS APPROVAL

The following faculty members served as the supervisory committee chair and members for the thesis of **Alan John Walker**. Dates at right indicate the members' approval of the thesis.

John D. McLennan	, Chair	**December 17, 2014** Date Approved
Milind Deo	, Member	**December 15, 2014** Date Approved
Swomitra Mohanty	, Member	**December 15, 2014** Date Approved

This thesis has been approved by **Milind Deo**, Chair/Dean of the Department of the Department/College/School of **Chemical Engineering** and by David B. Kieda, Dean of The Graduate School.

ABSTRACT

The evolution of the Utah Energy Research Triangle began August 2009 with Governor Gary Herbert's inauguration. On January 26, 2010 Governor Herbert delivered his first State of the State Address and announced the "most impactful economic initiative ever taken in our state…the Utah Energy Initiative." Even before this speech, actions were underway as the Governor assembled 16 energy professionals who forged *Utah's 10-Year Strategic Energy Plan* (Plan) released March 2011.

The priorities in the Plan included: (1) establishing the Office of Energy Development in 2011; (2) launching the annual Governor's Energy Development Summits beginning in 2012; and (3) executing the first cycle of the Utah Energy Research Triangle in 2013 through 2015. Other objectives would be achieved as the Plan unfolded but those lower priorities are beyond the scope of this case study. This study will review the three priorities noted and focus on the execution of the Energy Research Triangle as a nexus of applied research and public policy.

The Plan's vision was to "align the State's main research universities…into a powerful energy research and development triangle…through increased collaboration." In March 2014, execution of the first cycle of the Energy Research Triangle resulted in seven new research efforts across three research university campuses in Utah – Brigham Young University (BYU), Utah State University (USU), and the University of Utah (UofU). These research programs included eighteen researchers tackling principle energy issues: air quality, hydrocarbon transportation, and safety. Seven other researchers were awarded Governor's Energy Leadership Scholarships with

requirements to address topics including efficient solar power, cold-weather battery performance, and molten salt energy storage.

Final results will be known in June 2015, but collaboration on energy issues is active and ongoing. Together the three research teams are successfully reaching out to industry and federal agencies to expand their capability to address Utah energy issues.

This case study provides a road map and lessons learned for developing a meaningful grass roots research program with modest resources. Public policy is notorious for cycling through good ideas. This study provides guidance to solve local issues using the collaborative capabilities of our universities.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

BEERC	Bingham Entrepreneur and Energy Research Center in Vernal
BYU	Brigham Young University
CEIC	Carbon Energy Innovation Center in Price
CO2	carbon dioxide
DAQ	Utah Division of Air Quality
DEQ	Utah Department of Environmental Quality
DOE	US Department of Energy
DOGM	Utah Division of Oil, Gas and Mining
EPA	US Environmental Protection Agency
ERT	Utah Energy Research Triangle
EV	electric vehicle
FY	fiscal year
HER	hydrogen evolution reaction
OED	Utah Office of Energy Development
OSP	Office of Sponsored Projects
PMOSA	plant mix oil sand asphalt
RFP	request for proposal
SIP	State Implementation Plan (air quality)
TE	thermoelectric material
UBETS	Uinta Basin Energy and Transportation Study
UDOT	Utah Department of Transportation
USU	Utah State University
UofU	University of Utah
USTAR	Utah Science Technology and Research
VOC	volatile organic compound
VPR	Vice President of Research

PREFACE

The purpose of this project is to design and optimize the technology component of Governor Gary Herbert's vision for a strategic 10-year energy plan and an "Energy Research Triangle" composed of Brigham Young University, Utah State University, and the University of Utah. At this point in my professional life, my involvement in technology and engineering focuses on commercialization, economic development, and workforce capability. This thesis encompasses my professional assignments, has been part of my professional life for over five years, and will continue to be part of my responsibilities at least until the summer of 2015.

Specific sectors of this project were directly related to petroleum engineering, such as the black wax characterization and the Uinta Basin ozone mitigation projects. Other projects such as carbon dioxide conversion, cold-weather battery performance, and molten-salt utilization are energy related, but not directly tied to hydrocarbon issues. Regardless, $256,666 or 58% of the $445,000 available for this program and approximately half of the time that was devoted to that program were directly related to hydrocarbon production. From inception in October 2009 until March 2011, approximately twenty-five percent of my effort was directed to the 10-year plan, from March 2011 until October 2012, approximately ten percent of my time was directed to the 10-year plan and the Energy Research Triangle development, and from October 2012 through the present, approximately one-quarter of my effort was directed primarily to the Energy Research Triangle development and associated projects. To date, approximately one man-year of my effort and a similar amount of time by Mr. Rob

Simmons, Esq. and Mr. Ryan Streams have been devoted by Utah Science Technology and Research (USTAR) to the Utah Energy Research Triangle.

In addition to a normal bibliography, appendices with PowerPoint™ presentations, correspondence, and reports that would not normally be readily available for public review have been attached as Appendices A through S. These files can also be found in USTAR records.

The author wishes to express his gratitude to the colleagues that played a significant role in development and execution of the Utah Energy Research Triangle: Milind Deo, Ph.D., Department of Chemical Engineering, Ivy Estabrooke, Ph.D., Utah Science Technology and Research , Gary Herbert, Governor of the State of Utah, Samantha Mary Julian, Utah Office of Energy Development, Edward (Ted) McAleer, Utah Science Technology and Research, Swomitra Mohanty, Ph.D., Department of Chemical Engineering , Jeff Muhs, Utah Energy Research Triangle at Utah State University, John McLennan, Ph.D., Energy & Geoscience Institute, Laura Nelson, Ph.D., Utah Office of Energy Development, Robert Simmons, Esq., Utah Office of Energy Development, Cody Stewart, Utah Governor's Energy Advisor, Ryan Streams, Utah Science Technology and Research, and Victoria Walker, supportive and loving spouse.

The author wishes to express his gratitude to the organizations that played a significant role in development and execution of the Utah Energy Research Triangle: Brigham Young University (BYU), Governor's Energy Task Force, University of Utah (UofU), Utah Governor's Office of Economic Development (GOED), Utah Office of Energy Development (OED), Utah Science Technology and Research (USTAR), Utah State University (USU), and Utah System of Higher Education (USHE).

CHAPTER 1

INTRODUCTION

The genesis of the Utah Energy Research Triangle (ERT) was in the fall of 2009, a few weeks after Governor Gary R. Herbert was sworn in as the 17th Governor of the State of Utah. During his Inaugural Speech, on August 11, 2009, Governor Herbert spoke of three pillars for his administration: economy, education, and energy. In later speeches, he added a fourth pillar, self-determination. These four pillars became the touchstones of the public policy that set the challenges and provided legitimacy for what, in time, would become the Utah Energy Research Triangle (Herbert, 2009).

As he spoke of Utah's energy resources, he focused on Utah's innovative spirit and entrepreneurism to explore ways to exploit coal, oil and gas, wind, solar, biofuels, and hydroelectric energy sources. Governor Herbert spoke of our duties as stewards of the land and responsibilities to future generations to protect the beauty of our state. He recognized that protecting nature and meeting our energy needs through innovation and development are not mutually exclusive. The Governor then challenged the research community to develop innovative technologies to benefit society and preserve the environment for future generations (Herbert, 2009).

In October 2009, to bring his speech into action, Governor Herbert assembled and formally appointed the Energy Task Force chaired by an environmental advocate and former Salt Lake City Mayor Ted Wilson and 15 other energy professionals from

industry, government, and academia. The Energy Task Force was charged to develop a 10-year strategic energy plan to address comprehensive topics such as energy efficiency, transportation, air quality, workforce development, and infrastructure. Mayor Wilson developed six subcommittees with up to 29 members each. The six committees were:

- Energy Development and Environment
- Energy Efficiency, Conservation, and Demand Response
- Transportation and Air Quality
- Energy Careers, Manufacturing, and Workforce Development
- Transmission, Infrastructure, and Transportation
- Developing and Applying Technology and Science

The subcommittees and their duties will be discussed further in Section 2.1. All told, more than 100 of Utah's energy professionals volunteered their time and expertise to contribute in this collaborative effort (Herbert, 2011).

The Developing and Applying Technology and Science subcommittee was composed of Dr. Robert Behunin of Utah State University, Dr. Douglas Smoot of Brigham Young University, President Robert Brehms of the Utah College of Applied Technology, and Mr. Michael Hagood of the Idaho National Laboratory and was chaired by Mr. Alan Walker of the Utah Science Technology and Research Initiative (USTAR). USTAR, through Robert Simmons, Esq., and interns Ms. Vatsala Kaul and Mr. Yogesh Mishra, also provided administrative and research support to that committee. This committee was primarily established to lead the effort to improve coordination between the State's research universities, national labs, and other energy industry research and development assets. In particular, Governor Herbert envisioned a powerful energy and research triangle formed by the collaborative research capabilities of Brigham Young

University (BYU), Utah State University (USU), and the University of Utah (UofU). Eventually, this collaboration was termed the Utah Energy Research Triangle (ERT) and it proposed a modest collaborative grant program that encouraged collaborative research between the three universities. The process to establish this collaborative effort will be discussed further in this paper, but within three years, seven research programs were proposed and funded that improved the coordination between the State's universities as envisioned by Governor Herbert. To date, the success of the Energy Research Tringle is modest, as is the $455,000 of programmatic funds allocated to the program (Herbert, 2011).

The Energy Task Force and its purpose were introduced to the Utah State Legislature and the public at large on January 26, 2010 during the Governor Herbert's first State of the State Address. The Governor stated that this effort, "will be one of the most impactful economic initiatives ever undertaken in our state…it is the Utah Energy Initiative. I am assembling the best minds in the state and charging them with creating a 10-year strategic energy plan whose purpose is threefold: to ensure Utah's continued access to our own clean and low-cost energy resources; to be on the cutting edge of new energy technologies; and to foster economic opportunities and create more jobs" (Herbert, 2010). The second advocated purpose – embracing cutting edge new energy technologies - fell squarely on the shoulders of the aforementioned subcommittee challenged with developing and applying technology and science avenues for the Energy Task Force.

CHAPTER 2

STRATEGIC ENERGY PLAN DEVELOPMENT

2.1 Strategic Energy Plan Development

Preliminary work on the Strategic Energy Plan had begun, behind the scenes, several months before the State of the State address. Approximately every two months, the Energy Task Force met with the Governor. The meetings were convened by the Governor and either Mayor Wilson or the Governor's Energy Advisor, Dr. Dianne Nielson, would conduct these meetings. Governor Herbert took the Energy Task Force meetings very seriously and generally spent an hour or more with the task force shaping the plans and policy to implement his vision. Select committees would provide updates on their activities, and one or two specific topics would be discussed in moderate detail. These joint political leadership and task force meetings helped to direct the course of the plan such that it effectively realized the Governor's vision. The Governor stressed that this was a 10-year plan and the most important objectives would be prioritized and achieved in order. He made certain that the task force understood that this process would be expected to continue over several years and that an appropriate amount of time would be allowed to achieve objectives. For example, establishment of the Office of Energy Development and an annual Governor's Energy Summit were prioritized ahead of what would be known as the Utah Energy Research Triangle. Another Energy Task Force discussion with the Governor involved where to house the Utah Energy Research Triangle when it was established. The Energy Task Force decided that Utah State University (USU) would host the effort and USU would dedicate twenty percent of

Professor Jeff Muhs' time to development of viable proposals on how to implement Governor Herbert's vision and establish the Utah Energy Research Triangle. Concurrently with the bi-monthly meetings, the committees developed their contributions to the Strategic Energy Plan. The six committees included: Energy Development and Environment chaired by Mr. Paul Barber, Energy Efficiency chaired by Mr. Ron Jibson, Energy Careers and Workforce Development chaired by Dr. Rob Behunin, Transmission Infrastructure chaired by Mr. Rich Walje, Transportation and Air Quality chaired by Mr. Ron Jibson, and Developing and Applying Technology and Science chaired by Mr. Al Walker. Each of the committees developed its own work plan with the objective of having a draft finalized by summer 2010. This would allow several months to vet and edit the final edition of the 10-Year Strategic Energy Plan, and ensure that a final plan was in place before the November 2010 special election (Herbert, 2011). Mayor Wilson explained to the task force that the intention of the administration was to establish the energy plan as an important legacy issue that demonstrated to the electorate that the Governor was a man of action. Therefore the intent, at that time, was to release the plan several months before the election. As will be seen as this report unfolds, this task grew to be bigger than expected and that timeline was not achieved.

The Developing and Applying Technology and Science committee met in Salt Lake City to develop a work plan to accomplish the Governor's goals prior to the summer 2010 deadline. The team decided to meet by telephone every two weeks to review and discuss progress. The actual work was divided between team members, but the bulk of the work was done by the USTAR support team of Mr. Rob Simmons, Esq., Ms. Vatsala Kaul, and Mr. Yogesh Mishra. Ultimately, the committee developed approximately 45 pages of unabridged content describing the capabilities of BYU, USU, and the UofU; the challenges of aligning, connecting, and empowering a collaborative effort; and a research initiatives roadmap to enable the Energy Research Triangle to

optimize research capabilities to address Utah's energy issues. This content was archived by the Governor's office in its entirety. Ultimately, the 45-page contribution was edited by the Governor's staff and Energy Task Force to approximately five pages in *Chapter VIII, Utah's 10-Year Strategic Energy Plan* (Herbert, 2011).

2.2 Release of Utah's 10-Year Strategic Energy Plan

The initial version of the Strategic Energy Plan was released on November 3, 2010, a day after the special election in which Governor Herbert had been elected to fill the remaining term of Governor Jon Huntsman, who had resigned to take the position of U.S. Ambassador to China. (One could speculate that this was meant to ensure the Energy Plan did not receive undue coverage in the media.) Governor Herbert received 64% of the vote in defeating Salt Lake County Mayor Peter Caroon. Although the release of the plan had no significant bearing on the outcome of the election, the election and other political activities had a tremendous bearing on the plan, as will be discussed in Chapters 3 and 5.

CHAPTER 3

GOVERNOR HERBERT AND THE ENERGY TASK FORCE

3.1 Initial Actions of Governor Herbert and the Energy Task Force

Under the prior administration of Governor Jon Huntsman, the Utah Energy Office had been dissolved. Shortly after the Energy Office was dissolved, Governor Huntsman established the position of the Governor's Energy Advisor. Governor Huntsman appointed Dr. Laura Nelson to this position and she held the office until July 2007, and then was succeeded by Dr. Diane Nielson. The 10-Year Strategic Energy Plan development process began under Dr. Nielson with former Salt Lake City Mayor Ted Wilson appointed to lead the Energy Task Force. Together they developed the planning process and initiated the planning. Dr. Nielson retired in the winter of 2010 and was succeeded by Amanda Smith as the Governor's Energy Advisor. Ultimately, in March 2011, Amanda Smith and Mayor Wilson accomplished the remarkable task of editing the collective work of the six committees and publishing a coherent 10-Year Strategic Energy Plan.

Prior to January 2010, the Utah Office of Energy Development (OED) did not exist. The first recommendation by the Energy Task Force was to establish this office to replace the defunct Utah Energy Office and assist the Governor's Energy Advisor (Herbert, 2011). The first director was Ms. Samantha Mary Julian. Her office absorbed several staff members from the Utah Geologic Survey who were involved in federally-funded sustainable energy projects. With a small staff and limited resources, OED

began the next step of executing the Plan, which was the inaugural Governor's Energy Development Summit, targeted for January 2012 (Herbert, 2011).

The second priority of the Plan was to design and implement a Governor's Energy Development Summit (Herbert, 2011). The first Governor's Energy Development Summit was held on January 10, 2012. Over 1,000 attendees participated in a two-day summit in the Salt Palace Convention Center that covered a wide range of topics concerning energy development in Utah. This annual event has occurred in 2013 and 2014 and each was an unequivocal success. As the Utah Energy Research Triangle was still in development at the time of the 2012 Summit, there was no discussion or role for it during the inaugural event. After the concept had been presented and accepted by the Governor, there was a preliminary presentation during the 2013 Summit and during the 2014 Summit, the role was very significant. The Energy Research Triangle's role and impact upon the future Summits will be discussed subsequently.

With the Office of Energy Development moving forward, building an impactful track record, and a successful 2012 Governor's Energy Summit, it was time to address and focus on the third priority of the 10-Year Plan: the Utah Energy Research Triangle.

3.2 Preliminary Energy Research Triangle Activities

Meanwhile, Utah State University was the host for the first cycle of the Utah Energy Research Triangle proposals to fulfill Governor Herbert's vision. During the summer of 2011, a USTAR professor with a background in energy innovation from the Oak Ridge National Laboratory, Professor Jeff Muhs, was asked to develop a proposal and plan to implement the Utah Energy Research Triangle. Professor Muhs held numerous discussions within the research community and government agencies on how to proceed. The concept he proposed to the Governor's Energy Task Force was to

develop a state fund that could be used by research teams to provide matching funds that are required for many Department of Energy (DOE) programs. Many DOE solicitations require that the awardee provide matching funds or in-kind effort as a criterion for award. The state fund that Muhs suggested would demonstrate state commitment and help to overcome the matching fund hurdle that often prohibits proposal submission by research organizations (Appendix A).

The details of this concept are enclosed as Appendix A. This addendum includes a presentation to the Governor and the Energy Task Force on August 22, 2013 as well as a promotional release that explains the proposed concept. The original stated mission was to develop a "best-in-country" energy innovation ecosystem by 2016. The stated goal included improved cooperation and coordination by the universities for leveraging the strengths and resources of both industry and the universities. Professor Muhs performed a capability and strength inventory of relevant research areas and held key discussions with stakeholders at the universities, with industry, and within the state government (Appendix A).

In this initial embodiment of the Energy Research Triangle, the proposed focus area was unconventional resource development. This included oil sand extraction, national grid integration, and other next-generation energy resources such as biomass co-firing and in-situ coal extraction (Appendix A). As a result of the presentation, the "Utah LEADs Initiative" was soon released and called for a $10 million fund to initiate "large-scale, first-of-a-kind demonstrations of transformative energy systems" (Appendix A). The anticipated benefits of the program were to improve Utah's competitiveness nationwide and job creation.

Ultimately, the matching fund proposal did not gain enough traction with Governor Herbert and the Energy Task Force to receive budgetary support. Professor Muhs decided to resign from USU and USTAR in October 2012 to take an opportunity in

the private sector that capitalized on his innovation and research capabilities. Timing proved critical in this failed attempt. The proposal rejection came two months after the Governor's budget proposal for the upcoming legislative session had been finalized. Adequate funding could not be projected in the Utah General Fund for Fiscal Year 2014 (FY14) that would begin on July 1, 2013. Therefore, no appropriated funds could be made available for the Energy Research Triangle until July 1, 2014, unless they came from an outside source or through another state program authorized to promote such an initiative.

3.3 USTAR'S Initial Proposal on the Utah Energy Research Triangle

When Professor Muhs announced his departure in October 2012, the Governor's Energy Advisor, Mr. Cody Stewart, turned to OED and USTAR for suggestions on how to proceed with the Governor's vision. Since USTAR already had numerous strong connections with USU and the UofU, USTAR was asked to develop a concept on how to proceed. USTAR's Technology Outreach and Innovation Program (TOIP) team for Eastern Utah was asked to assume this responsibility. Alan Walker and Ryan Streams began developing and vetting potential concepts. During November and December, the TOIP team met informally with numerous faculty from BYU, USU, and the UofU and the respective technology commercialization offices (TCO) to solicit ideas on how to proceed with the vision for statewide collaborative research.

As the 2013-14 legislative session approached, a concept was developed to fund three tiers of research. Each so-called tier would focus on solutions to relevant Utah energy issues that would have a reasonable chance of succeeding in a three-year period. Tier 1 would be the Principle program allocated among the state's three research-oriented universities (Brigham Young University, Utah State University, University of Utah). The Tier 1 grant was the largest of the three tiers and intended to

address one of Utah's most important energy issues, such as air quality or safety. One university would lead a three-year $450,000 program ($150,000 annually) with at least 20% going to each of the other two universities. Tier 2 would be the Core program and was the next largest grant. It was also intended to address Utah's important energy issues where the other two universities would each lead a three-year $225,000 program ($75,000 annually), again with at least 20% going to each of the other institutions. Tier 3 would be the Energy Leadership Scholars program. Each university would receive a total grant of $250,000 to fund three scholars for three years at $25,000 annually per scholar. This proposal was discussed with the Governor's Energy Task force in November 2012 and approved for development, but would not be sponsored in the Governor's budget proposal for the 2012-13 legislative session and FY14, due to timing.

The first public disclosures of the USTAR version of the Energy Research Triangle proposals came on January 10-11, 2013, at the Governor's Energy Development Summit held in Salt Lake City. During this session, representatives from BYU, USU, and the UofU discussed what their universities' energy innovation programs were and how they would collaborate. Mr. Mike Alder from the BYU Technology Commercialization Office (TCO) represented BYU, Dr. Rob Behunin represented USU, and Alan Walker represented the UofU. Since this version of the Energy Research Triangle was still conceptual, the presentations were generic and budget requirements were not presented. Regardless, the three panelists agreed that the vision of the three universities complimenting the others capabilities to address Utah energy issues had tremendous merit and promise.

The next opportunity to discuss the ERT proposal came a few weeks later on January 22, 2013, during an energy innovation panel discussion organized by the Exoro Group in the Zion's Bank building, on the eve of the legislative session. The relevant presentation is archived in Appendix B. The key presentation messages were that the

Energy Research Triangle was the next logical step in the 10-year strategic energy plan and that Utah had tremendous innovation assets that could be capitalized upon. The program proposal was designed to promote the next level of collaboration between Utah's research universities by funding energy research relevant to Utah. The audience that included business, academia, and government officials asked questions of the panel and were invited to participate through suggestions and dialogue with the Energy Research Triangle team (Appendix B).

In late January 2013, this concept was further reviewed with the Vice Presidents of research or commercialization (VPRs) at BYU, USU, and the UofU. At BYU, Dr. Alan Harker designated Dr. Conrad Monson as the primary point for future contact. At USU, Dr. Rob Behunin provided the information flow into the university regarding the ERT. At the UofU, Dr. Tom Parks designated Dr. Eric Eddings as the primary point of contact. A copy of the presentation given to Dr. Tom Parks on January 26, 2013 is in Appendix C. Similar presentations were used in the discussions with Dr. Harker and Dr. Behunin and their respective staffs and technology commercialization offices (Appendix C).

As described previously, the program at this stage had three components:

- Tier 1 Principle Research, led by one university with a 60/20/20 split of $450,000 over a three-year period;
- Tier 2 Core Research, which was also a 60/20/20 split of two $225,000 projects over a three-year period; and
- Tier 3 Energy Leadership Scholars Program providing $25,000 per year to three students at each university for a three-year period.

The total proposed cost of the program for 2014 through 2017 was $1,650,000 (Appendix C).

The reviews of the proposed program at the universities were mixed, but the criticism and lessons were important to development of the program that was later

successfully adopted. The proposal for the Energy Leadership Scholars was universally accepted as being helpful to students and all universities encouraged the USTAR team to continue on that track. The concept of Tier 1 Principle and Tier 2 Core energy research programs was also worthy, as long as each university was assured to be the winner of the Tier 1 grant and the other universities shared appropriate amounts of funds under the Tier 2 grants. It was obvious that none of the universities wanted to support or participate in a program where they received a lesser amount of grant funds than the others in the Energy Research Triangle. After discussions with the VPRs and follow-up discussions with their designees, it was decided that if the program were to gain active participation, the playing field would need to be level and the triangle would need to be as equilateral as possible.

Additionally, some research faculty felt the funding level was too low to attract serious faculty participation. Research sponsored by the Department of Energy (DOE) could entail awards on the order of millions to hundreds of millions of dollars and often extended for or beyond three- to 10-year research project cycles. This difference in funding magnitude and duration encouraged evolution of the Energy Research Triangle in a different direction. Instead of the highly funded federal energy research funding initiatives, a more modest approach was used. While the DOE and similar entities support large projects using national labs, and pursues issues such as climate change and national energy security, the Energy Research Triangle had a modest agenda. The ERT's goal was to identify applied research projects that could most effectively "move the needle" on energy issues relevant to Utah, in the time allowed, with a modest funding level. The ERT's goal was to address Utah-centric energy issues with niche research funding provided directly from Utah resources for Utah-based research teams. Without many alternatives to large-scale, multimillion dollar federally- or industrially-

funded projects, Utah-centric energy research needs were not met. The Energy Research Triangle targets small-scale projects designed to fill that gap.

In an effort to ensure equivalent funding to each research institution and gain the support of the potential research university participants, a redesigned and simplified program was proposed. The new and simplified program was reviewed with the Governor's Energy Advisor, OED, and important members of the Energy Task Force. They all indicated the revised proposal would likely receive approval from the Governor and that the program should be discussed at the next meeting. This version will be described in following sections.

3.4 Approval by Governor Herbert

"Powering the Energy Research Triangle" is a PowerPoint presentation used to promote the revised ERT model (Appendix D). The program was approved by Governor Herbert, but could not be funded in the Governor's budget proposal until FY15 which began on July 1, 2014. Meanwhile, with the Governor's authorization and promise of strong support, USTAR's TOIP was encouraged to pursue other funding opportunities, until the next budget cycle. During the FY15 budget cycle, Governor Herbert would make funding of the Utah Energy Research Triangle a priority budget item.

An additional element that had not been included in previous proposals was a line item for an allocation of a research project to promote research by a Utah Indian Tribal member. This proposal recognized the important role that tribal members and tribal lands played in energy development in Utah. The intent was for a matriculated student at BYU, USU, or the UofU to apply for a grant to conduct research as part of what would become the Tier 2, Governor's Energy Leadership Scholars program.

CHAPTER 4

FUNDING THE ENERGY RESEARCH TRIANGLE

4.1 Initial Proposal to the USTAR Governing Authority

After receiving approval from Governor Herbert and his Energy Task Force, the TOIP team approached the USTAR Executive Director to pursue funding for the Energy Research Triangle in FY14. The Executive Director did not have authority to approve the funding level but approved bringing the issue before the USTAR Governing Authority (GA). The USTAR GA is the appointed governing body for major expenditures and oversight on behalf of the executive and legislative branch in Utah. Therefore, it was necessary to fully justify the requested funds during the monthly meeting of the GA and receive approval from a quorum (Appendix E).

The overview to the USTAR GA discussed how the Energy Research Triangle would potentially increase revenue to the Utah education system in a number of ways, but most importantly, this program would promote collaboration between Utah's research universities by identifying and funding research applicable to Utah energy issues (Appendix E).

The proposed selection criteria for grant awards were unique. Collaboration between Utah's research universities and local applicability of the research topic were just as important as feasibility. In this program, while local applicability, timeliness, and potential impact of the collaborative research were the criteria for selection, the collaborative nature of the research was an overriding qualification for award. These criteria differentiated the Energy Research Triangle from other energy research

programs by building upon the collaborative nature and capitalizing on the respective capabilities of each university in Utah (Appendix E).

Firstly, the proposed research would need to address a significant energy issue relevant to Utah. Transportation issues related to black wax or waxy crude oil production in the Uinta Basin, as well as the need for water management in energy production and other multiple uses, were discussed with the GA as possible research topics. Being particularly relevant to Utah, these types of research projects could potentially win a collaborative grant. These are local issues that would not normally be addressed by a major DOE grant, no single energy company would likely have the research resources, and no single university might have the ability to address the issue on their own. Therefore, this could be the ideal kind of issue for the ERT to address since BYU has strengths in chemical engineering and social sciences, USU has expertise in water management and rural impact, and the UofU has strengths in petroleum technology. When combined, these specific capabilities might unlock solutions that would not otherwise be found by separate efforts.

Secondly, the proposed research must have a high likelihood of being completed in the limited amount of time available. Again, waxy crude oil transportation from the Uinta Basin to market refineries can be taken as a relevant example. No known techno-economic solution existed. Potentially, BYU's capabilities in microbial treatments, USU's expertise in bio-fuels and mechanical engineering, and the UofU' s abilities in hydrocarbon characterization and flow assurance could be harnessed in a collaborative nature. Given the combined capabilities of the three research institutions, a solution could be developed that might not otherwise be found through individual and separate university efforts.

The third criterion entails having a high likelihood of being impactful and beneficial to Utah. This pragmatic goal recognizes the need to at least modestly resolve

substantive problems and expect a tangible result through collaborative efforts. Using the water management in energy development as an example, it was envisioned that USU, with a world-class water resource laboratory, could take the lead positon in collaborative research, while BYU provided support with bioremediation methods, and the UofU used its in-depth knowledge of coal and hydrocarbon energy development to optimize water usage. It was envisioned that the three universities working together, with their respective capabilities, could more effectively find a pragmatic solution than any of the individuals would separately.

As an illustration of how USTAR TOIP could successfully oversee a project of this nature and deploy a modest amount of funds on a locally applicable, short-term, and impactful research project, the 2010 project to develop an oil sand pavement specification was used as an illustration. This project was jointly sponsored by USTAR, the Uintah County Transportation District, and the Impact Mitigation Special Services District in Vernal, Utah. In this instance, a local issue (use of Uinta Basin oil sand for highway pavement) that had existed for decades was resolved with less than $50,000 in a two-year research effort (Appendix F). Uinta Basin oil sand had been used to pave parking lots, local roads, and portions of state highways for over 80 years. In the 1980s, the use of oil sand pavement was discontinued on any roads funded by state and federal funds since a specification for using oil sand in pavement did not exist. Therefore, oil sand use as a pavement component was substantially decreased and practically all asphalt highways had to use federal Superpave specifications. Consequently, oil sand resource development declined and was primarily relegated to parking lot pavement (Appendix F).

To develop a specification that would allow the use of locally procured oil sand as a component in asphalt, USTAR and the other collaborators funded research through the UofU Department of Civil Engineering. Dr. Pedro Romero and an MS degree

candidate, Michael Vrtis, developed solutions in the Utah Department of Transportation (UDOT) pavement laboratory and on the University of Utah campus. As a result of the jointly sponsored research, UDOT approved a Plant Mix Oil Sand Asphalt (PMOSA) material specification for use on secondary roads. The PMOSA specification was subsequently incorporated in the "Orange Book," which provides specifications for publicly funded secondary and municipal roadway construction throughout the nation. The total cost of the two-year research project was $46,400 and the annual UDOT savings were forecast to be $425,000 per year (Appendix F).

The final part of the presentation to the USTAR GA was a request for partial funding in FY14 for $450,000 for the Tier 1, Utah Principle Energy Issues, and $87,500 for the Tier 2, Governor's Energy Leadership Scholars program. As details of the funding request were discussed, the USTAR GA found that the program was unique and promising, but the GA members objected to any portion of the funding that would be earmarked for a private university such as BYU and further clarified that USTAR funding could not be used for any form of grants or scholarships to students. The USTAR GA felt that the request went outside their statutory authority and, given the ongoing legislative audit of USTAR, timing was again a factor in the public policy decisions about energy research. Consequently, the request for partial funding was rejected until issues related to private university grants and student funding could be resolved.

4.2 Utah Cluster Acceleration Grant Proposal

As mentioned above, the rejection by the USTAR GA was concurrent with an ongoing, first-ever Utah Legislative Auditor General performance-audit of USTAR. In fact, representatives of the Legislative Auditor General attended the presentation. The audit process was not heading in a positive direction and consumed an extraordinary amount of resources and attention by USTAR GA and its headquarters. Consequently,

the TOIP team decided to explore other funding opportunities for the Utah Energy Research Triangle.

In particular, the Utah Cluster Acceleration Partnership (UCAP) was a new program with uncommitted funding. UCAP was a collaborative program between the Utah System of Higher Education (USHE), the Governor's Office of Economic Development (GOED), and the Utah Department of Workforce Services (DWS). UCAP had developed two reports entitled "Accelerating Utah's Energy Industry." The initial report was issued in fall 2010. In an updated January 2013 report, UCAP reported on the establishment of the Energy Cluster Acceleration Partnership (ECAP). (As a side note, in the 2013 report, ECAP stated a major successful outcome was that ECAP had "collaborated with the Utah Energy Research Triangle, which is a statewide partnership among Utah's research and other universities, regional colleges, and applied technology colleges.") ECAP received a $4.6 million grant from the US Department of Labor and stated in the 2013 report that one of its five key recommendations for moving forward was to "enhance now established partnerships between academia, industry, and government" and a second recommendation was to "support research collaboration opportunities." As such, this appeared to be an ideal opportunity and justifiable source of funding for the Utah Energy Research Triangle. Consequently, in July 2013, an application to the UCAP grant program was submitted for $265,000. A copy of the grant proposal is included in Appendix G.

The UCAP grant proposal referenced the Governor's Strategic Energy Plan for legitimacy, but also relied upon the 2010 UCAP report. In the 2010 report, UCAP espoused the first three key supporting strategies as: talent development, applied research, and research and development. Since the Energy Research Triangle vision encompassed these three supporting strategies, the grant application focused on

delivering to UCAP exactly what UCAP stated should be pursued by the research community (UCAP, 2010).

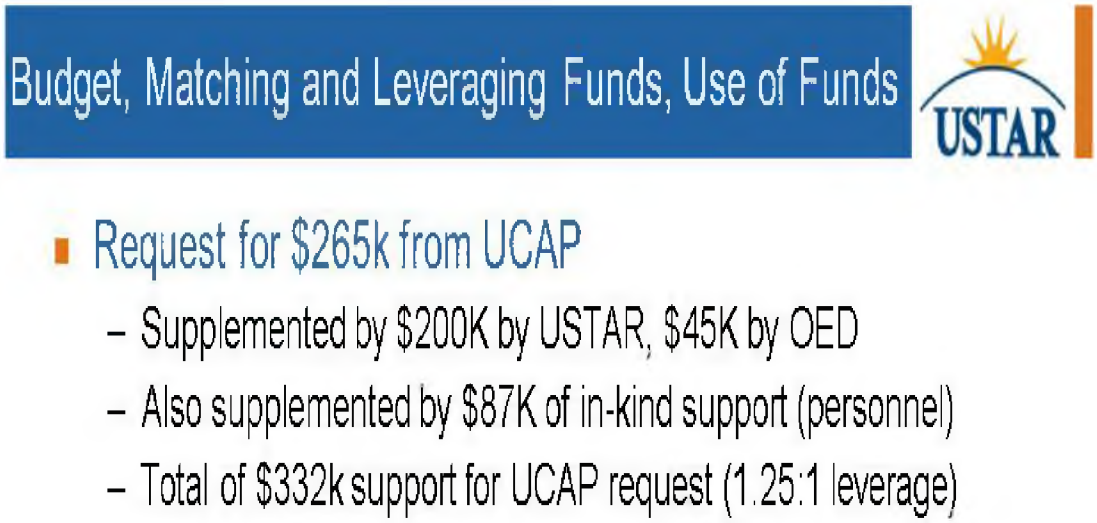
The budget request was built around a one-year, two-tier program.

- The Tier 1 program included three equally funded Principle Research projects of $150,000 each. It was preferred, but not required, that BYU, USU, and the UofU each lead one of the Tier 1 projects. Further, it was intended that each lead university would explicitly collaborate with the two other universities and would allocate a meaningful percentage of the grant to the other collaborators.
- The Tier 2 program included four $15,000 grants to students. These Governor's Energy Leadership Scholars would include one student from BYU, USU, UofU, and a Utah Indian Tribal member.

Table 1 details the proposed allocations for the funds requested. In this proposal, the final funding allocation was $265,000 from UCAP, supplemented by $200,000 from USTAR and $45,000 by OED. An additional $87,000 was provided as in-kind administrative support by USTAR. As USTAR and OED were providing this additional $322,000, the UCAP $265,000 was matched 1.25 to 1.00.

To further support the request for $265,000, the Energy Research Triangle requested and received support from government, academia, industry, and advocacy groups. This assistance came directly in the form of letters of support from the Governor's Energy Advisor, Mr. Cody Stewart; the University of Utah, Dr. John McLennan; the Western Energy Alliance, Mr. Lowell Braxton; and Utah Clean Energy, Ms. Sarah Wright. These letters are attached at the end of Appendix G. Additional support was provided by the Governor's staff in informal discussions with the granting agencies. On September 6, 2013, the Energy Research Triangle Proposal was presented to the UCAP award committee - as shown in Appendix H. This proposal summarized the grant request by focusing that advocacy for the Energy Research

Table 1: Proposed Budget Allocation for UCAP Grant.
Source: Appendix G, Utah Cluster Acceleration Program Application



Program					
Utah Energy Research Triangle			USTAR (Utah Science Technology and Research)	OED (Office of Energy Development)	UCAP (Utah Cluster Acceleration Partnership)
Tier 1: Principle Research	Project 1	$ 150,000	$ 100,000		$ 50,000
Tier 1: Principle Research	Project 2	$ 150,000	$ 100,000		$ 50,000
Tier 1: Principle Research	Project 3	$ 150,000			$ 150,000
Tier 2: Governor's Energy Leadership Scholar	Brigham Young University	$ 15,000		$ 15,000	
Tier 2: Governor's Energy Leadership Scholar	Utah State University	$ 15,000		$ 15,000	
Tier 2: Governor's Energy Leadership Scholar	University of Utah	$ 15,000		$ 15,000	
Tier 2: Governor's Energy Leadership Scholar	Utah Tribal Member	$ 15,000			$ 15,000
In-Kind, 33% ERT Ex Director	USTAR	$ 49,000	$ 49,000		
In-Kind, 50% ERT Analyst	USTAR	$ 28,000	$ 28,000		
In-Kind, Finance and Administrative Support	USTAR	$ 10,000	$ 10,000		
		$ 597,000	$ 287,000	$ 45,000	$ 265,000
			48%	8%	44%

Triangle in the UCAP report and the Strategic Energy Plan. The Energy Research Triangle's proposal to UCAP also referenced the Uinta Basin Energy and Transportation Study (UBETS) as an example of a third-party analysis that quantified the impact of the energy industry on the state. This report addressed Uinta Basin oil and gas development. The report forecast and quantified lost opportunity cost that would be experienced if the state failed to address transportation issues facing Uinta Basin oil and gas development (Figure 4.1 and Appendix H). These transportation issues have potential technical solutions that could be addressed by the ERT. An aggressive timeline was proposed. This called for release of the Request for Proposal (RFP) in October 2013, with review and selection in November and December, and grant awards in January 2014. The proposed timeline is shown in Figure 4.2.

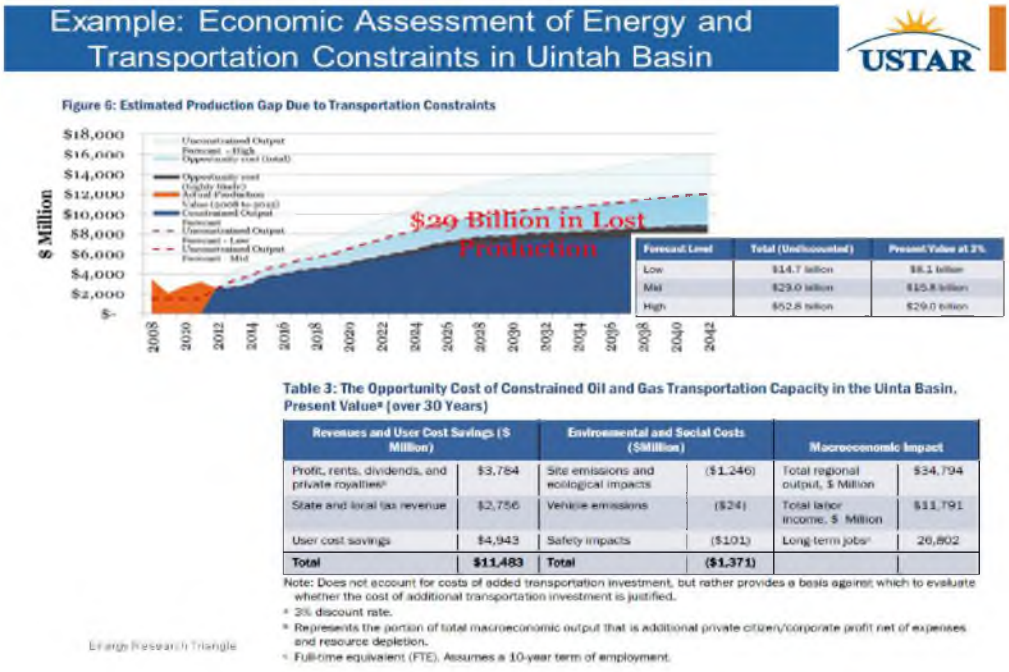


Figure 4.1: Uinta Basin Energy and Transportation Opportunity Cost.
Source: Utah Department of Transportation

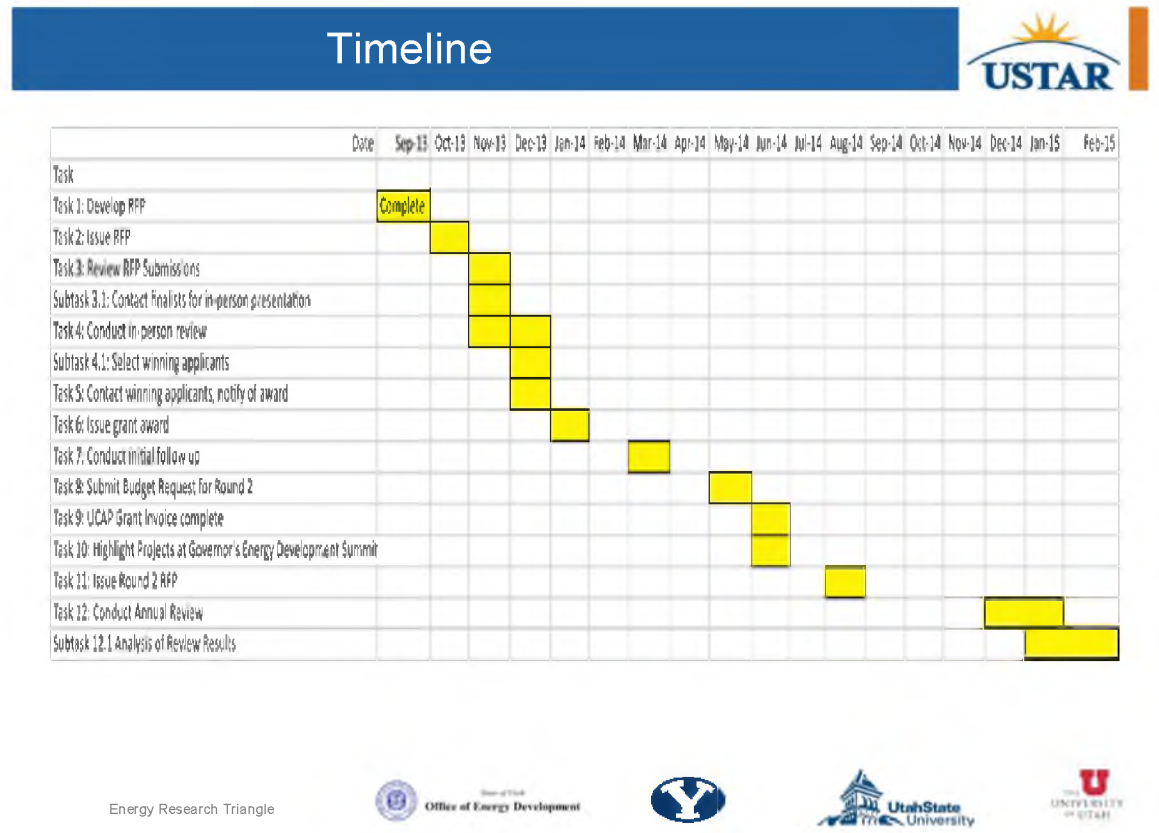


Figure 4.2: Preliminary Utah Energy Research Triangle Timeline
Source: Appendix H, Utah Cluster Acceleration Program Presentation

The aggressive timeline was driven in part by the UCAP requirements in FY14 and the Governor's budget cycle for FY15. The UCAP budget guidance required that the grant awardees needed to expend the allocated funds before the end of FY14 on June 30, 2014. This was only nine months from the time of the presentation to the UCAP award panel. An additional objective was to establish an Energy Research Triangle "track record" before the next Utah legislative session in January through March 2014. The intent was to justify a legislative appropriation in the Governor's 2015 budget. The rationale was that the Utah Legislature would not seriously consider a research program without demonstration of some history of success, a precedent, or some other compelling reason.

The $265,000 requested was decreased by the UCAP award panel and only $200,000 was awarded, with the requirement that:

1) The student grants would be fully funded at $15,000 each.
2) The three awards for Tier 1 projects would be proportionately decreased in order to fully fund the student grants.
3) The funds would be expended before the end of fiscal year 2015.

Given this constrained award and the rationale provided by the USTAR GA when the program was initially rejected, the program was again redesigned and optimized. Due to the ongoing audit, it took several months to schedule a funding request before the USTAR GA. During this interlude, the team redesigned the RFP that would go to the universities, redesigned the submission guidelines, ensured that the program was in compliance with state legal guidelines, and refamiliarized the university VPRs and designees with the Energy Research Triangle. In the background, the USTAR program continued to be scrutinized through a highly-visible legislative performance audit.

4.3 Final Proposal to the USTAR Governing Authority

On December 5, 2013, eight months after the initial request, the Energy Research Triangle request for $200,000 of Strategic Initiative funding was presented to the USTAR GA. The presentation is included in Appendix I. During these eight months, the concerns of the USTAR GA had been addressed, $200,000 of matched funding from UCAP had been secured, and the majority of the administrative, legal, and finance processes had been finalized.

To address the USTAR GA's major concerns, the request for strategic initiative funding (a line item in USTAR's budget) was simplified to two line items of $100,000 each. These were both restricted to Tier 1, Principle Research projects that could only be awarded to USU or the UofU. To satisfy the USTAR GA's concerns about private

university grants, any grants to BYU would be fully funded by UCAP resources only. To satisfy the GA's concerns about student scholarships and UCAP's stipulations, the funding for these programs were taken from other resource allocations. The student projects received full funding as outlined by the Energy Research Triangle proposal to UCAP and grants to Tier 2, Governor's Energy Leadership scholars would be fully funded only by UCAP and OED resources. Specifically, no USTAR funds would be used for private university research grants or student research grants. This request was voted on by the USTAR GA quorum present and unanimously approved (Appendix I).

This revised budget is shown in Table 2 and shows the allocation of grants to Tier 1 and Tier 2 from each of the funding sources. As total funding was now $445,000 and Tier 2 funding was set at $15,000 each by UCAP requirements, the Tier 1 Principle Research projects used the remaining funding and were each allocated $128,333. This allocation left $1.00 on the table (Appendix I).

Table 2: Final FY14 Budget for Utah Energy Research Triangle
Source Appendix I, Energy Research Triangle Proposal for USTAR Governing Authority

			Funding Contributions		
Utah Energy Research Triangle Components		**Total**	**USTAR[1]**	**OED[2]**	**UCAP[3]**
Tier 1: Principle Research	Project 1	$128,333	$100,000		$28,333
Tier 1: Principle Research	Project 2	$128,333	$100,000		$28,333
Tier 1: Principle Research	Project 3	$128,333			$128,333
Tier 2: Governor's Energy Leadership Scholar	Brigham Young University	$15,000		$15,000	
Tier 2: Governor's Energy Leadership Scholar	Utah State University	$15,000		$15,000	
Tier 2: Governor's Energy Leadership Scholar	University of Utah	$15,000		$15,000	
Tier 2: Governor's Energy Leadership Scholar	Utah Tribal Member	$15,000		$-	$15,000
[1] Utah Science Technology and Research		$445,000	$200,000	$45,000	$200,000
[2] Office of Energy Development [3] Utah Cluster Acceleration Partnership			45%	10%	

CHAPTER 5

EXECUTION

5.1 Execution of Phase 1

Now that the final funding was in place, TOIP reinitiated a number of pending actions whose approval had been delayed while the funding mechanisms were being refined and approved. This included: alerting university administrators that the proposed program was approved and funded; a finalized request for proposals that would be put in the public domain required approval by the Attorney General (AG), OED, and USTAR counsels; and final execution of the UCAP Agreement.

The respective university administrators and their representatives were notified on Friday December 6, 2013, by Alan Walker, while Ryan Streams finalized RFP issues with the AG, OED, and USTAR. The program was unique and had been modified significantly since the initial discussions in January 2013. Of particular note was that the program was now a year-by-year program and the previous Tier 1 and Tier 2 program had been simplified into a single Tier 1 program with three projects. The discussions with the VPRs and representatives were lengthy, but very helpful in ensuring that all needed adjustments were made to the RFP and as many issues as possible were discussed and understood prior to sending out the formal RFP. Of particular interest to the University administrators were the Facilities and Administrative (F&A) rate or indirect overhead rate for Tier 1 and Tier 2 projects, the split of the allocation between Tier 1 grant collaborators, evaluation criteria, and other items of clarification.

The F&A rate had been set at 10% for each of the Tier 1 Principle programs and no F&A was authorized for the Tier 2 student grants. The relatively low F&A was a source of contention with each university. The justification for the low F&A was that the funding source was Utah taxpayer money and that the taxpayers were already providing a considerable amount of funding for at least USU and the UofU with some indirect tax incentive to BYU. Since the Tier 2 student grants were relatively low, agreement to no F&A for student grants was resolved easily.

For the Tier 1 projects, allocation guidelines were deliberately not prescriptive or definitive as the intent was that the amount that each university shared in the grant would be based on the contribution and capability each university brought to the research team. To dictate a 50-25-25% split or a 33-33-33% split would have been arbitrary and may not have encouraged the most efficient deployment of resources. Ultimately the universities made their own allocation work, and there was a wide range of allocations among the proposals. Each had a unique solution and amount. For the winning grants, one of the teams split their allocation on nearly equal amounts at 34-34-32%, one at 40-40-20%, and one grant award was based on a 70-15-15% split.

The evaluation criteria and the composition of the award panel that would select the awardees were also discussed with each university. It was made clear that in addition to what was normally expected of a research project regarding efficacy and impact, this program was unique in that the primary intent was to strongly incentivize the three universities to collaborate on energy issues relevant to Utah. A diverse awards evaluation panel (award panel) was convened to assess submitted Tier 1 and Tier 2 proposals and select awardees. This award panel was comprised of people from industry, academia, and government to select the grant winners based upon proposed collaborative effort, potential impact to Utah, feasibility of the given funding and timing, and overall feasibility. The awards panel will be discussed in detail later in Section 5.1.

With matching funding from USTAR approved, it was now appropriate for OED and DWS to execute the agreement for the UCAP funding that was approved in September 2012. DWS was the state agency that had execution authority for the UCAP funding. Therefore, OED and DWS executed the Utah Cluster Acceleration Grant Agreement in Appendix J on December 17, 2013. Both parties had deliberately delayed commitment of the UCAP funds until the USTAR GA had approved the matching funds for the program. The next day, the central administration at BYU, USU, UofU were again notified of this and a formal RFP was simultaneously released to the appropriate administration officials at BYU, USU, and the UofU and to a representative of the Ute Indian Tribe. A copy of the notification regarding the Tier 1 and Tier 2 RFP is shown in Appendix K and the notice to the Ute Indian Tribe for the Tier 2 grant particular to the Native American student is also included in Appendix K.

As the discussion with university officials had been progressing, discussions and final approval of the RFP format, research agreement, written guidelines, and accountability were ongoing with the AG, USTAR, and OED. The written formats for the program were based upon previous documents used by USTAR for similar, relatively small local research projects, such as Technology Commercialization Grants and Concept to Company contests. These formats were web-based and user friendly. The intent was to make it simple to apply for the grants and efficient for the awards panel to evaluate.

The program that was ultimately submitted to the universities and Ute Indian Tribe in December 2013 was much smaller in scope and funding than the original proposals from January 2013. This was primarily driven by the need to equalize the funding opportunities for the participating universities, meet the objectives of the funding state agencies, operate within a budgetary limitation $445,000 total for a one-year period of performance, and meet regulatory requirements for expenditures and commitments

within the fiscal year. While each of these drivers was significant in their own right, the necessity of completion within the fiscal year was a serious challenge. Given that the final funding stream was not assured until December 10, 2013, and the funds needed to be dispersed when the fiscal year ended on June 30, 2014, explicit guidance to the universities and careful management by USTAR was needed to meet state fiscal guidelines.

As can be seen in Table 2, the total funding was divided into a Principle Energy Issues program funded at $385,000 and a Governor's Energy Leadership Scholars program funded at $60,000. The Tier 1 and Tier 2 programs were consolidated into a single Tier 1, Principle Energy Issues Program. This program called for the available $385,000 to be dispersed as three potential grants of $128,333 each. The remaining $60,000 was designated for the repurposed Tier 2, Governor's Energy Leadership Scholars program which provided for up to four awards at $15,000 per student.

Over the eight-month period of acquiring funds and interagency agreements, the Tier 1 program had been redesigned. Although it was not required, the intent of the program was for each of the three grants to be led by a principal investigator (PI) from a different one of the three universities in the Energy Research Triangle. Further, the intent was that an appropriate fraction of each grant and research would be allocated to the other two collaborating universities. For instance, should BYU win a grant for a research project, it was expected by the program management that BYU would, in turn, fund an appropriate amount of collaborative research at USU and the UofU. The amount of the collaborative research would depend on the capability and contribution of the collaborating universities.

The RFPs (see Appendix K) were publically released to the appropriate university and tribal representatives on December 18, 2013. The final date for submission was noon on Monday, January 13, 2014. This constricted time schedule

was driven by the Governor's Energy Task Force schedule. The next meeting of the Task Force was set for Friday, January 17, 2014. Given that the grant awards panel would need to meet at least two days before the Task Force meeting, the date for reviewing proposals and finalizing recommendations was set for Wednesday, January 15, 2014, and the awards panel was notified and committed to that date. Further, given that the TOIP team would need at least two days to review proposals and prepare the assessment by the awards panel, the due date for proposal to the RFP was accordingly set at noon Monday, January 13, 2014. If this schedule were not followed, the next meeting of the Task Force with the Governor would be in April 2014, which would make meaningful expenditure of research funds by June 30, 2014 virtually impossible.

Recognizing this as a short period of time, particularly given the exams and grading on one side, the holidays in between, and the beginning of a semester on the other side, the door was left open for a second round. A further consideration was that this first cycle was the first time an approach like this had been used in Utah. Given these conditions, it was uncertain if any quality proposals would be received. Fortunately, the groundwork had been well laid with the universities, questions for clarification started arriving immediately, and interest was steady from the time of release of the request for proposals to immediately prior to the submission deadline. Table 3 summarizes key events and timelines.

Table 3: Execution of Timeline of Phase 1 Energy Research Triangle

October 15, 2013	UCAP funding awarded, $200,000
December 5, 2013	USTAR funding awarded, $200,000
December 17, 2013	UCAP Grant agreement executed
December 18, 2013	Received AG approval, finalize the website, issue RFP
January 13, 2014	Responses to RFP due at noon
January 15, 2014	Proposals review and recommendations selected by panel
January 17, 2014	Recommendations approved by Governor and Task Force

By noon on January 13, 2014, 23 proposals had been received and the quality was considered excellent. After the TOIP team did an initial screening and did not find reason to disqualify any of the proposals, the initial process of sorting and evaluation was initiated. For the Tier 1 program, there were two proposals from BYU, one proposal from USU, and six from the UofU. These proposals ran the full spectrum of fossil fuel, renewable energy, energy efficiency, and environmental remediation. For the Tier 2 program, there were two proposals from BYU, five from USU, and seven proposals from the UofU. Again, the proposals encompassed the full spectrum of energy issues relevant to Utah. All told, there were approximately 800 pages of proposals for the TOIP team to sort and screen in a short period. This was accomplished overnight, and on January 14, 2014, the proposals were electronically transmitted to the award panel for review (Appendix L).

The award panel met on Wednesday, January 15, 2014 at 10:00 A.M. to evaluate the proposals and develop a set of recommendations to provide to the Governor and the Energy Task Force on Friday, January 17. The award panel's schedule of evaluations and selection is shown in Appendix L. The panel was composed of Mr. Cody Stewart, Ms. Sarah Wright, Mr. Ian Andrews, and Mr. Alan Walker. Support was provided by Mr. Ryan Streams of USTAR for administration and management of the program. Ms. Michele Pasker of OED provided contractual and fiscal guidance to ensure that the program met appropriate state guidelines for expenditure.

Mr. Cody Stewart was the Governor's Energy Advisor and provided the executive branch oversight and tie-breaking authority should that be needed. Ms. Sarah Wright is the President of Utah Clean Energy, a nonprofit advocacy group for air quality. She provided balance for environmental and efficiency advocates. Mr. Ian Andrews was the Director of Resource Development for PacifiCorp. Ian is an engineer who provided

energy industry technical input. Finally, Mr. Alan Walker, Executive Director of the Energy Research Triangle, provided the research and academic perspective.

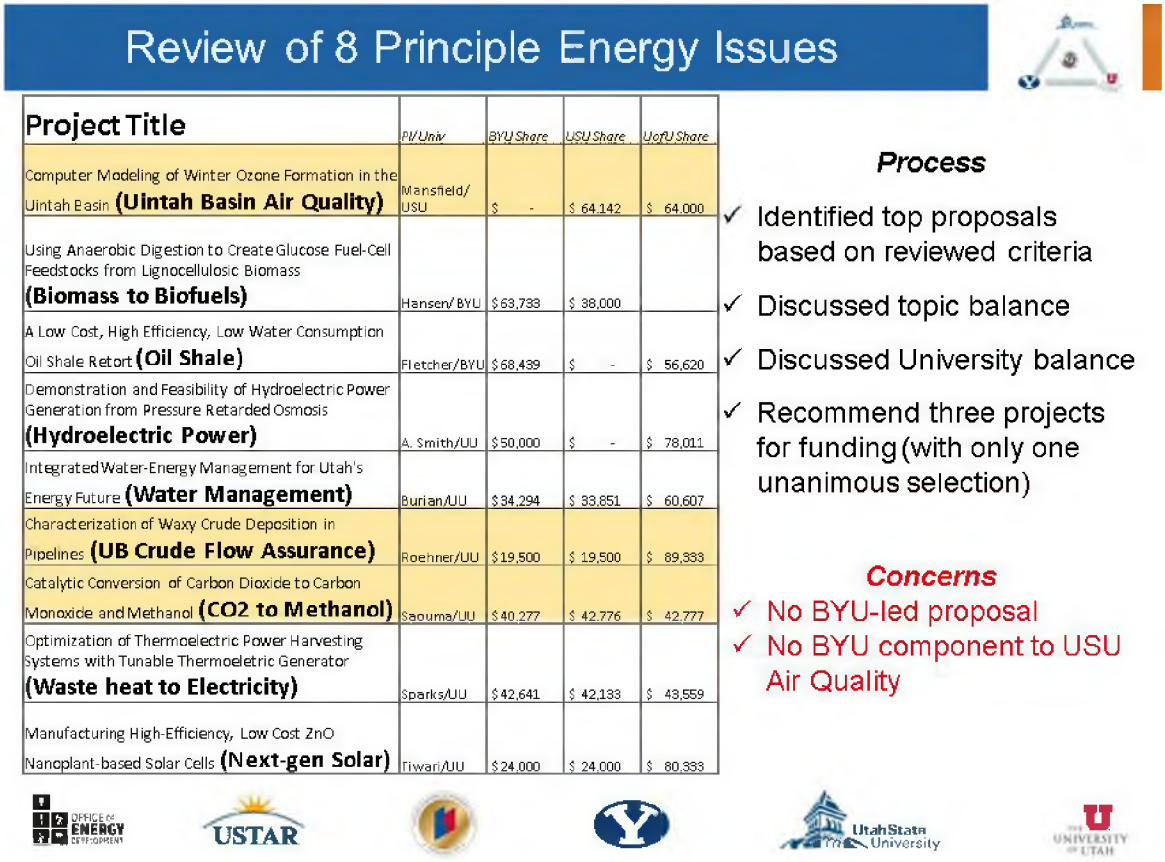
In the time allowed, the award panel completed its work and developed a consensus on the proposals to recommend to Governor Herbert. There was only one unanimous selection for the Tier 1 proposals, the USU-led Uinta Basin Air Quality proposal. This air quality proposal did not have a BYU collaboration indicated and there were no Tier 1 BYU-led proposals selected by the panel. The Tier 2 proposals were relatively easy to sort, select, and reach consensus with one awardee for each university. As there was sufficient funding for four Tier 2 projects, and no tribal proposals were received, the award panel felt it was important for the Governor to have an option to award a fourth grant. Therefore, the panel evaluated a fourth project to recommend to the Governor.

On Friday January 17, 2014, the presentation included in Appendix M was used to brief Governor Herbert and the Energy Task Force on the awards selection panel's recommendations. The nine Tier 1 projects are seen in Table 4.

The three Tier 1 projects recommended to the Governor were the Uinta Basin Air Quality project led by Dr. Marc Mansfield of USU from the Bingham Entrepreneur and Energy Research (BEERC) Center in Vernal, a Uinta Basin Crude Flow Assurance project led by Dr. Richard Roehner of the UofU Chemical Engineering Department, and a CO2 to Methanol project initially led by Dr. Caroline Saouma of the UofU Chemistry Department. There were minor issues related to each project that were discussed with the Governor before requesting his approval (Appendix M).

The concerns with the slate of projects were laid out for Governor Herbert and the Energy Task Force. There were no issues related to the Uinta Basin Crude Oil project let by the UofU. A recommended course of action to address each of the

Table 4: Recommended Principle Energy Issues
Source, Appendix M, Energy Research Triangle Project Recommendations



concerns on the other two projects was laid out for the Governor and subject to completing those actions, the slate of research projects was approved. These concerns and solutions are discussed below for the Uinta Basin Air Quality project and the CO_2 to Methanol project (Appendix M).

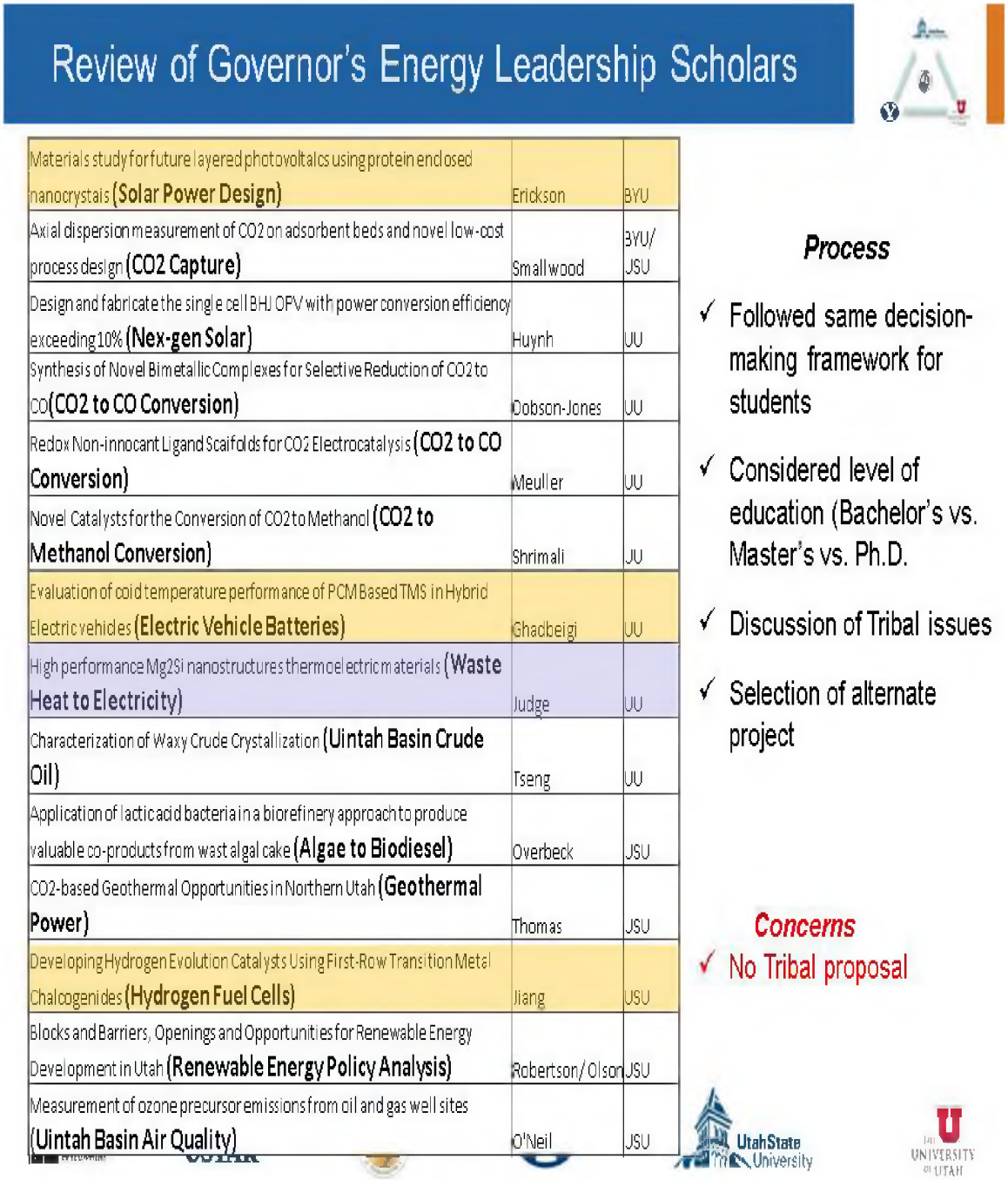
In regard to the Uinta Basin Air Quality project, there was no participation in the application for BYU. This undermined the collaborative intent of the program. To resolve this, Dr. Mansfield was urged to find a collaborator at BYU. He found an excellent biochemist with air quality background in Dr. Jaren Hansen. Dr. Hansen was subsequently added to the research team, which made the USU-led project a collaborative effort by all three universities.

As for the CO_2 to Methanol project, the split between universities was equal, but if this project was awarded, there would be two UofU-led projects and no BYU-led projects. This again undermined the intent of the collaborative program. To resolve this, Dr. Caroline Saouma was asked to consider having Dr. Daniel Ess of BYU become the lead PI for the project. Dr. Saouma and Dr. Ess readily agreed to this adjustment. Dr. Ess was in fact the more senior researcher and had recently published an article in *Science* regarding the conversion of methane to methanol. With these adjustments, there was a research project led by BYU, USU, and the UofU, with roughly equivalent participation by each university.

The Tier 2, Governor's Energy Leadership Scholars program had fourteen applicants. The projects proposed by the applicants included solar materials, catalysis, battery performance, biofuels, nanoscience, and environmental mitigation. In several cases, it was apparent that the Tier 2 applicant would be part of the research team that had been selected for a Tier 1 grant recommendation; going in another direction would provide for new avenues of discovery (Appendix M). Table 5 shows the fourteen proposed projects for Tier 2, Governor's Energy Leadership Scholars.

There was only one issue discussed with the Governor regarding the Tier 2 program. There were no proposals from Utah Tribal entities and therefore, no grant could be recommended in that category. An exceptional effort had been made to find and mentor potential applicants from Utah Native American Indian tribes for the grant, but none had applied. Therefore, the panel recommended that an alternate award be made to the current pool of applicants and that on future rounds, another strong effort would be made to include a researcher from the Utah Indian tribes. The Energy Task Force agreed and the projects that were recommended and approved were Stephen Erickson from BYU, Nan Jiang from USU, and Leila Ghadbeigi from the UofU; the alternate awardee selected was Matthew Judge from the UofU (Appendix M).

Table 5: Tier 2, Governor's Energy Leadership Scholars
Source: Appendix M, Energy Research Triangle Project Recommendations



Following approval on January 17 by Governor Herbert and the Energy Task Force, the research teams and scholars were notified by telephone and email of the grant award on January 18, 2014. Copies of an example notification to a Tier 1 grant awardee and an example of the notification to a Tier 2 grant awardee are included in Appendix N. The respective academic administrative representative and funding offices were notified of the Tier 1 and Tier 2 awards. The applicants whose proposals were not successful received feedback regarding how they could improve their opportunity for a grant in potential future rounds of the Energy Research Triangle funding process (Appendix N).

5.2 Tier 1: Principle Energy Issues

The three Tier 1, Principle Energy Issues projects were selected through a merit-based process with a subsidiary intent of promoting the major Utah research universities to collaborate while solving Utah-centric energy issues. This was an initial step in building the foundation for a cross-institutional collaboration on Utah-specific energy issues. The as-awarded Tier 1 program formally involves at least 18 researchers who range from undergraduates to senior faculty (Appendix O).

5.2.1 Brigham Young University Tier 1 Award

For the BYU-led project, Dr. Daniel Ess was the lead PI and his Co-PIs are Dr. Yujie Sun of USU and Dr Caroline Saouma of the UofU (Figure 5.1). Their research focuses on conversion of CO2 to synthetic gas an dliquid fuels by using unique catalytic conversion materials and processes (Appendix O).

This new but accomplished team of researchers is exploring novel catalysis processes to product transportation fuels from renewable resources. Dr Ess recently published an article in the journal *Science* regarding catalysis of methane to methanol.

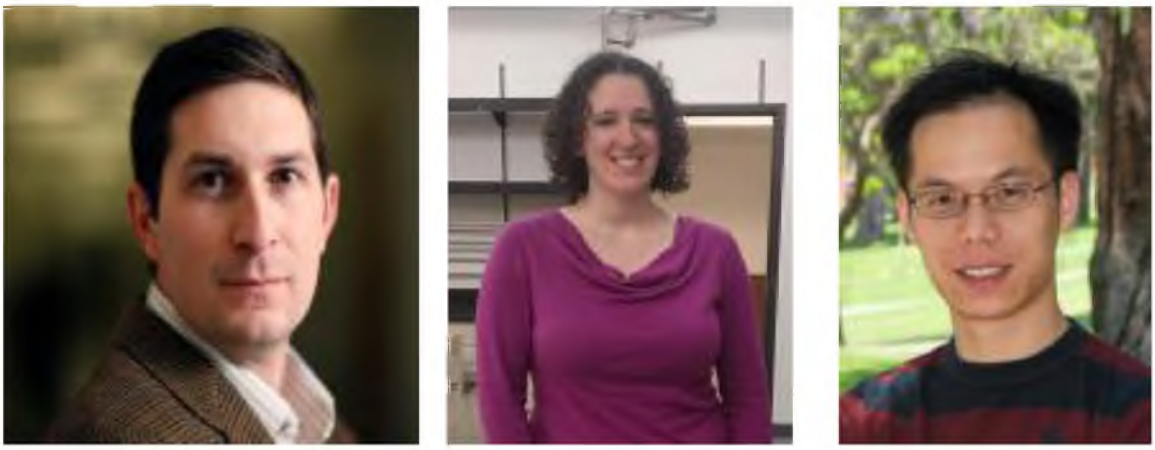


Figure 5.1. Principal Investigators are shown for the CO2 to methanol award. From left to right are Ess, Saouma, and Sun.

This team has connected the BYU expertise with the UofU capability in electrocatalysis and the USU capability in photocatalysis (Appendix O).

5.2.2 Utah State University Tier 1 Award

For the USU-led project, Dr. Mark Mansfield was the lead PI and his co-PIs were Dr. Jaron Hansen of BYU, Dr. John Horel of the UofU, and Dr. Seth Lyman of USU-Bingham Research Center in Vernal, Utah (Figure 5.2). Their research focuses on the mitigation and modeling of winter-time ozone formation in the Uinta Basin. This is particularly unique to Utah. Only two locations in the world are commonly cited as having this issue.

The impact of ozone nonattainment in the Uinta Basin could negatively impact hydrocarbon production and development in Utah, let alone jobs in other sectors such as tourism (Appendix N). The team combines USU's extensive working knowledge of the Uinta Basin, meteorology capabilities at the UofU, and atmospheric chemistry assets at BYU. The team had already secured a letter of cooperation from the Utah

Figure 5.2. Principal Investigators are shown for the Uinta Basin air quality assessment award. From left to right are Mansfield, Lyman, Horel, and Hansen.

Division of Air Quality (DAQ) ensuring that the research could quickly be applied in the regulatory arena (Appendix O).

5.2.3 University of Utah Tier 1 Award

For the UofU–led project, Dr. Richard Roehner is the lead PI and his co-PIs are Dr. Michael Hoepfner of the UofU, Dr. John Hedengren of BYU, and Dr. Scott Hill of USU, Carbon Energy Innovation Center in Price, Utah (Figure 5.3). Their research focuses on pipeline safety and the characterization of waxy crude oil in order to improve its value and transportability through flow assurance studies (Appendix N). This project will characterize the issues that waxy crude oil present to transportation infrastructure

Figure 5.3. Principal Investigators are shown for the Uinta Basin waxy crude award. From left to right are Roehner, Hill, and Hedengren.

and explores next-generation fiber optic technology for pipeline safety and monitoring (Appendix O). This is particularly relevant to Utah since approximately 60,000 barrels of waxy crude oil are transported over the state's highways every day. That volume of produced waxy crude is projected to increase for the next two decades (UDOT, 2013). Currently at least two pipeline projects and one railroad have been proposed to relieve this highway congestion.

5.3 Tier 2: Governor's Energy Leadership Scholars

The Tier 2, Governor's Energy Leadership Scholars program was designed to fund student-led applied energy research on Utah-specific energy issues. The program was intended to foster these research scholars while tackling unique energy challenges and developing future leaders in energy research within the state. From the fourteen applicants, one scholar was selected from each of BYU, USU, and the UofU. In addition, a supplementary award was made to fill the full slate of four awardees. All awardees were selected on the merits of their research proposal.

The scholars who were awarded these $15,000 grants were Stephen Erickson of BYU for research in high-efficiency photovoltaics; Nan Jiang from USU for research in hydrogen production from fuels cells using earth-abundant catalysts; Leila Ghadbeigi from the UofU for research on cold weather performance of hybrid electric vehicle batteries; and Matthew Judge for research in utilizing magnesium - a commodity abundant in Utah - as a thermoelectric material (refer also to Appendix P). The research proposed by the Tier 2 scholars is discussed in the next section.

5.4 Governor Herbert's 2014 Energy Development Summit

During the June 10, 2014 Governor's Energy Development Summit, the promise of progress made by Energy Research Triangle proponents during the 2013 Energy

Development Summit was realized, in part. The Energy Research Triangle was featured at the initial breakfast address and during the final panel of the day. The Tier 2 grant awardees were each presented with checks for $15,000 at the opening session in front of 1,200 participants. The Governor's Energy Advisor, Mr. Cody Stewart, made the presentations and recognized these individuals (see also Figure 5.4 to 5.8 and Appendix P). During the Summit, each scholar participated in a poster session during the plenary session breaks. These posters are reproduced in Appendix Q.

The makeup of the awardees for the Tier 1, Principle Energy Issues program was presented at a separate panel on innovation. Principal Investigators from each project gave an update on their ongoing research funded through the Energy Research Triangle.

Figure 5.4. The Governor's Energy Leadership Scholars grant awardees are shown with their symbolic checks. From left to right are Jiang, Ghadbeigi, Judge, and Ericson (photograph permission Ryan Streams, USTAR).

Figure 5.5. The Governor's Energy Advisor, Cody Stewart (at left), presents Stephen Erickson with a $15,000 Governor's Energy Leadership Scholar grant (photograph permission of Ryan Streams, USTAR).

5.4.1 Stephen Erickson: Brigham Young University Tier 2 Award

Stephen Erickson, BYU, was awarded a grant to research photovoltaic production process improvements by using protein-enclosed nanocrystals. His proposal was entitled *Materials Study for Future Layered Photovoltaics Using Protein-Enclosed Nanocrystals.* His research is supervised by Dr. John Colton. Erickson plans to test effects of nanocrystals size, doping, chemical composition, and aging in a laboratory setting (Appendix R). Erickson acknowledged the opportunity to enhance his education through applied research:

> While my course work has been of great worth and provides the basis for my understanding, nothing has taught me more about what it actually means to be a physicist than researching in Dr. Colton's lab. There is ... so much more that you can learn from hands-on experience working on a meaningful project in your field.

Figure 5.6. The Governor's Energy Advisor, Cody Stewart (at left), presents Nan Jiang with a $15,000 Governor's Energy Leadership Scholar grant (photograph courtesy of Ryan Streams, USTAR).

5.4.2. Nan Jiang: Utah State University Tier 2 Award

At USU, Ph.D. candidate Nan Jiang was selected for her proposal on *Developing Hydrogen Evolution Catalysts Using First-Row Transition Metal Chalcogenides,* which would develop hydrogen in fuel cells using solar power. The research will investigate using common elements instead of rare and expensive catalysts such as platinum for widespread application. This research is supervised by Prof. Yujie Sun and explores application of inexpensive catalysts to split water into hydrogen and oxygen. Dr. Sun is also a collaborator on the BYU-led project discussed earlier (Figure 5.1 and Appendix R).

Jiang described the impact of her research:

> Solar-driven water splitting to produce hydrogen and oxygen is widely considered as a sustainable approach to meet the increasing global energy demand and the slow kinetics of [the] hydrogen evolution reaction (HER) in water necessitates the development of novel HER catalysts.

Figure 5.7. The Governor's Energy Advisor, Cody Stewart (at left), presents Leila Ghadbeigi with a $15,000 Governor's Energy Leadership grant (photograph permission of Ryan Streams, USTAR).

5.4.3. Leila Ghadbeigi: University of Utah Tier 2 Award

At the University of Utah, the first scholar selected was Ph.D. candidate Leila Ghadbeigi for her proposal entitled *Evaluation of Cold Temperature Performance of PCM Based TMS in Hybrid Electric Vehicles.* Her supervisor is Dr. Taylor Sparks. Ghadbeigi is studying hybrid electric vehicle (EV) performance in the cold temperatures that are common in Utah (refer to Figure 5.7 and Appendix R). High temperatures can cause thermal damage, but Leila's and Dr. Sparks' research examines efficiency loss and decreased battery life expectancy, which are relevant in certain colder climatic regimes in Utah (see Figure 5.7, Appendix O and Appendix R).

Ghadbeigi described the impact of her research as follows:

> Temperature significantly affects battery performance and life expectancy. Accordingly, thermal management systems in EVs have been developed to mitigate the undesirable impact of temperature.

Figure 5.8. The Governor's Energy Advisor, Cody Stewart (at left), presents Matthew Judge with a $15,000 Governor's Energy Leadership grant (photograph permission of Ryan Streams, USTAR).

5.4.4. Matthew Judge: University of Utah Tier 2 Award

The second grant winner at the UofU was Matthew Judge. Judge, a student veteran, was selected for his proposed research into molten salt applications. His proposal was entitled *High Performance MgSi Nanostructured Thermoelectric Materials.* Magnesium is an important commodity and Utah is the major producer in the US (Figure 5.8, Appendix O and R). Mr. Judge is also supervised by Dr. Taylor Sparks. Current molten salt technologies use toxic and expensive materials such as bismuth and antimony.

Matthew indicated that:

> ...development of improved thermoelectric materials has the potential to generate a significant improvement in the efficiency with which we produce electric power. Using magnesium that is abundant in Utah "balances moderate performance with good resource considerations.

CHAPTER 6

LESSONS LEARNED FROM ROUND 1

Numerous adjustments to the program since Governor Herbert's initial concept of the Energy Research Triangle in 2009 have resulted in program improvements. A summary of lessons learned during Phase 1 is discussed below.

6.1 Equal Opportunity for Award

For researchers and their teams to be interested in submitting research proposals, there must be the perception of a level playing field and an equal chance of being awarded a grant. The initial concepts for competitive bidding by the three universities (when there were three tiers) were viewed suspiciously by administrators. and the original perception was that research teams would not want to submit proposals when there was a high likelihood that they would be in a secondary position to other research universities.

6.2 Budget Cycle

At the very outset, the Energy Research Triangle was an unresourced and unfunded expectation by the Governor and the Energy Task Force. In order for a program to be funded in the Governor's budget recommendation to the Legislature, justification must be submitted to the Governor's Office of Management and Budget in June of the year prior to when the fiscal year begins. For example, to be funded in FY16, which begins on July 1, 2015, justification was, in fact, submitted in June 2014.

Without consideration of the long-lead budget cycle, the earliest iterations failed. The FY14 awards were possible because of USTAR and onetime funding by UCAP. In contrast, the FY15 funding did not clear the legislative approval process.

6.3 External Factors

External factors that are tangentially related to programs can impact program success. In this case, the funding for the Energy Research Triangle in FY15 was disapproved, in part, because of the negative feelings toward research and the USTAR audit during the 2013-14 legislative session. The audit had no direct connection to the Energy Research Triangle, yet, in the author's opinion, the emotion regarding USTAR cast a shadow that could not be overcome. Additionally, the OED funding request to increase full-time employees had a chilling impact, again in the author's opinion, as there was some backlash from the Legislature due to growing the OED bureaucracy.

6.4 Branding

Careful consideration must be given to branding at the very onset of a program. Governor Herbert referred to the Energy Research Triangle at the inception of the program. There were several failed attempts to rebrand later using terms such as "Energy Triad" and "Energy Pentagon," but these attempts only served to cause temporary confusion. An example of excellent branding, conceived and implemented early in the program development process, was the use of terminology referring to the "Governor's Energy Leadership Scholars." Not only did the Governor look favorably on this, but applicants found it to be a prestigious title.

6.5 Feedback

For long-term success of a funding initiative such as this, it is important to receive feedback from researchers and provide feedback to others. This facilitates improving the program. When the researchers saw adjustment to the program that they had asked for, the level of interest increased. It is also particularly important to provide feedback to researchers with unsuccessful proposals. The unsuccessful researchers were grateful when they received feedback from the program management on how to potentially succeed on the next cycle.

6.6 Public Appearance and Recognition

There were numerous public appearances by program management during the planning process and by the researchers as part of their program contractual requirements. These were generally excellent opportunities to make the energy community and other stakeholders, such as faculty and legislators, aware of ongoing efforts and to provide opportunities for researchers to receive recognition. Of particular note was the opening presentation at the Governor's Energy Development Summit where the four student awardees were given $15,000 checks in front of 1,200 energy professionals. The joy and pride of these young scholars was exciting to witness.

6.7 Legislative Outreach

To be successful at funding a new program, legislative outreach must be done well in advance of the Legislative Session. During the 2013-14 session, every attempt to explain the Utah Energy Research Triangle failed to gain any traction with legislators. There simply are too many programs competing for the attention of legislators and only critical issues can be considered. For the 2014-15 and a Phase 2 award cycle,

discussions began in October 2014. These efforts to reach legislators to gain pre-approval are discussed below in Chapter 7.

CHAPTER 7

PHASE 2, SUSTAINMENT

The next phase of the Energy Research Triangle is a work in progress that will not be concluded until the end of the legislative session on March 12, 2015. The first step to sustain the ERT was the submission of the final report to the UCAP and an immediate request for a continuation of the current funding. The final report to the UCAP is Appendix R, which contains accomplishments of the ERT through June 20, 2014, and additional support letters for continuation of the program. Of particular note are the letters from faculty on page 10 to 12 of Appendix R that stated strong faculty support. Regardless of this justification, UCAP did not award a second round and funding for the next round of the ERT is currently being pursued with the Utah Legislature.

The definitive start of the legislative outreach was on October 15, 2014, when Mr. Cody Stewart and Dr. Laura Nelson made a formal request for continuous funding of the Utah Energy Research Triangle before the meeting of the Utah Legislature Natural Resources, Agriculture, and Environment Interim Committee. Their presentation is incorporated in Appendix S. Funding for the ERT was the singular request at that meeting. Given that the first cycle of the ERT will not be completed until June 2015, it was decided to keep the program at the same level and to delay seeking any changes in funding until a future date (Appendix S).

APPENDIX A

UTAH ENERGY RESEARCH TRIANGLE OVERVIEW

Utah Energy Research Triangle Overview

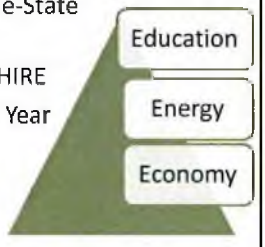
Jeff D. Muhs, Director

UTAH ENERGY RESEARCH TRIANGLE

Background

Background

- ENERGY RESEARCH TRIANGLE
  - Recommendation 3 in 10 year energy plan
  - Highlighted in 2012 State-of-the-State Address
- STAFF: JEFF D. MUHS; USU USTAR HIRE
  - USDOE - ORNL Engineer of the Year
  - 14 patents & R&D 100 Award
  - Four spin-out technologies
  - $50M+ in R&D funding
  - U.S. Senate Energy Fellow involved in EPACT2005 and America Competes Act



FY2012 USU donated 20% of Muhs' time

FY2013 OED/USU share 30% of Muhs' time

Mission

Mission / Goals

- MISSION: "BEST-IN-COUNTRY" ENERGY INNOVATION ECOSYSTEM BY 2016.
  - guided by Governor's 10 year plan
  - focus on strategic opportunities
- GOALS / OBJECTIVES:
  - improve cooperation and coordination
  - leverage university/industry strengths & resources
  - secure large-scale funding; build new capacity
  - leapfrog other states in strategic areas
  - catalyze Utah energy industries-of-the-future
  - create jobs and enhance quality of life

Activities

Activities (Past and Planned)

- ✓ INVENTORY CAPABILITIES / IDENTIFY STRENGTHS
- ✓ INTERVIEW STAKEHOLDERS
- ✓ BENCHMARK OTHER STATES
- ✓ GATHER PUBLIC INPUT
- ✓ IDENTIFY NICHE AND POSSIBLE FOCUS AREAS
- ✓ LAUNCH COORDINATION ACTIVITIES
- BRIEF TASK FORCE
- AMEND / MODIFY STRATEGY & INITIATIVE(S)
- DOWNSELECT TO SPECIFIC FOCUS AREAS
- OBTAIN LEGISLATIVE BUY-IN FOR SUPPORT

Strength Inventory

University Research Area	BYU	USU	U of U
Energy Supply / Generation			
Conventional Fossil	**Extensive**	Moderate	**Extensive**
Unconventional Fossil	**Extensive**	Moderate	**Extensive**
Nuclear	Moderate	Moderate	Moderate
Renewables	Moderate	Moderate	**Extensive**
Energy Distribution & Transmission			
Pipelines	Limited	Limited	Limited
Electricity Transmission/Distribution	Limited	Limited	Limited
Energy Surface Transport	Limited	Limited	Limited
Energy End Use Efficiency			
Buildings	Limited	Moderate	Moderate
Vehicle Transportation	Moderate	**Extensive**	Moderate
Industrial Processes	Moderate	Moderate	Moderate
Environmental Science & Technology			
Air/CO_2	Limited	Moderate	**Extensive**
Water	Limited	**Extensive**	Moderate
Soil	Moderate	Moderated	Moderate
Crosscutting Science and Technology	Moderate	Moderate	Moderate

Strength Inventory

Energy Sector

Energy Supply / Generation
- Conventional Fossil
- Unconventional Fossil
- Nuclear
- Renewables

Industry & Natural Resource Strength

Energy Distribution & Transmission
- Pipelines
- Electricity Transmission/Distribution
- Energy Surface Transport

Industry & Infrastructure Strength

Energy End Use Efficiency
- Buildings
- Vehicle Transportation
- Industrial Processes

Environmental Science & Technology
- Air/CO_2
- Water
- Soil

Crosscutting Science and Technology

Stakeholder Input

Stakeholder Input (In-State)

UNIVERSITY RESEARCH LEADERS
- Provide networking opportunities
- Identify and help secure large projects
- Provide matching funds (require peer review)
- Incentivize interdisciplinary teaming

UNIVERSITY ADMINISTRATORS
- Balance w/ other priorities; avoid duplication

INDUSTRY
- Think big and leverage our strengths
- Use Governor Herbert's convening authority

STATE AGENCIES
- Avoid duplication w/ USTAR, COE, SBIR, etc.
- Minimize risk (require outside validation)
- Award prizes for meeting grand challenges

Stakeholder Input

Federal and Other State Input

- SECURE VISIBLE TOP-LEVEL SUPPORT
- FOCUS ON UNIQUE RESOURCE, INFRASTRUCTURE AND HUMAN CAPITAL STRENGTHS
- CONSIDER "LAST-IN" STATE MATCHING FUND FOR FIRST-OF-A-KIND LARGE-SCALE DEMONSTRATIONS
  - Require extensive cost-sharing – no grants
  - Example: State of Tennessee Experimental Biorefinery [Total Project:~$60M; State - ~$10M]
- FOCUS ON UNIQUE UNCONVENTIONAL RESOURCES AND ADVANCED TOPICS RELATED TO THE ELECTRIC GRID
  - Arun Majumdar (USDOE Under Secretary)
  - Jon Wellinghoff (FERC Chairman)
  - Multiple USDOE National Laboratory Directors

Proposed Focus Areas

Proposed Focus Areas

- ✓ CLEAN, LOW-COST PROCESSES FOR DEVELOPING UNCONVENTIONAL RESOURCES
  - Oil Sands Innovation Zone

$50M Innovation Hub planned by DOE in out-years

- ✓ NATIONAL GRID INTEGRATION TEST BED
  - novel grid-scale energy storage
  - integration of intermittent renewables, and
  - novel dynamic demand control strategies

- ○ OTHER IDEAS DISCUSSED:
  - next generation biomass co-firing
  - in-situ coal extraction
  - waste-to-fuel systems

Project Scenarios

Project Scenarios

University-led; industry involvement; 80% federal match

University-led; strong industry involvement; 60% federal match; 20% industry match

Industry-led; strong university involvement; 60% industry match; 20% federal match

Industry-led; university involvement; 80% private match

80% (Develop) 80% (Demonstrate) 80% (Deploy)

Cost-sharing requirements

(Projects may move through phases w/ differing cost-share requirements)

Project Scenarios

Approach:

- Pick focus areas not projects
- Allow market to downselect (outside competition/peer review)
- Minimize risk via last-in matching funds guaranteeing >4:1 ROI

University-led; industry involvement; 80% federal match

University-led; strong industry involvement; 60% federal match; 20% industry match

Industry-led; strong university involvement; 60% industry match; 20% federal match

Industry-led; university involvement; 80% private match

80% (Develop) 80% (Demonstrate) 80% (Deploy)

Cost-sharing requirements

(Projects may move through phases w/ differing cost-share requirements)

Go-Forward Plans

Go-Forward Plans

- ✓ CONTINUE COORDINATION ACTIVITIES
  - Develop working groups and provide networking opportunities in focus areas:
    - Governor convene stakeholders
    - Host national experts, workshops, WGA events
    - OED convene visioning/planning sessions
    - Promote w/ public/private sponsors
    - Create innovation zones
  - Present Governors Award(s) at Energy Summit
- CONSIDER STATE FUND IN TARGETED AREAS **(?)**
  - Matching fund (large-scale first-of-a-kind demos)
  - Innovation prizes for teams meeting grand challenges
- CODIFY LEGISLATIVELY (?)

GARY R. HERBERT
Governor

GREG BELL
Lieutenant Governor

Office of the Governor

AMANDA SMITH
Energy Advisor

SAMANTHA MARY JULIAN
Director, Office of Energy Development

Utah LEADs Initiative

Overview: Utah LEADs is a new initiative aimed at creating Utah energy industries of the future. The signature program, administered by the Governor's Office of Energy Development, will make strategic co-investments in large-scale, first-of-a-kind Leading Energy Advanced Demonstrations (LEADs). Utah LEADs will mobilize interdisciplinary teams from Utah's "research triangle" universities, regional stakeholders and industry to attract outside capital, solve major energy challenges, create energy industries-of-the-future, develop Utah's workforce, and lead the nation in clean energy job creation. Innovative financial structuring can help bring both capital and significant guidance from the private investment community. Engaging and leveraging these resources will lead to impactful, free market-led investments that assures that Utah leads the way.

New energy industries require extensive capital and early demonstrations are difficult to catalyze and finance because of the inherent risk. Other states recognize this need and co-invest in new energy systems to attract extensive outside capital for large, cost-shared demonstrations that lead to new energy industries. For example, Tennessee provided $10 million in matching funds for a $60 million experimental bio-refinery focused on demonstrating new techniques for converting woody biomass into liquid fuels. To compete, Utah Governor Gary R. Herbert is creating a signature program to co-invest in energy industries of the future that leverage the strengths of Utah's research universities, industries, and unique natural resources. Specifically, the Initiative focuses on large, first-of-a-kind demonstrations of transformative energy production, delivery and end-use systems. Matching state funds with federal and private capital for co-investment in strategic areas will increase Utah's ability to compete, become a national leader and hotbed for energy innovation and clean energy job creation.

Suggested Actions: Establish a $10 million Utah LEADs fund for co-investment in large-scale, first-of-a-kind demonstrations of transformative energy systems:
- Competitively-awarded requiring extensive cost-sharing (no less than 50%),
- Independent proposal and project review by nationally-recognized experts,
- Administration and monitoring through the Governor's Office of Energy Development, and
- Incentives for interdisciplinary teaming between universities, industry, and regional stakeholders.

Examples of Possible Utah LEADs Large-Scale Demonstration Focus Areas:
- Clean, low-cost upgrading of heavy crudes, oil sands or oil shale
- National test bed for wireless electric vehicle charging systems and technologies
- Energy storage systems that improve grid reliability & incorporate intermittent resources
- Biomass co-firing, in-situ coal extraction, waste-to-fuel, and or flywheel storage systems

Anticipated Benefits: Create "best-in-country" energy innovation ecosystem:
- Enhance cooperation, innovation, and initiatives between Utah universities and industry,
- Better leverage university and industry strengths and Utah's abundant natural resources,
- Leapfrog other states in a strategic energy industries of the future, and
- Improve Utah competitiveness and create a broad spectrum of energy jobs.

Jeff Muhs, Director Utah Energy Research Triangle Initiative
Utah Office of Energy Development • 1695 North Research Park Way, N. Logan, UT 84341
Telephone: (435) 713-3800 • Fax (435) 713-3801
jeff.muhs@usu.edu • www.energy.utah.gov

APPENDIX B

POWERING THE ENERGY RESEARCH TRIANGLE

POWERING THE ENERGY RESEARCH TRIANGLE

A competitive and collaborative proposal designed to tackle Utah's biggest energy challenges

Alan Walker

Director, USTAR Technology Outreach and Innovation Program

Utah Governor's Office of Economic Development BUSINESS · TOURISM · FILM | USTAR | Office of Energy Development | UTAH

Powering the Energy Research Triangle

- Introduction
- Why are we launching an Energy Research Triangle
  - 10 Year Energy Plan: Principles, Goal, Cross-cutting strategies
  - Governor to Cody to Al
- What are the innovation assets we are capitalizing on
  - U of U: Energy & Geoscience Institute (EGI), Institute for Clean & Secure Energy (ICSE), Energy Commercialization Center (ECC)
  - Utah State University (USU) world-class research in water management, air quality, sensor technology
  - Brigham Young University (BYU) world-class research in combustion, carbon management, biofuels
  - Industry – vertically integrated from development and production to transmission and distribution to utilization
  - Resource Base – R&D in conventional, unconventional, renewable, efficiency
- The Energy Triangle Plan
  - Vision, Mission, Strategic Objectives, Metrics , Strategic Initiatives, Organization Structure, Budget
- Discussion and Q and A

Utah Governor's Office of Economic Development BUSINESS · TOURISM · FILM | USTAR | Office of Energy Development | UTAH

The Governor's 10-year Energy Plan: 2012

The Energy Plan's 8 Strategic Initiatives

1. Establish an Energy Office (HB475)
2. Develop Plans to Keep Public Lands Open
3. Enhance Technology Advancement
4. Review Role of Tax Incentives
5. Increase Regulatory/ Licensing Transparency
6. Reduce Energy Consumption State-Wide
7. Diversify Transportation Fuels
8. Lay Foundation for Base Load Growth

The Energy Research Triangle is directly focused on the accomplishment of Initiative 3 and "Innovation" in general can play a role in Initiatives 6,7 and 8

Overview of Program

- Governor's 10-Year Energy Strategic Plan has proposed the Energy Research Triangle to unlock the potential of Utah's energy resources
- "Powering the Research Triangle" is designed to:
  - Fund energy research relevant to Utah
  - Promote the next level of collaboration between Utah's research universities
  - Increase revenue for Utah education
- Takes into account the interest of all stakeholders: Using a "multi-tiered project" approach, the program would support research and translational development at multiple levels to tackle Utah's leading energy challenges while addressing sustainable energy development concerns: (Air Quality, Water Management, Land Use, Energy to Market)
- Industry Driven and Competitively Selected Research: Research projects would be selected through competition by panel of state energy experts

Powering the Energy Research Triangle

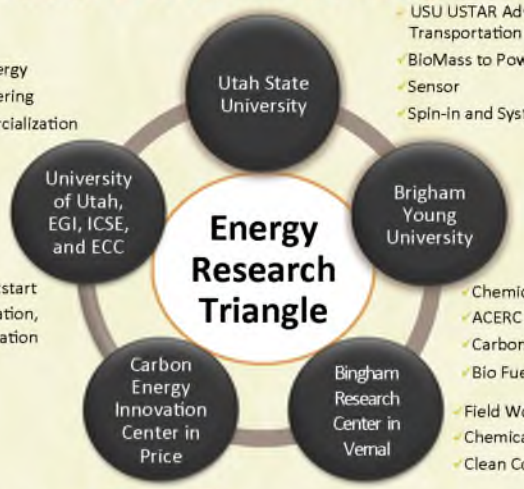
- Introduction
- Why are we launching an Energy Research Triangle
  - 10 Year Energy Plan: Principles, Goal, Cross-cutting strategies
  - Governor to Cody to Al
- What are the innovation assets we are capitalizing on
  - U of U: Energy & Geoscience Institute (EGI), Institute for Clean & Secure Energy (ICSE), Energy Commercialization Center (ECC)
  - Utah State University (USU) world-class research in water management, air quality, sensor technology
  - Brigham Young University (BYU) world-class research in combustion, carbon management, biofuels
  - Industry – vertically integrated from development and production to transmission and distribution to utilization
  - Resource Base – R&D in conventional, unconventional, renewable, efficiency
- The Energy Triangle Plan
  - Vision, Mission, Strategic Objectives, Metrics , Strategic Initiatives, Organization Structure, Budget
- Discussion and Q and A

Utah Governor's Office of Economic Development BUSINESS · TOURISM · FILM | USTAR | Office of Energy Development | UTAH

Resources: Infrastructure

- Fossil Energy
- Geothermal Energy
- Carbon Engineering
- Energy Commercialization Center (ECC)

Utah Industry
- EGI Associates
- Renewable Tech Ventures and Kickstart
- R&D, E&P, Generation, Transmission, Utilization



- USU USTAR Advanced Transportation Institute
- BioMass to Power
- Sensor
- Spin-in and Systems Integration

- Chemical Engineering
- ACERC (Combustion)
- Carbon Capture
- Bio Fuels

- Field Work/prototyping
- Chemical Analysis
- Clean Coke

Utah Governor's Office of Economic Development BUSINESS · TOURISM · FILM | USTAR | Office of Energy Development | UTAH

Program Rationale and Impact

Alignment with the Governor's Top priorities

- **Education** – Increasing revenues to raise new funding for education
- **Sustainable Energy Development**– Promote Utah as a National thought leader in practical energy innovation
- **Jobs** – Energy jobs have a large benefit to rural economies
- **Self-determination** – Shows Utah's resolve, independent of support from Federal government; Provides a leadership agenda for the Western Governor's Association

Utah Governor's Office of Economic Development · USTAR · Office of Energy Development · UTAH

It's time to power up Utah

- Input: Contact Alan Walker – Executive Director, Utah's Energy Research Triangle
- alanjwalker@utah.gov or alanjwalker@egi.utah.edu

Utah Governor's Office of Economic Development · USTAR · Office of Energy Development · UTAH

APPENDIX C

POWERING THE ENERGY RESEARCH TRIANGLE

Discussion with Dr. Tom Parks

- Genesis of the Utah Energy Research Triangle
  - Energy Plan
- Extended history
  - Dormant, Jeff Muhs, Al Walker
- Program
  - I-Principle: 60, 20, 20, split $450K, 2015 to 2018
  - II-Core: 60, 20, 20, split $225 K x 2 = $450K, 2015 to 2018
  - III-Energy Leadership Scholar Program, split $750 equally
- Questions for Dr. Parks
  - Impactful
  - What can we point to now?
- Q&A from Dr. Parks

Powering the Energy Research Triangle

A competitive and collaborative proposal designed to tackle Utah's biggest energy challenges

Program Rationale and Impact

STRONG PAYOFF to Utah citizens for the Energy Research Triangle

- **$75 million/year in new State tax and royalty revenue** (assuming we address Black Wax's potential by mitigating roadblocks to increasing production by 35,000 BOPD as planned)

This program should be part of the Governor's Top 5 Program list for his new term due to it's ability to align the Governor's Top priorities

- **Education** – Increasing revenues from Energy projects can raise significant new funding for education without raising taxes
- **Energy** – Promotes Utah as the Nation's thought leader in energy independence and sustainable energy development
- **Jobs** – Energy jobs have a large benefit to rural economies
- **Self-determination** – Shows Utah's commitment, independent of support from Federal government; Provides a leadership agenda for the Western Governor's Association

Overview of Program

- Governor's 10-Year Energy Strategic Plan has proposed the Energy Research Triangle to unlock the potential of Utah's energy resources
- "Powering the Research Triangle" is designed to:
  - Increase revenue for Utah education
  - Fund energy research relevant to Utah
  - Promote the next level of collaboration between Utah's research universities
- Appeals to conservatives and moderates: Using a "multi-tiered project" approach, the program would support research at multiple levels to tackle Utah's leading energy challenges while addressing sustainable energy development concerns
  - Air Quality
  - Water Management
  - Energy to Market
- Industry Driven and Competitively Selected: Research projects would be selected through competition by panel of state energy experts

Tier 1 – "Principle" Project

- "Principle" Project Objectives: Address the leading challenges Utah faces in its path to energy independence and sustainable energy development
- Project(s) must have the highest possible impact for the state (Utah's "Moon shot")
  - Example – Black Wax, three year effort could help create $75 Million in new tax revenue for Education funding

	Tier 1 - Principle Energy Issue					
PI University	***Sub PI***	**2014**	**2015**	**2016**	**2017**	**Project Total**
U of U		$120,000	$75,000	$75,000	$0	$270,000
Black Wax	BYU	$40,000	$25,000	$25,000	$0	$90,000
	USU	$40,000	$25,000	$25,000	$0	$90,000
					Total cost	$450,000

Tier 2 – "Core" Projects

- "Core" Project Objectives: Projects will propose new solutions to energy challenges
- Technology may take longer to shape the marketplace, but they are just as important for establishing Utah as a forward-thinking thought leader in the energy space (Example: Methyl Viologen)

	Tier 2 - Core Energy Issues					
PI University	***Sub PI***	**2014**	**2015**	**2016**	**2017**	**Project Total**
USU		$60,000	$37,500	$37,500	$0	$135,000
Water Resource Management	BYU	$20,000	$12,500	$12,500	$0	$45,000
	U of U	$20,000	$12,500	$12,500	$0	$45,000
					Total cost	$225,000
PI University	***Sub PI***	**2014**	**2015**	**2016**	**2017**	**Project Total**
BYU		$60,000	$37,500	$37,500	$0	$135,000
Air Quality	USU	$20,000	$12,500	$12,500	$0	$45,000
	U of U	$20,000	$12,500	$12,500	$0	$45,000
					Total cost	$225,000

Tier 3 – "Advancing Energy Leadership" Projects

- "Energy Innovation Leadership" Project Objectives: Focused on grooming homegrown Utah talent to be the next generation of Utah's scientific and engineering innovation leadership
  - for the promising PhD candidate or appropriate MS, approved by University faculty to be completed in two years or less
  - 3 Grants for USU Students, 3 for BYU Students, 3 for UofU students and 1 for Ute Indian Tribe student (attending any of the 3 universities)

Tier 3 Details – Grant breakdown

- **Each of these research grants would be for 1 year, eligible for a 2nd year of funding if approved by the selection panel.**

Tier 3 - Advancing Energy Innovation and Leadership

Graduate Scholarship	2014	2015	2016	2017	Project Total
BYU	$12,500	$25,000	$25,000	$12,500	$75,000
BYU	$12,500	$25,000	$25,000	$12,500	$75,000
BYU	$12,500	$25,000	$25,000	$12,500	$75,000
USU	$12,500	$25,000	$25,000	$12,500	$75,000
USU	$12,500	$25,000	$25,000	$12,500	$75,000
USU	$12,500	$25,000	$25,000	$12,500	$75,000
U of U	$12,500	$25,000	$25,000	$12,500	$75,000
U of U	$12,500	$25,000	$25,000	$12,500	$75,000
U of U	$12,500	$25,000	$25,000	$12,500	$75,000
Ute Tribe (at BYU, USU or U of U)	$12,500	$25,000	$25,000	$12,500	$75,000
Yearly Totals	$125,000	$250,000	$250,000	$125,000	$750,000

Tier 3	2014	2015	2016	2017	
Annual Cost	$125,000	$250,000	$250,000	$125,000	
Percentage of funds dispersed, annually	16.67%	33.33%	33.33%	16.67%	
Research projects initiated	10	10	10		
Completed projects		10	10	10	
				Total tier funding	$750,000

Tier 3 Details: USTAR interns and employees are already Utah's next generation of energy and technology leadership (partial list)

5 Year History (partial list)

- **Startup Companies**: Ben Rollins, CEO of Vaporsens; James May, VP of WAVE; Ameya Chaudhari, Principal at Navillum (won $100,000 and internship at TerraTek-Schlumberger)
- **Growth Companies**: Tareq al Najjar, Mgr of Business Development at Purestream; Ben France, Engineering Manager at Enefit American Oil and CEO of Seismic Safety Solutions
- **Established Companies**: Joseph Hulse, Business Development at Questar Pipeline; Terence Hass, Management Trainee at International Castings; Yi Li, Goldman Sachs
- **Government**: Rob Simmons, Manager of Office of Energy Development - Unconventional Energy; Gibson Peters – Manager, OED - Conventional Energy; Vatsala Kaul, Manager of Business Analysis at GOED
- **Education**: Varun Gowda – Principal Investigator, DOE Energy Commercialization Center; Mike Vrtis- PhD candidate Civil & Environmental Engineering

Energy Research Triangle Program Summary

- Multifaceted, interdisciplinary approach
- Collaboration requirements
  - Tier 1 and Tier 2 grants will stipulate as part of the funding **that a portion of the grant money be spent at each of the three universities.**
  - The winning PI for each grant will be responsible for "subcontracting" out 20% of the research to each of the other universities.
  - Research objective becomes to attack the problem from as many innovative angles as possible

	2014	2015	2016	2017	2014-2017
Total Cost	$525,000	$500,000	$500,000	$125,000	$1,650,000
Research Projects initiated	13	10	10		33
Research Projects completed		10	13	10	33

Are we ready to power up?

Tier 3 Details – Effectiveness of Grants

- USTAR has proven that "**Seed Grants" work –**
  - $3.4m in grants – over $1m to local entrepreneurs, provided they collaborate with Universities
  - TCG has $20.3 Million in new private capital generating a 6x ROI
  - Pipeline of projects includes 98+ prototypes, 30+ new companies, 176+ new employees

APPENDIX D

POWERING THE ENERGY RESEARCH TRIANGLE

Powering the Energy Research Triangle

A competitive and collaborative program designed to tackle Utah's biggest energy challenges

Program Rationale and Impact

STRONG PAYOFF to Utah citizens for the Energy Research Triangle

- **$85 million/year in new State tax and royalty revenue** (assuming we address Black Wax's potential by mitigating roadblocks to doubling production)

This program should be part of the Governor's Top 5 Program list for his new term due to it's ability to align the Governor's Top priorities

- **Education** – Increasing revenues from Energy projects can raise significant new funding for education without raising taxes
- **Energy** – Promotes Utah as the Nation's thought leader in energy independence and sustainable energy development
- **Jobs** – Energy jobs have a large benefit to rural economies
- **Self-determination** – Shows Utah's commitment, independent of support from Federal government; Provides a leadership agenda for the Western Governor's Association

Overview of Program

- Governor's 10-Year Energy Strategic Plan has proposed the Energy Research Triangle to unlock the potential of Utah's energy resources
- "Powering the Research Triangle" is designed to:
  - Increase revenue for Utah education
  - Fund energy research relevant to Utah
  - Promote the next level of collaboration between Utah's research universities
- Appeals to conservatives and moderates: Using a "multi-tiered project" approach, the program would support research at multiple levels to tackle Utah's leading energy challenges while addressing sustainable energy development concerns
  - Air Quality
  - Water Management
  - Transportation
- Competitive and Industry driven: Research projects would be selected through competition by panel of state energy experts

Tier 1 – "Principle" Project(s)

- "Principle" Project Objectives: Address the leading challenges Utah faces in its path to energy independence and sustainable energy development
- Project(s) must have the highest possible impact for the state (Utah's "Moon shot")
  - Example – Black Wax, three year effort could create $85 Million in new tax revenue for Education funding

	Tier 1 - Principle Energy Issue					
PI University	***Sub PI***	**2014**	**2015**	**2016**	**2017**	**Project Total**
U of U		$120,000	$75,000	$75,000	$0	$270,000
Black Wax	BYU	$40,000	$25,000	$25,000	$0	$90,000
	USU	$40,000	$25,000	$25,000	$0	$90,000
					Total cost	$450,000

Tier 2 – "Core" Projects

- "Core" Project Objectives: Projects will propose new solutions to energy challenges
- Technology may take longer to shape the marketplace, but they are just as important for establishing Utah as a forward-thinking thought leader in the energy space (Example: Methyl Viologen)

	Tier 2 - Core Energy Issues					
PI University	***Sub PI***	**2014**	**2015**	**2016**	**2017**	**Project Total**
USU		$60,000	$37,500	$37,500	$0	$135,000
Water Resource Management	BYU	$20,000	$12,500	$12,500	$0	$45,000
	U of U	$20,000	$12,500	$12,500	$0	$45,000
					Total cost	$225,000
PI University	***Sub PI***	**2014**	**2015**	**2016**	**2017**	**Project Total**
BYU		$60,000	$37,500	$37,500	$0	$135,000
Air Quality	USU	$20,000	$12,500	$12,500	$0	$45,000
	U of U	$20,000	$12,500	$12,500	$0	$45,000
					Total cost	$225,000

Tier 3 – "Advancing Energy Leadership" Projects

- "Energy Leadership" Project Objectives: Focused on grooming homegrown Utah talent to be the next generation of Utah's scientific and engineering innovation leadership
  - for the promising PhD candidate or appropriate MS, approved by University faculty to be completed in two years or less
  - 3 Grants for USU Students, 3 for BYU Students, 3 for UofU students and 1 for Ute Indian Tribe student (attending any of the 3 universities)

Tier 3 Details – Grant breakdown

- **Each of these research grants would be for 1 year, eligible for a 2nd year of funding if approved by the selection panel.**

Tier 3 - Advancing Energy Innovation and Leadership

Graduate Scholarship	2014	2015	2016	2017	Project Total
BYU	$12,500	$25,000	$25,000	$12,500	$75,000
BYU	$12,500	$25,000	$25,000	$12,500	$75,000
BYU	$12,500	$25,000	$25,000	$12,500	$75,000
USU	$12,500	$25,000	$25,000	$12,500	$75,000
USU	$12,500	$25,000	$25,000	$12,500	$75,000
USU	$12,500	$25,000	$25,000	$12,500	$75,000
U of U	$12,500	$25,000	$25,000	$12,500	$75,000
U of U	$12,500	$25,000	$25,000	$12,500	$75,000
U of U	$12,500	$25,000	$25,000	$12,500	$75,000
Ute Tribe (at BYU, USU or U of U)	$12,500	$25,000	$25,000	$12,500	$75,000
Yearly Totals	$125,000	$250,000	$250,000	$125,000	$750,000

Tier 3	2014	2015	2016	2017	
Annual Cost	$125,000	$250,000	$250,000	$125,000	
Percentage of funds dispersed, annually	16.67%	33.33%	33.33%	16.67%	
Research projects initiated	10	10	10		
Completed projects		10	10	10	
				Total tier funding	$750,000

Tier 3 Details: USTAR interns and employees are already Utah's next generation of energy and technology leadership (partial list)

4 Year History (partial list)

- **Startup Companies**: Ben Rollins, CEO of Vaporsens; James May, VP of WAVE; Ameya Chaudhari, Principal at Navillum (won $100,000 and internship at TerraTek-Schlumberger)
- **Growth Companies**: Tareq al Najjar, Mgr of Business Development at Purestream; Ben France, Engineering Manager at Enefit American Oil and CEO of Seismic Safety Solutions
- **Established Companies**: Joseph Hulse, Manager Pipeline at Questar
- **Government**: Rob Simmons, Manager of Office of Energy Development - Unconventional Energy; Gibson Peters – Manager, OED - Conventional Energy; Vatsala Kaul, Mgr of Business Analysis at GOED
- **Education**: Varun Gowda – Principal Investigator, DOE Energy Commercialization Center; Mike Vrtis- PhD candidate Civil & Environmental Engineering

Energy Research Triangle Program Summary

- Multifaceted, interdisciplinary approach
- Collaboration requirements
  - Tier 1 and Tier 2 grants will stipulate as part of the funding **that a portion of the grant money be spent at each of the three universities.**
  - The winning PI for each grant will be responsible for "subcontracting" out 20% of the research to each of the other universities.
  - Research objective becomes to attack the problem from as many creative angles as possible

	2014	2015	2016	2017	2014-2017
Total Cost	$525,000	$500,000	$500,000	$125,000	$1,650,000
Research Projects initiated	13	10	10		33
Research Projects completed		10	13	10	33

Are we ready to power up?

Tier 3 Details – Effectiveness of Grants

- USTAR has proven that "**Seed Grants" work –**
  - $3.4m in grants – over $1m to local entrepreneurs, provided they collaborate with Universities
  - TCG has $20.3 Million in new private capital generating a 6x ROI
  - Pipeline of projects includes 98+ prototypes, 30+ new companies, 176+ new employees

APPENDIX E

USTAR GOVERNING AUTHORITY FUNDING REQUEST

Powering the Energy Research Triangle

A competitive and collaborative proposal designed to tackle Utah's biggest energy challenges

Alan Walker
Executive Director, Utah Energy Research Triangle

Office of Energy Development USTAR UTAH

The Governor's 10-year Energy Plan: 2012

The Energy Plan's 9 Strategic Initiatives

1. Establish an Energy Office (HB475)
2. Develop Plans to Keep Public Lands Open
3. Enhance Technology Advancement
4. Review Role of Tax Incentives
5. Increase Regulatory/ Licensing Transparency
6. Reduce Energy Consumption State-Wide
7. Diversify Transportation Fuels
8. Lay Foundation for Base Load Growth

The Energy Research Triangle is directly focused on the accomplishment of Initiative 3 and "Innovation" in general can play a role in Initiatives 6,7 and 8

Office of Energy Development USTAR UTAH

Overview of Program

- Governor's 10-Year Strategic Energy Plan has proposed the Energy Research Triangle to unlock the potential of Utah's energy resources
- "Powering the Research Triangle" is designed to:
  - Fund energy research relevant to Utah
  - Promote the next level of collaboration between Utah's research universities
  - Increase revenue for Utah education
- Aligned with Governor's top priorities
  - **Education** – Increasing revenues to raise new funding for education
  - **Sustainable Energy Development**– Promote Utah as a National thought leader In practical and applied energy innovation
  - **Jobs** – Energy jobs have a large benefit to rural economies
  - **Self-determination** – Shows Utah's resolve, independent of support from Federal government; Provides a leadership agenda for the Western Governor's Association
- Industry Driven and Competitively Selected Research: Research projects would be selected through competition by panel of state energy experts

Office of Energy Development USTAR UTAH

How the ERT Leverages Utah Energy Assets

- ✓ World-class research facilities
- ✓ Significant energy reserves
- ✓ Pro-development leadership

- These all exist independently, the ERT focuses each asset and brings them together to work in concert to catalyze energy research

Office of Energy Development USTAR UTAH

Energy Research Triangle Objectives

- The Energy Research Triangle bridges the gap between academic research and commercial deployment of innovation
- Criteria for selection include:
  - Must address significant energy issues in the State of Utah
  - Have a high likelihood of being completed in the time provided with the funds provided
  - Have a high likelihood of being impactful and beneficial to the residents of Utah
- Energy Research Triangle team has a strong working relationship with Utah's upstream and downstream energy network
- Regular collaboration with industry means ERT team works on economically significant issues
- **Connection to Capital Networks** – USTAR/ERT has the resources and network to connect Private Equity to promising innovations
  - Bridge the funding gap between early-stage Proof of Concept money and Seed/ Series A funding

Office of Energy Development · USTAR · UTAH

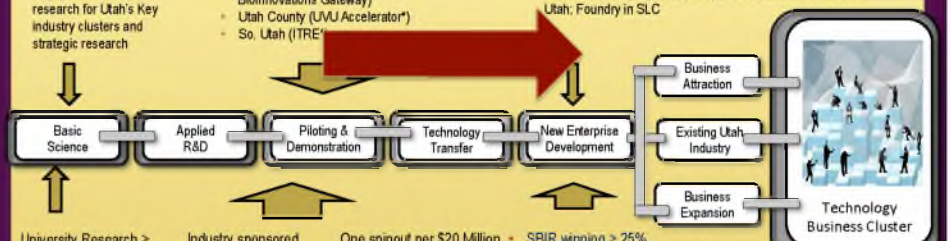
Objective 2:
FY2014 Draft Targets (Capital Intensive innovation)

340,000+sf at 2 USTAR Facilities housing 50+ catalyst-type interdisciplinary faculty aligned in 7 Utah Innovation Centers, engaged in strategic research for Utah's Key industry clusters and strategic research

7 Core* applications testing and industry sponsored research facilities strategically located across Utah:
- Logan (USTAR*)
- E. Utah (Bingham Ctr*, CEIC*)
- No. Utah (UCAID*)
- Salt Lake County (USTAR Bldg*, TCO Accelerator, BioInnovations Gateway)
- Utah County (UVU Accelerator*)
- So. Utah (ITRE

Well-coordinated Industry-led entrepreneurship networks established in all regions of the state
- No Utah (NFEA)
- Utah County (UVEF)
- So Utah (Dixie & Cedar Techs)
- Utah: BoomStartup, GUV, WBI

Student-centric programs (UEC) at 8 USHE locations around Utah; Foundry in SLC



University Research > $680 Million in FY14, and target growth of 5% per year

USTAR > $68M

Industry sponsored research (ISR) at 10% of the base or a total of > $68M

USTAR ISR > 15% or $10.2M

One spinout per $20 Million in University Research = 34 spinouts and "spinins"

USTAR projects > 20/year
- 6 at U of U
- 4 at USU
- 3 at each TOIP region

SBIR winning > 25%
- $1.6M in Proof of Concept / Commercial Relevance (TCIP) funding deployed strategically;
- $3.9M USBGI deployed into strategic seed funds
- > $7.8 M in Private Angel investment
- > $16M deployed in Seed and early Series A funding

Launched Utah FoF $45 Million Phase II Expansion - Incl: $20 Million in Seed and Series A Venture Capital targeting strategic growth

Office of Energy Development · USTAR · UTAH

Timeline

- **Nov 2012** – Introduced ERT 2.0 to Governor Herbert's Energy Taskforce
- **Jan 10-11, 2013** – Presented ERT at Governor's Energy Summit
- **Jan 2013** – Visit with University VPs of Research to vet proposal
- **Feb/Mar 2013** – Refined proposal based on feedback
- **Apr 4, 2013** – Present to USTAR Governing Authority
- **Apr 10, 2013** – Present to Governor Herbert's Energy Taskforce
- **Apr 2013** – Revisit with Universities
- **May 1, 2013** – Issue RFP
- **June 1, 2013** – Accept completed RFPs
- **June 6, 2013** – Present recommendations to USTAR GA
- **July 1, 2013** – Announce award recipients
- **Dec 2013** – Review progress with Tier II (Scholars)winners
- **Jan 2014** – Review progress with Tier I (Principle) winners
- **Jan/Feb 2014** – Recognize winners at Governor's 2014 Energy Summit

Office of Energy Development USTAR UTAH

Budget Summary

ERT Projection Tier 2 (27 Projects)	
Project Cost (4 year)	$675,000
Project Gross Benefit (4 years, 30% probability)	$2,332,775
Project Gross Benefit (6 year, 30% probability	$4,193,051
Project ROI (4 year)	246%
Project ROI (6 year)	521%
Project Net Benefit (4 year)	$1,657,775
Project Net Benefit (6 year)	$3,518,051

ERT Projection Tier 1 (3 Projects)	
Project Cost (3 year)	$900,000
Project Gross Benefit (3 years, 30% probability)	$3,110,367
Project Gross Benefit (4 year, 30% probability	$5,590,735
Project ROI (3 year)	246%
Project ROI (4 year)	521%
Project Net Benefit (3 year)	$2,210,367
Project Net Benefit (4 year)	$4,690,735

Example Project: Natural Asphalt Solutions (with Indirect Costs)	
Project Cost (2 year non-repeating)	$46,364
Project Gross Benefit (2 year)	$425,925
Project Gross Benefit (4 year)	$851,850
Project ROI (2 year)	819%
Project ROI (4 year)	1737%
Project Net Benefit (2 year)	$379,561
Project Net Benefit (4 year)	$805,486

6 Year Economic Impact (Projected) $8,208,786

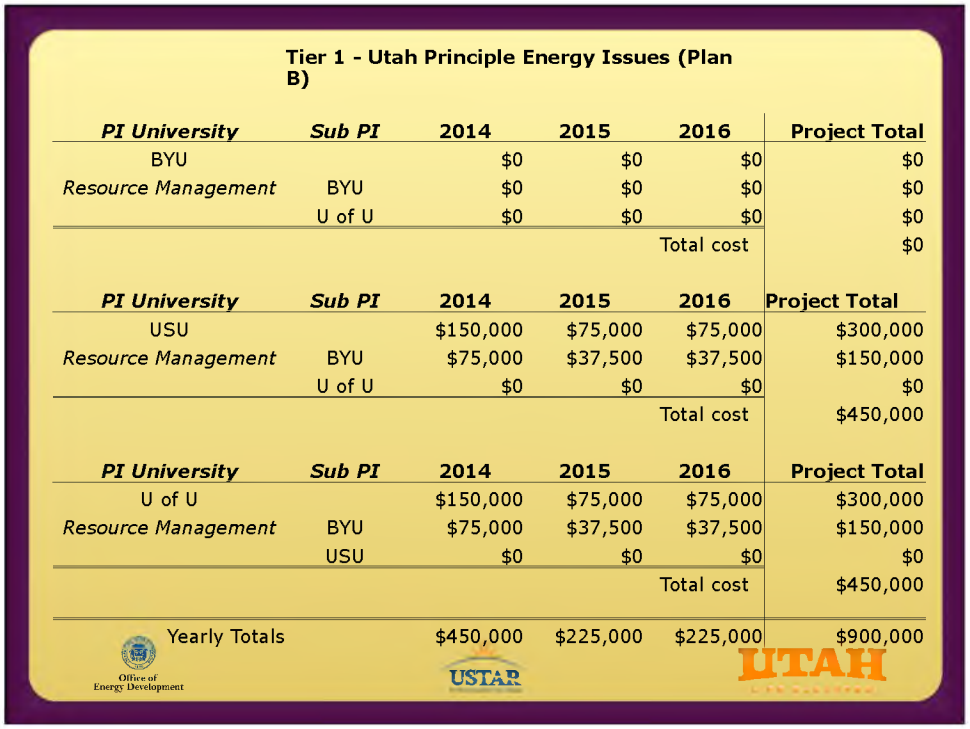
- **$75,000 from FY 13 for Tier II in FY 14**
- **$450,000 from FY 14 for Tier I in FY 14**
- $1.575M funding, $8.2M impact
- Execute Gov. Herbert's priority agenda
- Facilitate University collaboration
- Address key Utah energy issues

Office of Energy Development USTAR UTAH

APPENDIX

Utah Principle Energy Issues	2014	2015	2016	2017	
Annual Cost	$450,000	$225,000	$225,000		
Research projects initiated	3				
Completed projects			3		
Total Program Cost					**$900,000**

Governor's Energy Leadership Scholars	2014	2015	2016	2017	
Annual Cost	$87,500	$212,500	$250,000	$125,000	
Research projects initiated	7	10	10	0	
Completed projects		7	10	10	
Total Program Cost					**$675,000**



Tier 1 - Utah Principle Energy Issues (Plan B)

PI University	*Sub PI*	2014	2015	2016	Project Total
BYU		$0	$0	$0	$0
Resource Management	BYU	$0	$0	$0	$0
	U of U	$0	$0	$0	$0
				Total cost	$0

PI University	*Sub PI*	2014	2015	2016	Project Total
USU		$150,000	$75,000	$75,000	$300,000
Resource Management	BYU	$75,000	$37,500	$37,500	$150,000
	U of U	$0	$0	$0	$0
				Total cost	$450,000

PI University	*Sub PI*	2014	2015	2016	Project Total
U of U		$150,000	$75,000	$75,000	$300,000
Resource Management	BYU	$75,000	$37,500	$37,500	$150,000
	USU	$0	$0	$0	$0
				Total cost	$450,000

Yearly Totals		$450,000	$225,000	$225,000	$900,000

Office of Energy Development

USTAR

UTAH

APPENDIX F

ECONOMIC FEASIBILITY OF OIL SAND USE IN ASPHALT PAVEMENT

UTAH SCIENCE, TECHNOLOGY AND RESEARCH INITIATIVE (USTAR)

Economic Feasibility of Oil Sand Use in Asphalt Pavements

Tyler S. Gwilliam

7/27/2010

1 Abstract

An economic analysis of the effects of using oil sands in asphalt pavement was conducted. An overall favorable economic result for private industry as well as both local and state governments is predicted.

2 Table of Contents

3 Introduction

This report addresses the economic feasibility of incorporating Oil Sands as a major component in asphalt pavement mixes. A project has been commissioned by the Uintah County Transportation and Impact Mitigation Special Service Districts to assess the technical feasibility of the above said purpose. This report will outline the most common current asphalt mixing process, components and costs. It will then detail a proposed new process incorporating oil sands and compare the costs of the old process to the new process. While some of the numbers are approximates and averages and the actual values and prices stated in the report may be erroneous to a certain degree, the overall purpose of the report is to prove the economic value of making the proposed changes to asphalt mixes and specifications.

3.1 Background

Oil Sands have been used on local roads in Uintah County for over 80 years. Many local construction companies have found the oil sands to be desirable for both its chemical properties and less fluctuant pricing structure. As oil prices continue to increase, the use of oil sands becomes more economically feasible. There is a potentially large cost savings associated with the use of oil sands in asphalt pavement in Uintah County. It is for this purpose that USTAR has requested that this economic analysis be conducted.

3.2 Assumptions

In an effort to make the model simple to understand, we have used multiple assumptions in its development. These assumptions are outlined below.

3.2.1 Oil Sand Production Levels

There are two major deposits in the Uintah Basin. Both sites have the facilities to extract oil sands at efficient rates. However, due to current economic conditions and market demand for oil, neither of these operations is currently in large scale operation. Therefore, it is difficult to obtain low costs on oil sands due to lack of economies of scale. We have developed this model under the assumption that these facilities will ramp up production to 100% capacity over the next five years. This creates a decreasing cost for oil sands during that time period. In addition, we have included in Appendix 2 a sensitivity analysis showing the effects that no increase in production levels would have on oil sand asphalt prices.

3.2.2 Oil Sand Material Pricing

We have developed the economic model under the assumption that the oil sands mining sites will maintain their net income/ton constant as they ramp up their operations rather than maintain a constant markup.

Appendix 2 again addresses the effects that a constant oil sands price would have on pavement costs.

3.2.3 Oil Sand Asphalt Mix Composition

We have developed this model utilizing an oil sand asphalt mix with the following composition:

55%	Coarse Aggregate
5 %	Fine Aggregate
39%	Oil Sands
1%	Liquid Asphalt Binder

This composition was developed using recommendations from paving companies who have prior experience with oil sand paving. It is presumed that the oil sands specification developed by UDOT will be similar in composition to the above mentioned mixture. In Appendix 1, we also include a sensitivity analysis showing the effects of different oil sand concentrations on oil sand pavement costs.

3.2.4 Delivery Costs

This model was developed under the assumption that: 1) The oil sands mining facility delivers the material to the construction company, 2) that the average distance between the deposit and the mixing plant is 10 miles and 3) Delivery costs are $0.10/ton-mile. The delivery costs are also subject to volume and therefore, can only be estimated. This constant rate was chosen to most accurately reflect delivery costs for large volume orders.

3.2.5 Pavement Pricing

We have developed the economic model under the assumption that the paving companies are operating in a perfectly competitive market. Therefore, as more competitors begin to use the lower cost oil sands, contractors will slowly decrease their pavement prices until their net income reaches the same level as it was before adopting oil sands. We have assumed that this process will also occur over a five year period.

3.2.6 Comparison to Current Conditions

We have developed a five year economic model. We have compared the results of using oil sands with current market prices and conditions. This means that we have assumed that over the next five years, if oil sands were not adopted, all pavement costs would remain constant and would not fluctuate. We did not attempt to forecast the future costs of liquid

asphalt and aggregate since these materials fluctuate significantly and it is not possible to accurately predict these fluctuations over a five year period.

3.2.7 Lane Mile

A lane mile is defined as a 12 foot wide by 1 mile long strip of road. The total amount of road work being done on any particular job is frequently measured in Lane Miles. A thickness is not defined since each road is designed to a different thickness. A road thickness of 6 inches was assumed for this model in order to calculate a volume. A density of 135 pounds per square foot was used to then convert the volume to weight. **This model breaks down costs on a per lane mile basis rather than use an estimate for total lane miles paved per year.**

4 Pavement Volume

Since 2006, Uintah County has commissioned the laying of more than 235,000 tons of asphalt pavement, and average of 48,000 tons per year. This accounts for approximately 23 lane miles per year on average. This only accounts for road paved by the Uintah County Transportation District. We expect that Duchesne County paves a similar number of roads each year. Since a new state specification is being written using oil sands, we expect that many state and federal roads will also be paved in these two counties using oil sand pavement. Therefore, it is plausible that over 100,000 tons of pavement could be laid each year.

5 Costs

5.1 Oil Sand Mining Costs

The oil sands mining facilities in the Uintah Basin are the first major point in the supply chain. Based on data that we have been able to gather regarding surface mining and from local oil sand operations, we have been able to develop a fairly accurate cost structure for oil sands raw material. These costs are all on a per ton basis and are broken down over a five year period using the above mentioned assumptions.

Table 1 Oil Sand Mining Cost Breakdown

Oil Sand Mining Costs	Year 1	Year 2	Year 3	Year 4	Year 5
Mine Plan ($/ton)	$0.53	$0.40	$0.29	$0.16	$0.05
Core Drilling exploration ($/ton)	$0.53	$0.40	$0.29	$0.16	$0.05
mine planning ($/ton)	$0.53	$0.40	$0.29	$0.16	$0.05
Permitting ($/ton)	$2.50	$2.11	$1.75	$1.36	$1.00
Overburden Removal ($/ton)	$7.50	$6.85	$6.25	$5.60	$5.00
Mining ($/ton)	$7.50	$6.85	$6.25	$5.60	$5.00
Reclamation ($/ton)	$3.50	$3.11	$2.75	$2.36	$2.00
Lease Payments ($/ton)	$2.50	$2.24	$2.00	$1.74	$1.50
Total Materials Costs ($/ton)	$25.08	$22.36	$19.86	$17.15	$14.65
G&A Costs ($/ton)	$3.76	$3.35	$2.98	$2.57	$2.20
Transportation ($/mile-ton)	$0.10	$0.10	$0.10	$0.10	$0.10
Average Distance (miles)	10	10	10	10	10
Margin (%)	5%	5%	7%	8%	8%
Net Income ($/ton)	**$1.66**	**$1.53**	**$1.66**	**$1.78**	**$1.65**
Total Sales Price ($/ton)	$31.50	$28.25	$25.50	$22.50	$19.50
Taxes ($/ton)	$2.16	$1.94	$1.75	$1.54	$1.34
Total Cost to Asphalt Company ($/ton)	**$33.66**	**$30.19**	**$27.25**	**$24.04**	**$20.84**

Table 1 shows that as the oil sands mining facilities ramp up production over the next five years, their costs and consequently their sales price will drastically decrease. This will pass on significant cost savings on to the paving company and consequently to the County.

5.2 Asphalt Mix Costs

The next step we undertook was to assess the pricing structure of asphalt mixtures. We were able to gather data from multiple industry professionals and compile an average cost of asphalt pavement. Table 2 below details those costs.

Table 2 Current Asphalt Mix Costs

Base Asphalt Costs	% Weight	Cost/ton	Unit Cost
Coarse Aggregate ($/ton)	59%	$15.00	$8.85
Fine Aggregate ($/ton)	36%	$15.00	$5.40
Binder ($/ton)	5%	$600.00	$30.00
Unit Cost ($/ton)			$44.25
Transportation and Installation ($/ton)			$15.00
Sales Price ($/ton)			**$64.00**
Margin (%)			7%
Net Income ($/ton)			**$4.75**

A sales price of $64.00 was used for the final price. Asphalt costs range anywhere between $30.00 -$90.00/ton with an average around $55.00/ton. Since 2006, average asphalt costs for pavement in Uintah County have been closer to $64.00/ton. Therefore, we selected this average as our base cost. This is consistent with feedback we have received from the industry stating that asphalt paving is a very low margin operation.

We then developed a similar costing model using oil sands in the mixture and less liquid asphalt binder. We analyzed these costs over the 5 year period and incorporated the decreasing price of oil sands into that pricing structure. Table 3 below shows the results of this analysis. Note that Table 3 uses the above mentioned mixture.

Table 3 Oil Sands Pavement Mix Costs

Oil Sand Mix Costs	Year 1	Year 2	Year 3	Year 4	Year 5
Coarse Aggregate ($/ton)	$8.25	$8.25	$8.25	$8.25	$8.25
Fine Aggregate ($/ton)	$0.75	$0.75	$0.75	$0.75	$0.75
Oil Sands ($/ton)	$13.13	$11.77	$10.63	$9.38	$8.13
Binder ($/ton)	$6.00	$6.00	$6.00	$6.00	$6.00
Unit Cost ($/ton)	$28.13	$26.77	$25.63	$24.38	$23.13
Transportation and Installation ($/ton)	$15.00	$15.00	$15.00	$15.00	$15.00
Sales Price ($/ton)	**$62.00**	**$57.00**	**$52.00**	**$46.00**	**$43.00**
Margin (%)	30%	27%	22%	14%	11%
Net Income ($/ton)	**$18.87**	**$15.23**	**$11.37**	**$6.62**	**$4.87**

This analysis also operates under the assumption that aggregate and binder prices remain constant over the five year period. Since these costs also remain constant in the model to which it is compared, price fluctuations will have a much smaller

effect on the model when analyzing the actual economic effects that oil sands will have on the paving industry.

6 Economic Effects

We chose to examine the economic effects that the purchase of one lane mile of asphalt pavement would have on the entire supply chain. The following sections outline these effects for each individual segment of the supply chain.

6.1 Oil Sand Mining Economic Effects

Table 4 below details the expected revenue and net income increases for the oil sands mining operations over the next five years. One lane mile of asphalt uses approximately 834 tons of oil sands. Assuming the declining costs as production ramps up, the total revenue actually decreases and the net income remains relatively constant.

Table 4 Economic Effects on Oil Sand Mining Operations

Increase in Revenue to Oil Sand Operations:	2010	2011	2012	2013	2014
Oil Sand Sales (tons)	834	834	834	834	834
Sales Price ($)	$31.50	$28.25	$25.50	$22.50	$19.50
Total Costs ($)	$29.84	$26.72	$23.84	$20.72	$17.85
Total Revenue Effect($)	$26,270	$23,560	$21,266	$18,764	$16,263
Total Net Income Effect($)	**$1,388**	**$1,277**	**$1,383**	**$1,480**	**$1,378**

6.2 Paving Company Economic Effects

Table 5 details the expected revenue and net income changes over a five year period on a per lane mile basis. Initially, the net income will increase by $30,000.00 for every lane mile paved using oil sands. This will gradually decrease until their income levels return back to their initial condition and there is no significant income increase when compared to the base cost. This represents a significant amount of savings that can be passed on to the industry over this period of time.

Table 5 Base Mix Revenue

Base Mix Revenue	Years 1-5
Base Sales Price ($/ton)	$64.00
Base Costs ($/ton)	$59.25
Total Sales (tons)	2,138
Base Revenue ($)	$136,858
Base Net Income ($)	**$10,157**

Table 6 Oil Sand Mix Revenue

Oil Sand Mix Revenue	Year 1	Year 2	Year 3	Year 4	Year 5
Oil Sand Mix Sales Price ($/ton)	$62.00	$57.00	$52.00	$46.00	$43.00
Oil Sand Mix Costs ($/ton)	$43.13	$41.77	$40.63	$39.38	$38.13
Total Sales (tons)	2,138	2,138	2,138	2,138	2,138
Oil Sand Mix Revenue ($)	$132,581	$121,889	$111,197	$98,366	$91,951
Oil Sand Mix Net Income ($)	**$40,359**	**$32,563**	**$24,322**	**$14,165**	**$10,423**

Table 7 Oil Sand Pavement Effects of Revenue

Effects on Revenue	Year 1	Year 2	Year 3	Year 4	Year 5
Base Revenue ($)	$136,858	$136,858	$136,858	$136,858	$136,858
Oil Sand Mix Revenue ($)	$132,581	$121,889	$111,197	$98,366	$91,951
Effect on Revenue ($)	**($4,277)**	**($14,969)**	**($25,661)**	**($38,491)**	**($44,906)**

Table 8 Oil Sand Pavement Effects on Net Income

Effects on Net Income	Year 1	Year 2	Year 3	Year 4	Year 5
Base Net Income ($)	$10,157	$10,157	$10,157	$10,157	$10,157
Oil Sand Mix Net Income ($)	$40,359	$32,563	$24,322	$14,165	$10,423
Effect on Net Income ($)	**$30,202**	**$22,406**	**$14,164**	**$4,007**	**$265**

6.3 County Economic Effects

The largest amount of savings will be passed on to the entities which are purchasing the asphalt, in this case, the state and county. The economic effect passed on to the county is conversely related to the revenues of the paving companies. As more pavers adopt oil sands into their asphalt mixtures, market competition will drive prices down and thus pass those savings onto the state and counties. After five years of operation, it is expected that the county will save nearly $45,000 per lane mile of pavement each subsequent year.

Table 9 Economic Effects on County

Decrease in Costs to County:	Year 1	Year 2	Year 3	Year 4	Year 5
Base Cost ($)	$64.00	$64.00	$64.00	$64.00	$64.00
Oil Sand Cost ($)	$62.00	$57.00	$52.00	$46.00	$43.00
Cost Savings (per ton)	$2.00	$7.00	$12.00	$18.00	$21.00
Percent Savings (%)	3%	11%	19%	28%	33%
Total Weight Sales (tons)	2138.4	2138.4	2138.4	2138.4	2138.4
Total Cost Savings ($)	**$4,277**	**$14,969**	**$25,661**	**$38,491**	**$44,906**

The county also owns the mineral rights to the land holding the oil sands. These royalties range between $2.50 and $3.50 per ton. Table 7 shows the expected royalty contributions to the county as a result of one lane mile of pavement.

Table 10 Royalty Contributions

Lease and Royalty Incomes to County:	Year 1	Year 2	Year 3	Year 4	Year 5
Total Oil Sand Sales (Tons)	834	834	834	834	834
Royalty Rate ($)	$2.50	$2.24	$2.00	$1.74	$1.50
Total Royalty Income ($)	$2,084.94	$1,868.11	$1,667.95	$1,451.12	$1,250.96

7 5 Year Analysis

A case analysis was developed to provide a better idea of total cost savings to the counties over the 5 year period. Uintah County paves an average of 47,325 tons of asphalt each year. Table 11 below shows the total savings each year using this annual average.

Table 11 Total 5 Year Savings to County

Decrease in Costs to County:	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Base Cost ($)	$64.00	$64.00	$64.00	$64.00	$64.00	
Oil Sand Cost ($)	$62.00	$57.00	$52.00	$46.00	$43.00	
Cost Savings (per ton)	$2.00	$7.00	$12.00	$18.00	$21.00	
Percent Savings (%)	3%	11%	19%	28%	33%	
Total Weight Sales (tons)	47325	47325	47325	47325	47325	236,625
Total Cost Savings ($)	$94,650	$331,275	$567,900	$851,850	$993,825	$2,839,500

8 Conclusions

Our analysis of the effects of oil sands use in pavement has shown that the concept is economically providential to all parties involved. The adoption of oil sands into asphalt

mixes will result in an increase in net income for both the mining operations and paving companies and a significant positive savings to the county and state.

9 Appendix

Appendix 1- Sensitivity of Oil Sand Quantity in Pavement Mixture
- Appendix 1.1- 15% Oil Sand Use in Mixture
- Appendix 1.2- 40% Oil Sand Use in Mixture
- Appendix 1.3- 60% Oil Sand Use in Mixture

Appendix 2 – Sensitivity of Oil Sand Pavement Price to Oil Sand Mine Production Levels

Appendix 1.1 Sensitvity of using 15% oil sands in pavement mixture

Oil Sand Mining Costs

	Year 1	Year 2	Year 3	Year 4	Year 5
Mine Plan ($/ton)	$0.53	$0.40	$0.29	$0.16	$0.05
Core Drilling exploration ($/ton)	$0.53	$0.40	$0.29	$0.16	$0.05
mine planning ($/ton)	$0.53	$0.40	$0.29	$0.16	$0.05
Permitting ($/ton)	$2.50	$2.11	$1.75	$1.36	$1.00
Overburden Removal ($/ton)	$7.50	$6.85	$6.25	$5.60	$5.00
Mining ($/ton)	$7.50	$6.85	$6.25	$5.60	$5.00
Reclamation ($/ton)	$3.50	$3.11	$2.75	$2.36	$2.00
Lease Payments ($/ton)	$2.50	$2.24	$2.00	$1.74	$1.50
Total Materials Costs ($/ton)	$25.08	$22.36	$19.86	$17.15	$14.65
G&A Costs ($/ton)	$3.76	$3.35	$2.98	$2.57	$2.20
Transportation ($/mile-ton)	$0.10	$0.10	$0.10	$0.10	$0.10
Average Distance (miles)	10	10	10	10	10
Margin (%)	5%	5%	7%	8%	8%
Net Income ($/ton)	**$1.66**	**$1.53**	**$1.66**	**$1.78**	**$1.65**
Total Sales Price ($/ton)	$31.50	$28.25	$25.50	$22.50	$19.50
Taxes ($/ton)	$2.16	$1.94	$1.75	$1.54	$1.34
Total Cost to Asphalt Company ($/ton)	**$33.66**	**$30.19**	**$27.25**	**$24.04**	**$20.84**

Base Asphalt Pavement Costs

	% Weight	Cost/ton	Unit Cost
Coarse Aggregate ($/ton)	59%	$15.00	$8.85
Fine Aggregate ($/ton)	36%	$15.00	$5.40
Binder ($/ton)	5%	$600.00	$30.00
Unit Cost ($/ton)			$44.25
Transportation and Installation ($/ton)			$15.00
Sales Price ($/ton)			$64.00
Margin (%)			7%
Net Income ($/ton)			**$4.75**

Oil Sands Asphalt Pavement Costs

	Year 1	Year 2	Year 3	Year 4	Year 5
Coarse Aggregate ($/ton)	$8.25	$8.25	$8.25	$8.25	$8.25
Fine Aggregate ($/ton)	$3.90	$3.90	$3.90	$3.90	$3.90
Oil Sands ($/ton)	$5.05	$4.53	$4.09	$3.61	$3.13
Binder ($/ton)	$24.00	$24.00	$24.00	$24.00	$24.00
Unit Cost ($/ton)	$41.20	$40.68	$40.24	$39.76	$39.28
Transportation and Installation ($/ton)	$15.00	$15.00	$15.00	$15.00	$15.00
Sales Price ($/ton)	**$62.00**	**$61.25**	**$60.50**	**$59.75**	**$59.10**
Margin (%)	9%	9%	9%	8%	8%
Net Income ($/ton)	**$5.80**	**$5.57**	**$5.26**	**$4.99**	**$4.82**

Increase in Revenue to Oil Sand Operations

	2010	2011	2012	2013	2014
Oil Sand Sales (tons)	321	321	321	321	321
Sales Price ($)	$31.50	$28.25	$25.50	$22.50	$19.50
Total Costs ($)	$29.84	$26.72	$23.84	$20.72	$17.85
Total Revenue Effect($)	$10,104	$9,061	$8,179	$7,217	$6,255
Total Net Income Effect($)	**$534**	**$491**	**$532**	**$569**	**$530**

Resulting Decrease in Costs to County

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Base Cost ($)	$64.00	$64.00	$64.00	$64.00	$64.00	
Oil Sand Cost ($)	$62.00	$61.25	$60.50	$59.75	$59.10	
Cost Savings (per ton)	$2.00	$2.75	$3.50	$4.25	$4.90	
Percent Savings (%)	3%	4%	5%	7%	8%	
Total Weight Sales (tons)	2138.4	2138.4	2138.4	2138.4	2138.4	$10,692
Total Cost Savings ($)	$4,277	$5,881	$7,484	$9,088	$10,478	$37,208

Base Mix Revenue for Paving Companies

	Years 1-5
Base Sales Price ($/ton)	$64.00
Base Costs ($/ton)	$59.25
Total Sales (tons)	$2,138
Base Revenue ($)	$136,858
Base Net Income ($)	**$10,157**

Oil Sands Mix Revenue for Paving Companies

	Year 1	Year 2	Year 3	Year 4	Year 5
Oil Sand Mix Sales Price ($/ton)	$62.00	$61.25	$60.50	$59.75	$59.10
Oil Sand Mix Costs ($/ton)	$56.20	$55.68	$55.24	$54.76	$54.28
Total Sales (tons)	$2,138	$2,138	$2,138	$2,138	$2,138
Oil Sand Mix Revenue ($)	$132,581	$130,977	$129,373	$127,769	$126,379
Oil Sand Mix Net Income ($)	**$12,406**	**$11,916**	**$11,254**	**$10,679**	**$10,317**

Effects on Revenue to Paving Companies

	Year 1	Year 2	Year 3	Year 4	Year 5
Base Revenue ($)	$136,858	$136,858	$136,858	$136,858	$136,858
Oil Sand Mix Revenue ($)	$132,581	$130,977	$129,373	$127,769	$126,379
Effect on Revenue ($)	**($4,277)**	**($5,881)**	**($7,484)**	**($9,088)**	**($10,478)**

Effects on Net Income to Paving Companies

	Year 1	Year 2	Year 3	Year 4	Year 5
Base Net Income ($)	$10,157	$10,157	$10,157	$10,157	$10,157
Oil Sand Mix Net Income ($)	$12,406	$11,916	$11,254	$10,679	$10,317
Effect on Net Income ($)	**$2,248**	**$1,758**	**$1,097**	**$521**	**$160**

Lease and Royalty Incomes to County

	Year 1	Year 2	Year 3	Year 4	Year 5
Total Oil Sand Sales (tons)	321	321	321	321	321
Royalty Rate ($/ton)	$2.50	$2.24	$2.00	$1.74	$1.50
Total Royalty Income ($)	**$802**	**$719**	**$642**	**$558**	**$481**

Appendix 1.2 Sensitvity of using 40% oil sands in pavement mixture

Oil Sand Mining Costs

	Year 1	Year 2	Year 3	Year 4	Year 5
Mine Plan ($/ton)	$0.53	$0.40	$0.29	$0.16	$0.05
Core Drilling exploration ($/ton)	$0.53	$0.40	$0.29	$0.16	$0.05
mine planning ($/ton)	$0.53	$0.40	$0.29	$0.16	$0.05
Permitting ($/ton)	$2.50	$2.11	$1.75	$1.36	$1.00
Overburden Removal ($/ton)	$7.50	$6.85	$6.25	$5.60	$5.00
Mining ($/ton)	$7.50	$6.85	$6.25	$5.60	$5.00
Reclamation ($/ton)	$3.50	$3.11	$2.75	$2.36	$2.00
Lease Payments ($/ton)	$2.50	$2.24	$2.00	$1.74	$1.50
Total Materials Costs ($/ton)	$25.08	$22.36	$19.86	$17.15	$14.65
G&A Costs ($/ton)	$3.76	$3.35	$2.98	$2.57	$2.20
Transportation ($/mile-ton)	$0.10	$0.10	$0.10	$0.10	$0.10
Average Distance (miles)	10	10	10	10	10
Margin (%)	5%	5%	7%	8%	8%
Net Income ($/ton)	**$1.66**	**$1.53**	**$1.66**	**$1.78**	**$1.65**
Total Sales Price ($/ton)	$31.50	$28.25	$25.50	$22.50	$19.50
Taxes ($/ton)	$2.16	$1.94	$1.75	$1.54	$1.34
Total Cost to Asphalt Company ($/ton)	**$33.66**	**$30.19**	**$27.25**	**$24.04**	**$20.84**

Base Asphalt Pavement Costs

	% Weight	Cost/ton	Unit Cost
Coarse Aggregate ($/ton)	59%	$15.00	$8.85
Fine Aggregate ($/ton)	36%	$15.00	$5.40
Binder ($/ton)	5%	$600.00	$30.00
Unit Cost ($/ton)			$44.25
Transportation and Installation ($/ton)			$15.00
Sales Price ($/ton)			$64.00
Margin (%)			7%
Net Income ($/ton)			**$4.75**

Oil Sands Aphalt Pavement Costs

	Year 1	Year 2	Year 3	Year 4	Year 5
Coarse Aggregate ($/ton)	$8.25	$8.25	$8.25	$8.25	$8.25
Fine Aggregate ($/ton)	$0.75	$0.75	$0.75	$0.75	$0.75
Oil Sands ($/ton)	$13.13	$11.77	$10.63	$9.38	$8.13
Binder ($/ton)	$6.00	$6.00	$6.00	$6.00	$6.00
Unit Cost ($/ton)	$28.13	$26.77	$25.63	$24.38	$23.13
Transportation and Installation ($/ton)	$15.00	$15.00	$15.00	$15.00	$15.00
Sales Price ($/ton)	**$62.00**	**$57.00**	**$52.00**	**$46.00**	**$43.00**
Margin (%)	30%	27%	22%	14%	11%
Net Income ($/ton)	**$18.87**	**$15.23**	**$11.37**	**$6.62**	**$4.87**

Increase in Revenue to Oil Sand Operations

	2010	2011	2012	2013	2014
Oil Sand Sales (tons)	834	834	834	834	834
Sales Price ($)	$31.50	$28.25	$25.50	$22.50	$19.50
Total Costs ($)	$29.84	$26.72	$23.84	$20.72	$17.85
Total Revenue Effect($)	$26,270	$23,560	$21,266	$18,764	$16,263
Total Net Income Effect($)	**$1,388**	**$1,277**	**$1,383**	**$1,480**	**$1,378**

Resulting Decrease in Costs to County

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Base Cost ($)	$64.00	$64.00	$64.00	$64.00	$64.00	
Oil Sand Cost ($)	$62.00	$57.00	$52.00	$46.00	$43.00	
Cost Savings (per ton)	$2.00	$7.00	$12.00	$18.00	$21.00	
Percent Savings (%)	3%	11%	19%	28%	33%	
Total Weight Sales (tons)	2138.4	2138.4	2138.4	2138.4	2138.4	$10,692
Total Cost Savings ($)	$4,277	$14,969	$25,661	$38,491	$44,906	$128,304

Base Mix Revenue for Paving Companies

	Years 1-5
Base Sales Price ($/ton)	$64.00
Base Costs ($/ton)	$59.25
Total Sales (tons)	$2,138
Base Revenue ($)	$136,858
Base Net Income ($)	**$10,157**

Oil Sands Mix Revenue for Paving Companies

	Year 1	Year 2	Year 3	Year 4	Year 5
Oil Sand Mix Sales Price ($/ton)	$62.00	$57.00	$52.00	$46.00	$43.00
Oil Sand Mix Costs ($/ton)	$43.13	$41.77	$40.63	$39.38	$38.13
Total Sales (tons)	$2,138	$2,138	$2,138	$2,138	$2,138
Oil Sand Mix Revenue ($)	$132,581	$121,889	$111,197	$98,366	$91,951
Oil Sand Mix Net Income ($)	**$40,359**	**$32,563**	**$24,322**	**$14,165**	**$10,423**

Effects on Revenue to Paving Companies

	Year 1	Year 2	Year 3	Year 4	Year 5
Base Revenue ($)	$136,858	$136,858	$136,858	$136,858	$136,858
Oil Sand Mix Revenue ($)	$132,581	$121,889	$111,197	$98,366	$91,951
Effect on Revenue ($)	**($4,277)**	**($14,969)**	**($25,661)**	**($38,491)**	**($44,906)**

Effects on Net Income to Paving Companies

	Year 1	Year 2	Year 3	Year 4	Year 5
Base Net Income ($)	$10,157	$10,157	$10,157	$10,157	$10,157
Oil Sand Mix Net Income ($)	$40,359	$32,563	$24,322	$14,165	$10,423
Effect on Net Income ($)	**$30,202**	**$22,406**	**$14,164**	**$4,007**	**$265**

Lease and Royalty Incomes to County

	Year 1	Year 2	Year 3	Year 4	Year 5
Total Oil Sand Sales (tons)	834	834	834	834	834
Royalty Rate ($/ton)	$2.50	$2.24	$2.00	$1.74	$1.50
Total Royalty Income ($)	**$2,085**	**$1,868**	**$1,668**	**$1,451**	**$1,251**

Appendix 1.3 Sensitvity of using 60% oil sands in pavement mixture

Oil Sand Mining Costs

	Year 1	Year 2	Year 3	Year 4	Year 5
Mine Plan ($/ton)	$0.53	$0.40	$0.29	$0.16	$0.05
Core Drilling exploration ($/ton)	$0.53	$0.40	$0.29	$0.16	$0.05
mine planning ($/ton)	$0.53	$0.40	$0.29	$0.16	$0.05
Permitting ($/ton)	$2.50	$2.11	$1.75	$1.36	$1.00
Overburden Removal ($/ton)	$7.50	$6.85	$6.25	$5.60	$5.00
Mining ($/ton)	$7.50	$6.85	$6.25	$5.60	$5.00
Reclamation ($/ton)	$3.50	$3.11	$2.75	$2.36	$2.00
Lease Payments ($/ton)	$2.50	$2.24	$2.00	$1.74	$1.50
Total Materials Costs ($/ton)	$25.08	$22.36	$19.86	$17.15	$14.65
G&A Costs ($/ton)	$3.76	$3.35	$2.98	$2.57	$2.20
Transportation ($/mile-ton)	$0.10	$0.10	$0.10	$0.10	$0.10
Average Distance (miles)	10	10	10	10	10
Margin (%)	5%	5%	7%	8%	8%
Net Income ($/ton)	**$1.66**	**$1.53**	**$1.66**	**$1.78**	**$1.65**
Total Sales Price ($/ton)	$31.50	$28.25	$25.50	$22.50	$19.50
Taxes ($/ton)	$2.16	$1.94	$1.75	$1.54	$1.34
Total Cost to Asphalt Company ($/ton)	**$33.66**	**$30.19**	**$27.25**	**$24.04**	**$20.84**

Base Asphalt Pavement Costs

	% Weight	Cost/ton	Unit Cost
Coarse Aggregate ($/ton)	59%	$15.00	$8.85
Fine Aggregate ($/ton)	36%	$15.00	$5.40
Binder ($/ton)	5%	$600.00	$30.00
Unit Cost ($/ton)			$44.25
Transportation and Installation ($/ton)			$15.00
Sales Price ($/ton)			$64.00
Margin (%)			7%
Net Income ($/ton)			**$4.75**

Oil Sands Asphalt Pavement Costs

	Year 1	Year 2	Year 3	Year 4	Year 5
Coarse Aggregate ($/ton)	$6.00	$6.00	$6.00	$6.00	$6.00
Fine Aggregate ($/ton)	$0.00	$0.00	$0.00	$0.00	$0.00
Oil Sands ($/ton)	$20.19	$18.11	$16.35	$14.42	$12.50
Binder ($/ton)	$0.00	$0.00	$0.00	$0.00	$0.00
Unit Cost ($/ton)	$26.19	$24.11	$22.35	$20.42	$18.50
Transportation and Installation ($/ton)	$15.00	$15.00	$15.00	$15.00	$15.00
Sales Price ($/ton)	**$62.00**	**$55.00**	**$50.00**	**$45.00**	**$38.25**
Margin (%)	34%	29%	25%	21%	12%
Net Income ($/ton)	**$20.81**	**$15.89**	**$12.65**	**$9.58**	**$4.75**

Increase In Revenue to Oil Sand Operations

	2010	2011	2012	2013	2014
Oil Sand Sales (tons)	1283	1283	1283	1283	1283
Sales Price ($)	$31.50	$28.25	$25.50	$22.50	$19.50
Total Costs ($)	$29.84	$26.72	$23.84	$20.72	$17.85
Total Revenue Effect($)	$40,416	$36,246	$32,718	$28,868	$25,019
Total Net Income Effect($)	**$2,135**	**$1,964**	**$2,127**	**$2,278**	**$2,120**

Resulting Decrease in Costs to County

	Year 1	Year 2	Year 3	Year 4	Year 5
Base Cost ($)	$64.00	$64.00	$64.00	$64.00	$64.00
Oil Sand Cost ($)	$62.00	$55.00	$50.00	$45.00	$38.25
Cost Savings (per ton)	$2.00	$9.00	$14.00	$19.00	$25.75
Percent Savings (%)	3%	14%	22%	30%	40%
Total Weight Sales (tons)	2138.4	2138.4	2138.4	2138.4	2138.4
Total Cost Savings ($)	$4,277	$19,246	$29,938	$40,630	$55,064

Base Mix Revenue for Paving Companies

	Years 1-5
Base Sales Price ($/ton)	$64.00
Base Costs ($/ton)	$59.25
Total Sales (tons)	$2,138
Base Revenue ($)	$136,858
Base Net Income ($)	**$10,157**

Oil Sands Mix Revenue for Paving Companies

	Year 1	Year 2	Year 3	Year 4	Year 5
Oil Sand Mix Sales Price ($/ton)	$62.00	$55.00	$50.00	$45.00	$38.25
Oil Sand Mix Costs ($/ton)	$41.19	$39.11	$37.35	$35.42	$33.50
Total Sales (tons)	$2,138	$2,138	$2,138	$2,138	$2,138
Oil Sand Mix Revenue ($)	$132,581	$117,612	$106,920	$96,228	$81,794
Oil Sand Mix Net Income ($)	**$44,490**	**$33,977**	**$27,055**	**$20,476**	**$10,154**

Effects on Revenue to Paving Companies

	Year 1	Year 2	Year 3	Year 4	Year 5
Base Revenue ($)	$136,858	$136,858	$136,858	$136,858	$136,858
Oil Sand Mix Revenue ($)	$132,581	$117,612	$106,920	$96,228	$81,794
Effect on Revenue ($)	**($4,277)**	**($19,246)**	**($29,938)**	**($40,630)**	**($55,064)**

Effects on Net Income to Paving Companies

	Year 1	Year 2	Year 3	Year 4	Year 5
Base Net Income ($)	$10,157	$10,157	$10,157	$10,157	$10,157
Oil Sand Mix Net Income ($)	$44,490	$33,977	$27,055	$20,476	$10,154
Effect on Net Income ($)	**$34,333**	**$23,819**	**$16,898**	**$10,318**	**-$3**

Lease and Royalty Incomes to County

	Year 1	Year 2	Year 3	Year 4	Year 5
Total Oil Sand Sales (tons)	1283	1283	1283	1283	1283
Royalty Rate ($/ton)	$2.50	$2.24	$2.00	$1.74	$1.50
Total Royalty Income ($)	**$3,208**	**$2,874**	**$2,566**	**$2,232**	**$1,925**

Appendix 2 - Sensitivity of Oil Sand Pavement Price to Oil Sand Mine Production Levels

Oil Sand Mining Costs

	Year 1	Year 2	Year 3	Year 4	Year 5
Mine Plan ($/ton)	$0.53	$0.53	$0.53	$0.53	$0.53
Core Drilling exploration ($/ton)	$0.53	$0.53	$0.53	$0.53	$0.53
mine planning ($/ton)	$0.53	$0.53	$0.53	$0.53	$0.53
Permitting ($/ton)	$2.50	$2.50	$2.50	$2.50	$2.50
Overburden Removal ($/ton)	$7.50	$7.50	$7.50	$7.50	$7.50
Mining ($/ton)	$7.50	$7.50	$7.50	$7.50	$7.50
Reclamation ($/ton)	$3.50	$3.50	$3.50	$3.50	$3.50
Lease Payments ($/ton)	$2.50	$2.50	$2.50	$2.50	$2.50
Total Materials Costs ($/ton)	$25.08	$25.08	$25.08	$25.08	$25.08
G&A Costs ($/ton)	$3.76	$3.76	$3.76	$3.76	$3.76
Transportation ($/mile-ton)	$0.10	$0.10	$0.10	$0.10	$0.10
Average Distance (miles)	10	10	10	10	10
Margin (%)	5%	5%	5%	5%	5%
Net Income ($/ton)	**$1.66**	**$1.66**	**$1.66**	**$1.66**	**$1.66**
Total Sales Price ($/ton)	$31.50	$31.50	$31.50	$31.50	$31.50
Taxes ($/ton)	$2.16	$2.16	$2.16	$2.16	$2.16
Total Cost to Asphalt Company ($/ton)	**$33.66**	**$33.66**	**$33.66**	**$33.66**	**$33.66**

Base Asphalt Pavement Costs

	% Weight	Cost/ton	Unit Cost
Coarse Aggregate ($/ton)	59%	$15.00	$8.85
Fine Aggregate ($/ton)	36%	$15.00	$5.40
Binder ($/ton)	5%	$600.00	$30.00
Unit Cost ($/ton)			$44.25
Transportation and Installation ($/ton)			$15.00
Sales Price ($/ton)			$64.00
Margin (%)			7%
Net Income ($/ton)			**$4.75**

Oil Sands Asphalt Pavement Costs

	Year 1	Year 2	Year 3	Year 4	Year 5
Coarse Aggregate ($/ton)	$8.25	$8.25	$8.25	$8.25	$8.25
Fine Aggregate ($/ton)	$0.75	$0.75	$0.75	$0.75	$0.75
Oil Sands ($/ton)	$13.13	$13.13	$13.13	$13.13	$13.13
Binder ($/ton)	$6.00	$6.00	$6.00	$6.00	$6.00
Unit Cost ($/ton)	$28.13	$28.13	$28.13	$28.13	$28.13
Transportation and Installation ($/ton)	$15.00	$15.00	$15.00	$15.00	$15.00
Sales Price ($/ton)	**$62.00**	**$58.00**	**$54.00**	**$51.00**	**$48.00**
Margin (%)	30%	26%	20%	15%	10%
Net Income ($/ton)	**$18.87**	**$14.87**	**$10.87**	**$7.87**	**$4.87**

Increase in Revenue to Oil Sand Operations

	2010	2011	2012	2013	2014
Oil Sand Sales (tons)	834	834	834	834	834
Sales Price ($)	$31.50	$31.50	$31.50	$31.50	$31.50
Total Costs ($)	$29.84	$29.84	$29.84	$29.84	$29.84
Total Revenue Effect($)	$26,270	$26,270	$26,270	$26,270	$26,270
Total Net Income Effect($)	**$1,388**	**$1,388**	**$1,388**	**$1,388**	**$1,388**

Resulting Decrease in Costs to County

	Year 1	Year 2	Year 3	Year 4	Year 5	Total	
Base Cost ($)	$64.00	$64.00	$64.00	$64.00	$64.00		
Oil Sand Cost ($)	$62.00	$58.00	$54.00	$51.00	$48.00		
Cost Savings (per ton)	$2.00	$6.00	$10.00	$13.00	$16.00		
Percent Savings (%)	3%	9%	16%	20%	25%		
Total Weight Sales (tons)	2138.4	2138.4	2138.4	2138.4	2138.4	10692	1603.8
Total Cost Savings ($)	$4,277	$12,830	$21,384	$27,799	$34,214	$100,505	$201,010

Base Mix Revenue for Paving Companies

	Years 1-5
Base Sales Price ($/ton)	$64.00
Base Costs ($/ton)	$59.25
Total Sales (tons)	$2,138
Base Revenue ($)	$136,858
Base Net Income ($)	**$10,157**

Oil Sands Mix Revenue for Paving Companies

	Year 1	Year 2	Year 3	Year 4	Year 5
Oil Sand Mix Sales Price ($/ton)	$62.00	$58.00	$54.00	$51.00	$48.00
Oil Sand Mix Costs ($/ton)	$43.13	$43.13	$43.13	$43.13	$43.13
Total Sales (tons)	$2,138	$2,138	$2,138	$2,138	$2,138
Oil Sand Mix Revenue ($)	$132,581	$124,027	$115,474	$109,058	$102,643
Oil Sand Mix Net Income ($)	**$40,359**	**$31,805**	**$23,252**	**$16,837**	**$10,421**

Effects on Revenue to Paving Companies

	Year 1	Year 2	Year 3	Year 4	Year 5
Base Revenue ($)	$136,858	$136,858	$136,858	$136,858	$136,858
Oil Sand Mix Revenue ($)	$132,581	$124,027	$115,474	$109,058	$102,643
Effect on Revenue ($)	**($4,277)**	**($12,830)**	**($21,384)**	**($27,799)**	**($34,214)**

Effects on Net Income to Paving Companies

	Year 1	Year 2	Year 3	Year 4	Year 5
Base Net Income ($)	$10,157	$10,157	$10,157	$10,157	$10,157
Oil Sand Mix Net Income ($)	$40,359	$31,805	$23,252	$16,837	$10,421
Effect on Net Income ($)	**$30,202**	**$21,648**	**$13,094**	**$6,679**	**$264**

Lease and Royalty Incomes to County

	Year 1	Year 2	Year 3	Year 4	Year 5
Total Oil Sand Sales (tons)	834	834	834	834	834
Royalty Rate ($/ton)	$2.50	$2.50	$2.50	$2.50	$2.50
Total Royalty Income ($)	**$2,085**	**$2,085**	**$2,085**	**$2,085**	**$2,085**

APPENDIX G

UTAH CLUSTER ACCELERATION PROGRAM APPLICATION

Utah Cluster Acceleration Grant Proposal

GOED Cluster Director Submitting Proposal: Energy

Primary contact person for grant project:

Alan J. Walker, Executive Director Utah Energy Research Triangle, University of Utah Energy & Geoscience Institute, 423 Wakara Way, Suite 300, Salt Lake City, Utah 84108

Phone: 801 864-5960

E-mail: alanjwalker@egi.utah.edu alanjwalker@utah.gov

NARRATIVE

Governor Gary R. Herbert outlined a vision for the Utah Energy Research Triangle in his March 2011, "ENERGY INITIATIVES & IMPERATIVES, *Utah's Ten-Year Strategic Energy Plan*" (http://www.utah.gov/governor/docs/10year-stragegic-energy.pdf) and among the key steps are:

- "Align the State's main research universities – University of Utah (U of U), Utah State University (USU) and Brigham Young University (BYU) into a powerful energy research and development triangle
- Connect this "Research Triangle" with global industry, national laboratories, and regional universities to effectively commercialize new energy technologies and develop Utah's conventional, alternative, efficiency, and renewable energy resources
- Empower Utah's education system to expand its ability to train attract and retain skilled talent necessary to grow Utah's energy economy"

The development of the Strategic Energy Plan was preceded by a Utah Cluster Acceleration Partnership effort in 2009 through 2010 which resulted in a fall 2010 report (http://www.growutahventures.com/wp-content/uploads/Energy-Final_Report.pdf) entitled "ACCELERATING UTAH'S ENERGY INDUSTRY" and the first three key supporting strategies are:

- "TALENT DEVELOPMENT - Increase Trained Workforce
- APPLIED RESEARCH - Research Viability of Renewable Energy
- RESEARCH AND DEVELOPMENT - State Sponsored Research Agenda"

The Energy Research Triangle (ERT) will address serious energy-related issues, such as air quality, water management, and energy security. The ERT will assist identification of the best solutions for society and industry through collaborative applied research. As an example, a recent study by the Utah Department of Transportation identified that 26,802 long-term jobs (10-year FTE) are at risk, given the condition of the current transportation infrastructure. Solutions to this issue are being studied using limited public and private efforts in singular efforts, yet the ERT could accelerate development over multiple pathways at multiple universities. *This proposal requests UCAP support to supplement ERT funding such that OED and USTAR can operationalize Governor Herbert's vision and the UCAP Energy Cluster's key supporting strategies by launching the Utah Energy Research Triangle to develop solutions to Utah's most serious energy issues.*

I. Project Scope

Purpose of Funding

The goal of the Energy Research Triangle (ERT) is to promote collaborative energy research leading to innovations that improves the welfare and quality of life for Utah citizens with potential commercially deployable technologies. The Office of Energy Development (OED) with the assistance of USTAR (Utah Science Technology and Research) has been tasked to operationalize the ERT component of the bold vision in the Strategic Energy Plan and Cluster Acceleration Partnership. .

The Energy Research Triangle proposes to meet the Governor's and UCAP's goals through two major programs. The first, known as the Tier 1: Principle Energy Issues program is designed to fund up to three of Utah's University-based Principle Investigators (PI) to research solutions to significant challenges in the energy space for the benefit of society. Each PI will receive up to $150,000 grant annually with follow-on funding dependent on first year milestones and future sources. The PI will be responsible for developing and executing a scope of work that follows the principles of Utah's Strategic Energy Plan for collaborative research with other Utah universities. These applied research projects are limited in time and scope to address Utah unique energy issues in conventional energy, renewable energy, unconventional energy, and storage or energy efficiency. The goal is to spark collaboration among the research universities and develop a foundational capacity to promote future collaboration on energy research.

The second major program effort to meet the Governor's and UCAP's goals is through the Tier 2: Governor's Energy Leadership Scholars program. The purpose of this program is to accelerate Utah's next generation of talent for scientific and engineering innovation leadership while simultaneously addressing Utah's unique energy challenges with cutting-edge solutions. This program is designed to fund energy research by up to four of Utah's most promising scholars (B.S., M.S. or Ph.D. candidates) annually to develop applied research solutions to significant Utah energy challenges. Each scholar will receive up to a $15,000 grant on his or her proposed topic. After one year, winners can re-apply for an additional $15,000 for research on the same topic

Applied research proposals will be initially screened and nominated by the VP of Research at the respective universities. The final selection committee will include as a minimum, the Governor's Energy Advisor, Executive Director of the ERT, Director of OED, and others appointed by the Governor. Periodic review will ensure quality and the awardees progress will be highlighted and recognized at the Governor's Energy Summit in June 2014.

This grant submission proposes to supplement partial funding by OED and USTAR to enable the Tier 1: Principle Energy Issues program and the Tier 2: Governor's Energy Leadership Scholars program. For FY 14, OED has allocated $45,000 for Tier 2, USTAR has proposed allocation of $200,000 for Tier 1, and currently USTAR is absorbing all the overhead of approximately $87,000 for a total of $332,000. This request for $265,000 for Tier 1 ($250,000) and Tier 2 ($15,000) will be used entirely for programmatic expansion as the initial costs and overhead has been allocated. The program administration has been finalized and is modeled after the current Technology Commercialization & Innovation Program (TCIP) application template used by the

Governor's Office of Economic Development (GOED). For FY 15, funding has been requested through the Governor's budgeting process

Collaboration

The Energy Research Triangle has established collaborative relationships with academia, government and industry. University of Utah, Utah State University and Brigham Young University offices of Research have been supportive of this proposal. The ERT has also approached Utah energy companies and energy advocacy groups on supporting energy research. All parties have identified significant need within the energy industry for a highly skilled workforce. Currently, this skill gap is dramatic. As an example, on a national scale, Utah is 9th in natural gas production and 11th in crude oil production. However, Utah universities do not graduate sufficient petroleum engineers given demand. Now the first Master of Science in Petroleum Engineering program in Utah will begin in August 2013 and graduate in May 2015. This program is open to BYU and USU engineering students, web-based students on the UEN, and is taught, in part, by a BYU Professor Keach with a field study in the Uintah Basin partly hosted by USU. Filling this type of shortfall in Utah for the highly trained engineers and scientists for industry has been accomplished through support by OED, USTAR, ERT and dedicated faculty.

In addition to workforce concerns, there are major technical challenges facing energy production in Utah. As an example, transportation requirements associated with the high wax content of Uintah Basin crude oils tax our state infrastructure which is currently unable to accommodate expected growth in production. In a recent study by UDOT, an estimated lost opportunity associated with these technical issues is approximately $1 billion per year over the next 30 years (Fig A) and the loss of 26,802 long-term jobs (Fig. B). The Energy Research Triangle is positioning itself to encourage Utah's brightest researchers to address problems like these. Similarly, by USGS estimates, Utah possesses 9% of the United States' enhanced geothermal reserves, yet many current geothermal projects are being sited in neighboring Idaho and Nevada. There are many reasons for these decisions but they are undoubtedly influenced by the lack of public investment and workforce ability.

Figure A: Opportunity Cost

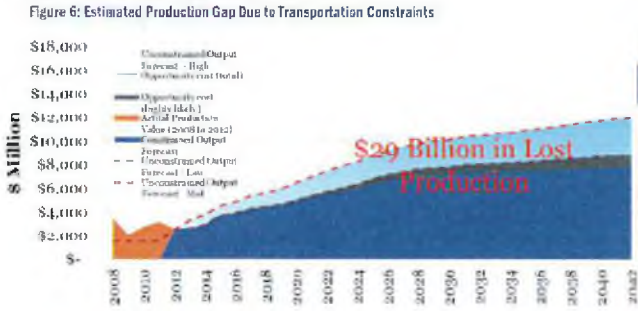


Figure B: Jobs, Revenue and Social Costs

Table 3: The Opportunity Cost of Constrained Oil and Gas Transportation Capacity in the Uinta Basin. Present Value* (over 30 Years)

Revenues and User Cost Savings ($ Million)		Environmental and Social Costs ($Million)		Macroeconomic Impact	
Profit, rents, dividends, and private royalties^	$3,764	Site emissions and ecological impacts	($1,246)	Total regional output, $ Million	$34,794
State and local tax revenue	$2,756	Vehicle emissions	($24)	Total labor income, $ Million	$11,791
User cost savings	$4,843	Safety impacts	($101)	Long-term jobs^	26,802
Total	$11,483	Total	($1,371)		

Note: Does not account for costs of added transportation investment, but rather provides a basis against which to evaluate whether the cost of additional transportation investment is justified

* 3% discount rate

^ Represents the portion of total state economic output that is additional private (labor/corporate profit net of expenses and resource depletion)

Full-time equivalent (FTE). Assumes a 10-year term of employment

Note: See Appendix A for full-size versions of these tables

The importance of developing a highly trained workforce and promoting a state-sponsored applied energy research agenda are vital themes touched on in the UCAP "ACCELERATING UTAH'S ENERGY INDUSTRY" report, the Strategic Energy Plan and the Uintah Basin Energy and Transportation Study. The ERT provides a pathway to operationalize the visions they have

previously outlined. It offers an opportunity to simultaneously invest in developing future leaders in Utah's knowledge economy, promote energy development vital to rural Utah and address major challenges the state faces with energy security, resource management, public health and environmental quality.

II. Project Outcomes

The primary outcome from the ERT proposal will be applied research projects: three by Principle Investigators and four by student-level Energy Leadership Scholars. These projects will be selected on the likelihood of their potential to improve the welfare and quality of life for Utah citizens with potential commercially deployable technology. Potentially, each university could lead one principle project and one scholar project, with one scholar project reserved for a Utah Indian tribal member. Regardless of location and applicant, these research projects will be judged on merit and be matched with industry interests. The universities will leverage their commercialization capabilities to roll out promising technology.

By focusing on a project-based initiative, the ERT will promote new capacity for certificate and degree programs in two ways. First, these projects will fund PIs, who in turn will hire post-doctorate scientists and engineers, Ph.D. and M.S. candidates, and undergraduates to assist in their research. These expanded opportunities for students in the STEM fields will be bolstered by the Governor's Energy Leadership Scholar program specifically designed to get resources to promising students who will in turn focus on energy topics. These opportunities will expand university research capacity and throughput in critical areas and in turn produce applied research solutions to serious issues and qualified graduates for the professional world.

The second way in which the Energy Research Triangle will promote University capacity is perhaps even more impactful. By promoting university collaboration, the ERT will draw on the complementary and unique resources at each of Utah's research universities. As we build this collaborative network, this cross-university synergy will become more and more common. This will expand the possibilities both for students and researchers and provides a strong foundation for Utah's knowledge economy.

These projects will be reviewed on a semi-annual basis by the Executive Director of the Energy Research Triangle under the guidance of the Governor's Energy Advisor. Applicants will be required to provide tangible milestones for their research and follow-on funding in future years will be dependent on meeting those milestones. The universities will track projects and any commercialization associated with ERT projects will be captured by the respective university.

III. Matching Funds

The ERT has identified matching funds that will leverage UCAP support. USTAR has proposed $200,000 to support the Tier 1, Principle Energy Issues program. In addition, USTAR is providing $87,000 in in-kind support with overhead of program management and administrative support. This includes 33% FTE for an Executive Director at $49,000, 50% FTE for an Analyst at $28,000, and Finance/Administrative Support at approximately $10,000.

ERT has also secured $45,000 from OED, designed to be used to fund three of the Governor's Energy Leadership Scholars. This comes to $245,000 in resource support and an additional

$87,000 of in-kind support, totaling $332,000 in support of UCAP's $265,000 investment. This is a 1.25:1 ratio of matching funds to UCAP funds.

IV. Budget

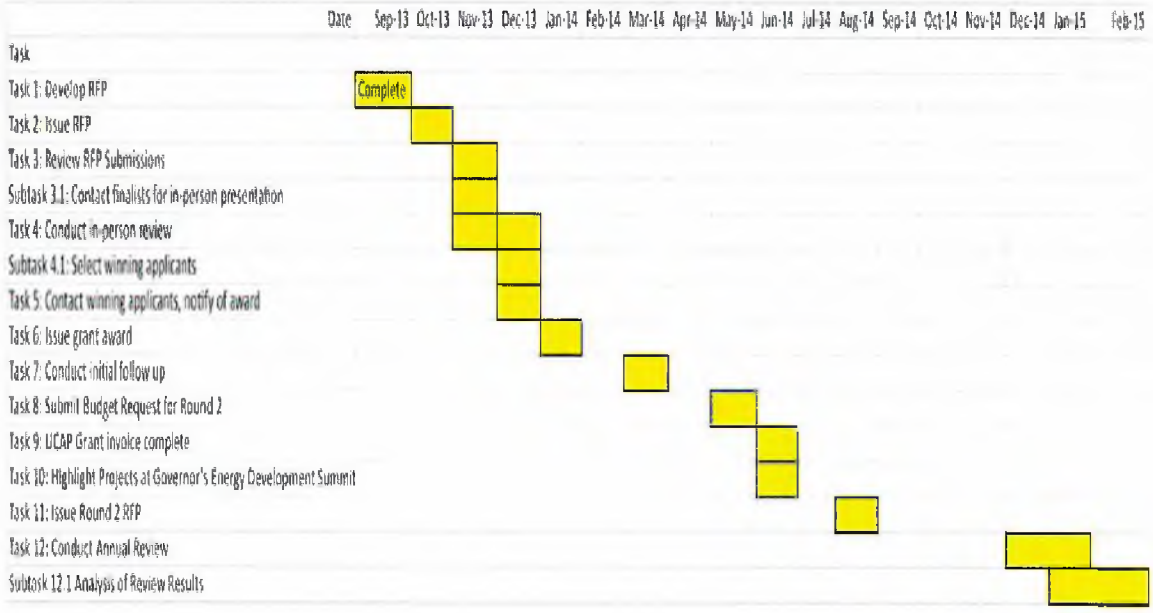
Leveraging UCAP Funding

An investment in the Energy Research Triangle by UCAP offers the opportunity for significant leveraging. The ERT request from UCAP of $265,000 will be matched with a $45,000 from OED, a proposed $200,000 by USTAR and an $87,000 in-kind participation by USTAR for a total of $332,000 in support for the ERT. The ERT has also been pursuing industry support and has submitted a request for Gov. Herbert's FY2015 budget. This gives the ERT the potential both to be highly impactful and sustainable beyond the initial UCAP investment.

Program			USTAR (Utah Science Technology and Research)	OED (Office of Energy Development)	UCAP (Utah Cluster Acceleration Partnership)
Utah Energy Research Triangle					
Tier 1: Principle Research	Project 1	$ 150,000	100000		50000
Tier 1: Principle Research	Project 2	$ 150,000	100000		50000
Tier 1: Principle Research	Project 3	$ 150,000			150000
Tier 2: Governor's Energy Leadership Scholar	Brigham Young University	$ 15,000		15000	
Tier 2: Governor's Energy Leadership Scholar	Utah State University	$ 15,000		15000	
Tier 2: Governor's Energy Leadership Scholar	University of Utah	$ 15,000		15000	
Tier 2: Governor's Energy Leadership Scholar	Utah Tribal Member	$ 15,000		0	15000
In-Kind, 33% ERT Ex Director	USTAR	$ 49,000	49000		
In-Kind, 50% ERT Analyst	USTAR	$ 28,000	28000		
In-Kind, Finance and Administrative Support	USTAR	$ 10,000	10000		
		$ 597,000	$ 287,000	$ 45,000	$ 265,000
			48%	8%	44%

V. Timeline

The graphic below shows the logical sequence of program elements.



The first step of developing the RFP criteria is modeled after the existing GOED TCIP program. The Request for Proposal (RFP) would be issued upon award of the grant and the final step in FY 14 would be highlighting the research at the Governor's Energy Summit. It is understood that all grant funds must be invoiced by June 30, 2014, with extensions granted by the Governing Board on an exceptional basis.

VI. Supporting Documentation

Links to supporting documentation are included in the narrative above and in the following Appendix A. The impetus for numerous energy industry acceleration initiatives, including the Utah Energy Research Triangle began with work by Utah Cluster Acceleration Partnership for energy in 2009 and was followed shortly by formation of the Governor's Energy Task Force. Many of the members of the UCAP effort served concurrently on the UCAP Steering Committee, the Governor's Energy Task Force, and subcommittees of the Energy Task Force. Two important documents, the UCAP fall 2010 report entitled "ACCELERATING UTAH'S ENERGY INDUSTRY" and the March 2011 Energy Task Force report entitled "ENERGY INITIATIVES & IMPERATIVES, *Utah's 10-Year Strategic Energy Plan*" enumerated strategies and recommended activates to accelerate Utah's energy industry. These reports list the proponents by name and company or agency that participated and contributed to these reports.

The UCAP focus on energy issues has continued with the Energy Cluster Acceleration Partnership (ECAP) and a second published report in January 2013 entitled "ACCELERATING UTAH'S ENERGY INDUSTRY". In the Executive Summary a major highlighted outcome is "Collaborated with the Utah Energy Research Triangle…" and a key recommendation for moving forward is to, "Support research collaboration opportunities."

VII. Conclusion

This proposal requests UCAP support to supplement Energy Research Triangle funding with $265,000 to enhance $332,000 from other agencies, such that OED and USTAR can operationalize Governor Herbert's vision and the UCAP Energy Cluster's key supporting strategies by launching the Utah Energy Research Triangle to develop solutions to Utah's most serious energy issues.

Appendix A

Utah Cluster Acceleration Program, Accelerating Utah's Energy Industry: http://www.growutahventures.com/wp-content/uploads/Energy-Final_Report.pdf – Key Supporting Strategies

Governor Herbert's 10-Year strategic Energy Plan: http://www.utah.gov/governor/docs/10year-stragegic-energy.pdf, See Section VII for Energy Research Triangle

Uintah Basin Energy and Transportation Study (UBETS), Utah Department of Transportation http://www.udot.utah.gov/main/uconowner.gf?n=3975604202569320 Outlines the $1B/year opportunity cost and threat to 26,802 long-term jobs

The figure and table below are sourced from the UBETS and forecast production growth and transportation constraints and resultant lost revenue and long-term job opportunities:

Figure 6: Estimated Production Gap Due to Transportation Constraints

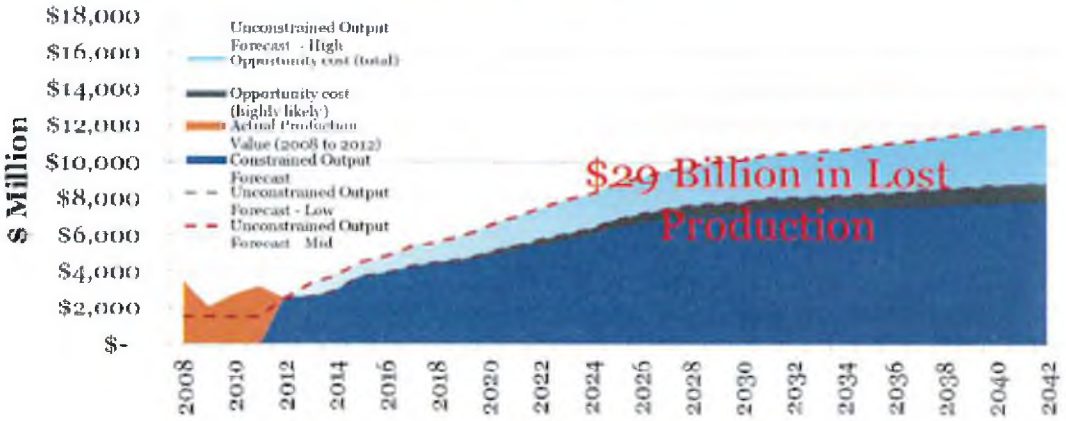


Table 3: The Opportunity Cost of Constrained Oil and Gas Transportation Capacity in the Uinta Basin, Present Value[a] (over 30 Years)

Revenues and User Cost Savings ($ Million)		Environmental and Social Costs ($Million)		Macroeconomic Impact	
Profit, rents, dividends, and private royalties[b]	$3,784	Site emissions and ecological impacts	($1,246)	Total regional output, $ Million	$34,794
State and local tax revenue	$2,756	Vehicle emissions	($24)	Total labor income, $ Million	$11,791
User cost savings	$4,943	Safety impacts	($101)	Long-term jobs[c]	26,802
Total	**$11,483**	**Total**	**($1,371)**		

Note: Does not account for costs of added transportation investment, but rather provides a basis against which to evaluate whether the cost of additional transportation investment is justified.

[a] 3% discount rate.

[b] Represents the portion of total macroeconomic output that is additional private citizen/corporate profit net of expenses and resource depletion.

[c] Full-time equivalent (FTE). Assumes a 10-year term of employment.

GARY R. HERBERT
Governor

GREG BELL
Lieutenant Governor

Office of the Governor

CODY B. STEWART
Energy Advisor

SAMANTHA MARY JULIAN
Director, Office of Energy Development

August 23, 2013

UCAP Grant Review Committee
Attn: Melisa Stark
1951 W 5400 S
Roy, UT 84067

RE:Utah Cluster Acceleration Partnership Grant Program Competitive Announcement for 2013-2014

Dear Ms. Stark and Grant Committee;

As Governor's Energy Advisor, I am writing to highly recommend the Utah Energy Research Triangle's application for the Utah Cluster Acceleration Partnership Grant Program for the Energy Cluster, 2013-2014. With anticipated substantial growth for Utah in the next twenty years, innovation will be vital in meeting future energy demand and addressing key energy issues.

This proposal aligns well with the mission of the Office of Energy Development(OED) to provide leadership in the balanced development of Utah's abundant energy resources through public and private partnerships for economic prosperity, energy independence and a reliable, affordable energy supply.

This grant proposal will support the efforts of OED, through the Utah Energy Research Triangle, to fulfill the recommendations of the Governor's 10-Year Strategic Energy Plan for Utah, including:

- Align the State's main research universities – University of Utah, Utah State University, Brigham Young University – into a powerful energy research and development triangle;
- Connect this "Research Triangle" with global industry, national laboratories, and regional universities to effectively commercialize new energy technologies and develop Utah's conventional, alternative and renewable energy resources; and,
- Empower Utah's educational system to expand its ability to train, attract and retain the skilled talent necessary to grow Utah's energy economy.

This proposal will further Governor Gary R. Herbert's *Four Cornerstones* including education, energy, jobs, and self-determination. Specifically, Objective 3 in Energy is to aggressively pursue technology innovation in energy efficiency and development. The two tier program identified in the proposal will expand the world-class energy technology innovation and research already being conducted in Utah's top universities and will enable Utah to remain a leader in energy development.

Thank you for your full consideration of this request. Please contact me if you have further questions.

Sincerely,

Cody Stewart

Cody B. Stewart
Governor's Energy Advisor
State of Utah

60 East South Temple, 3rd Floor • Salt Lake City, Utah 84111
Mailing Address: PO Box 144845 • Salt Lake City, Utah 84114-4845
Telephone: (801) 538-8732 • Fax 855-271-4373
www.energy.utah.gov

September 4, 2013

UCAP Grant Review Committee
Attn: Melisa Stark
1951 W 5400 S
Roy, UT 84067

Dear Grant Review Committee:

As an Associate Professor of Chemical Engineering at the University of Utah, I am very pleased to endorse the Utah Energy Research Triangle proposal to the Utah Cluster Acceleration Program. The proposal advocates an excellent methodology for providing relevant, Utah-centric research funding. The $150,000 level for research will generate substantial interest and afford the potential for real progress on relevant technical issues.

As a University faculty member with strong research interests in energy research and development, I perceive that the Utah Energy Research Triangle is an excellent opportunity to develop solutions to Utah's energy challenges, build cross-university collaboration, and facilitate learning opportunities for university students.

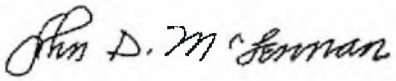
Utah's research universities have excellent capacities in science, technology and engineering; and each institution has internationally-recognized areas of specialization and research. However, there are relatively few existing pathways for effective cross-university synergies that can amalgamate research and collectively exploit these specializations. The Energy Research Triangle's proposed collaborative research projects provide an appropriate opportunity to work collaboratively on topics that would benefit Utah's citizens.

Having joined the University after nearly three decades with petroleum service and consulting organizations, I am very much aware of the energy industry's critical need for a highly trained workforce. The Energy Research Triangle also provides a rational approach for addressing this shortfall by funding the next generation of researchers - as the Governor's Energy Leadership Scholars.

I strongly support the Energy Research Triangle proposal – both as a long-time professional in the energy industry and as a newly-minted academic at the University of Utah. From a perspective of full disclosure, I candidly would be anxious to compete for

research funding. However, also from a broader, philanthropic perspective, this concept addresses fundamental energy and societal issues. These issues can be best resolved collaboratively - by blending specific strengths from the individual Utah educational organizations. This proposal strikes me as a well-conceived mechanism for developing technological solutions and for concurrently providing mature, well-educated students to the Utah work force.

I would be very pleased to provide clarification or additional information. I can be contacted at jmclennan@egi.utah.edu or 801-587-7925.
Sincerely,



John McLennan, Ph.D.
Associate Professor
Department of Chemical Engineering
University of Utah

WESTERN ENERGY ALLIANCE

September 5, 2013

UCAP Grant Review Committee
Attn: Melisa Stark
1951 W 5400 S
Roy, UT 84067

RE: Utah Energy Research Triangle Application – Utah Cluster Acceleration Partnership Grant Program for the Energy Cluster, 2013-2014

Dear Ms. Stark and Grant Review Committee:

Western Energy Alliance wishes to express its support for the Utah Energy Research Triangle's application for the Utah Cluster Acceleration Partnership Grant Program for the Energy Cluster, 2013-2014. We believe the endeavor will contribute toward continued energy technological innovation and benefit the economy of Utah while helping address important American energy issues. Western Energy Alliance represents over 400 companies engaged in all aspects of environmentally responsible exploration and production of oil and natural gas in Utah and across West.

Coordinating the research capabilities of Utah's major research universities will help foster technological innovation in the energy sector. We have seen how recent technological innovation in oil and natural gas exploration and development has brought about a renaissance in American energy production and changed the conversation on national energy security for the better, and it is vital to continue that trend. Collaborative efforts by Utah's leading universities will help contribute to further energy innovation.

Connecting Utah's universities with other academic institutions, laboratories, and global industry is an effective way to put new technologies to practical use. Moving ideas from the conceptual phase to real world application is the ultimate goal, which the proposal recognizes and seeks to achieve.

As the oil and natural gas industry moves forward with expanded production and improved technology, a skilled workforce is vital. The third leg of the proposal seeks to equip Utah's education system with the ability to train this workforce, and keep these high paying jobs in Utah. This is good for oil and natural gas companies in Utah, as well as for the economy of the state. I strongly recommend grant funding for UERT.

Sincerely,

Lowell Braxton

Lowell Braxton
Utah Representative, Western Energy Alliance

410 17th Street, Ste. 700 Denver, CO 80202
P 303.623.0987 F 303.893.0709 W westernenergyalliance.org

UTAH CLEAN ENERGY
'e Partner to Build the New Clean Energy Economy

September 6, 2013

UCAP Grant Review Committee
Attn: Melisa Stark
1951 W 5400 S
Roy, UT 84067

RE: Utah Cluster Acceleration Partnership Grant Program Competitive Announcement for 2013-2014

Dear Ms. Stark:

Utah Clean Energy is pleased to provide this letter of support for the Utah Energy Research Triangle's application for funding from the Utah Cluster Acceleration Partnership's 2013/2014 Grant Program.

The Utah Energy Research Triangle's commitment to advance research and deployment of energy efficiency and renewable energy is in direct alignment with Utah Clean Energy's goal to build the new clean energy economy in Utah. Furthermore, it directly aligns with Governor Herbert's goal (as expressed in his 10-Year Energy Plan) to commercialize new clean energy technologies and develop Utah's alternative, efficiency, and renewable energy resources. By increasing communication and collaboration between Utah's leading universities, Utah will become an even more powerful and effective leader on clean energy issues. Aggressive deployment of clean energy will also help mitigate some of the significant air and water quality issues that Utah is currently facing.

Utah Clean Energy has a long history of working with the Utah Office of Energy Development (OED) on advancing renewable energy and energy efficiency in Utah. We are pleased to see that the Utah Energy Research Triangle's proposal's primary objective is to coordinate with OED and Utah Science and Technology Research (USTAR) to operationalize Governor Herbert's vision for an collaborative energy research triangle, coupled with additional investments in workforce development to advance energy development in Utah.

Thank you for your consideration of the Utah Energy Research Triangle's proposal. Please contact me if you have further questions about Utah Clean Energy's support of this initiative.

Sincerely,

Sarah Wright
Executive Director

1014 2nd Avenue Salt Lake City Utah 84103 **(801) 363-4046** www.utahcleanenergy.org

APPENDIX H

UTAH CLUSTER ACCELERATION PROGRAM PRESENTATION

Utah Cluster Acceleration Grant Proposal

GOED Cluster Director Submitting Proposal: Energy

Primary contact person for grant project:

Alan J. Walker, Executive Director Utah Energy Research Triangle, University of Utah Energy & Geoscience Institute, 423 Wakara Way, Suite 300, Salt Lake City, Utah 84108

Phone: 801 864-5960

E-mail: alanjwalker@egi.utah.edu alanjwalker@utah.gov

NARRATIVE

Governor Gary R. Herbert outlined a vision for the Utah Energy Research Triangle in his March 2011, "ENERGY INITIATIVES & IMPERATIVES, *Utah's Ten-Year Strategic Energy Plan*" (http://www.utah.gov/governor/docs/10year-stragegic-energy.pdf) and among the key steps are:

- "Align the State's main research universities – University of Utah (U of U), Utah State University (USU) and Brigham Young University (BYU) into a powerful energy research and development triangle
- Connect this "Research Triangle" with global industry, national laboratories, and regional universities to effectively commercialize new energy technologies and develop Utah's conventional, alternative, efficiency, and renewable energy resources
- Empower Utah's education system to expand its ability to train attract and retain skilled talent necessary to grow Utah's energy economy"

The development of the Strategic Energy Plan was preceded by a Utah Cluster Acceleration Partnership effort in 2009 through 2010 which resulted in a fall 2010 report (http://www.growutahventures.com/wp-content/uploads/Energy-Final_Report.pdf) entitled "ACCELERATING UTAH'S ENERGY INDUSTRY" and the first three key supporting strategies are:

- "TALENT DEVELOPMENT - Increase Trained Workforce
- APPLIED RESEARCH - Research Viability of Renewable Energy
- RESEARCH AND DEVELOPMENT - State Sponsored Research Agenda"

The Energy Research Triangle (ERT) will address serious energy-related issues, such as air quality, water management, and energy security. The ERT will assist identification of the best solutions for society and industry through collaborative applied research. As an example, a recent study by the Utah Department of Transportation identified that 26,802 long-term jobs (10-year FTE) are at risk, given the condition of the current transportation infrastructure. Solutions to this issue are being studied using limited public and private efforts in singular efforts, yet the ERT could accelerate development over multiple pathways at multiple universities. *This proposal requests UCAP support to supplement ERT funding such that OED and USTAR can operationalize Governor Herbert's vision and the UCAP Energy Cluster's key supporting strategies by launching the Utah Energy Research Triangle to develop solutions to Utah's most serious energy issues.*

I. Project Scope

Purpose of Funding

The goal of the Energy Research Triangle (ERT) is to promote collaborative energy research leading to innovations that improves the welfare and quality of life for Utah citizens with potential commercially deployable technologies. The Office of Energy Development (OED) with the assistance of USTAR (Utah Science Technology and Research) has been tasked to operationalize the ERT component of the bold vision in the Strategic Energy Plan and Cluster Acceleration Partnership. .

The Energy Research Triangle proposes to meet the Governor's and UCAP's goals through two major programs. The first, known as the Tier 1: Principle Energy Issues program is designed to fund up to three of Utah's University-based Principle Investigators (PI) to research solutions to significant challenges in the energy space for the benefit of society. Each PI will receive up to $150,000 grant annually with follow-on funding dependent on first year milestones and future sources. The PI will be responsible for developing and executing a scope of work that follows the principles of Utah's Strategic Energy Plan for collaborative research with other Utah universities. These applied research projects are limited in time and scope to address Utah unique energy issues in conventional energy, renewable energy, unconventional energy, and storage or energy efficiency. The goal is to spark collaboration among the research universities and develop a foundational capacity to promote future collaboration on energy research.

The second major program effort to meet the Governor's and UCAP's goals is through the Tier 2: Governor's Energy Leadership Scholars program. The purpose of this program is to accelerate Utah's next generation of talent for scientific and engineering innovation leadership while simultaneously addressing Utah's unique energy challenges with cutting-edge solutions. This program is designed to fund energy research by up to four of Utah's most promising scholars (B.S., M.S. or Ph.D. candidates) annually to develop applied research solutions to significant Utah energy challenges. Each scholar will receive up to a $15,000 grant on his or her proposed topic. After one year, winners can re-apply for an additional $15,000 for research on the same topic

Applied research proposals will be initially screened and nominated by the VP of Research at the respective universities. The final selection committee will include as a minimum, the Governor's Energy Advisor, Executive Director of the ERT, Director of OED, and others appointed by the Governor. Periodic review will ensure quality and the awardees progress will be highlighted and recognized at the Governor's Energy Summit in June 2014.

This grant submission proposes to supplement partial funding by OED and USTAR to enable the Tier 1: Principle Energy Issues program and the Tier 2: Governor's Energy Leadership Scholars program. For FY 14, OED has allocated $45,000 for Tier 2, USTAR has proposed allocation of $200,000 for Tier 1, and currently USTAR is absorbing all the overhead of approximately $87,000 for a total of $332,000. This request for $265,000 for Tier 1 ($250,000) and Tier 2 ($15,000) will be used entirely for programmatic expansion as the initial costs and overhead has been allocated. The program administration has been finalized and is modeled after the current Technology Commercialization & Innovation Program (TCIP) application template used by the

Governor's Office of Economic Development (GOED). For FY 15, funding has been requested through the Governor's budgeting process

Collaboration

The Energy Research Triangle has established collaborative relationships with academia, government and industry. University of Utah, Utah State University and Brigham Young University offices of Research have been supportive of this proposal. The ERT has also approached Utah energy companies and energy advocacy groups on supporting energy research. All parties have identified significant need within the energy industry for a highly skilled workforce. Currently, this skill gap is dramatic. As an example, on a national scale, Utah is 9th in natural gas production and 11th in crude oil production. However, Utah universities do not graduate sufficient petroleum engineers given demand. Now the first Master of Science in Petroleum Engineering program in Utah will begin in August 2013 and graduate in May 2015. This program is open to BYU and USU engineering students, web-based students on the UEN, and is taught, in part, by a BYU Professor Keach with a field study in the Uintah Basin partly hosted by USU. Filling this type of shortfall in Utah for the highly trained engineers and scientists for industry has been accomplished through support by OED, USTAR, ERT and dedicated faculty.

In addition to workforce concerns, there are major technical challenges facing energy production in Utah. As an example, transportation requirements associated with the high wax content of Uintah Basin crude oils tax our state infrastructure which is currently unable to accommodate expected growth in production. In a recent study by UDOT, an estimated lost opportunity associated with these technical issues is approximately $1 billion per year over the next 30 years (Fig A) and the loss of 26,802 long-term jobs (Fig. B). The Energy Research Triangle is positioning itself to encourage Utah's brightest researchers to address problems like these. Similarly, by USGS estimates, Utah possesses 9% of the United States' enhanced geothermal reserves, yet many current geothermal projects are being sited in neighboring Idaho and Nevada. There are many reasons for these decisions but they are undoubtedly influenced by the lack of public investment and workforce ability.

Figure A: Opportunity Cost

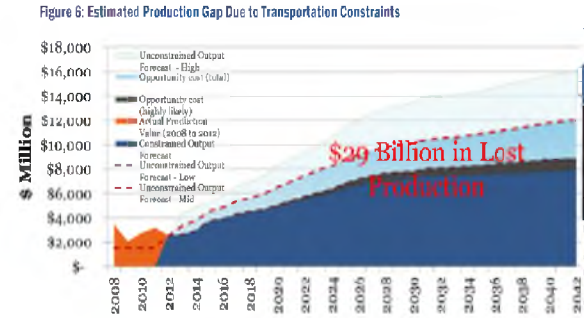


Figure B: Jobs, Revenue and Social Costs

Table 3: The Opportunity Cost of Constrained Oil and Gas Transportation Capacity in the Uinta Basin, Present Value[a] (over 30 Years)

Revenues and User Cost Savings ($ Million)		Environmental and Social Costs ($Million)		Macroeconomic Impact	
Profit, rents, dividends, and private royalties[b]	$3,784	Site emissions and ecological impacts	($1,248)	Total regional output, $ Million	$34,794
State and local tax revenue	$2,756	Vehicle emissions	($24)	Total labor income, $ Million	$11,791
User cost savings	$4,943	Safety impacts	($101)	Long-term jobs[c]	26,802
Total	$11,483	Total	($1,371)		

Note: Does not account for costs of added transportation investment, but rather provides a basis against which to evaluate whether the cost of additional transportation investment is justified.

[a] 3% discount rate.

[b] Represents the portion of total macroeconomic output that is additional private citizen/corporate profit net of expenses and resource depletion.

[c] Full-time equivalent (FTE). Assumes a 10-year term of employment.

Note: See Appendix A for full-size versions of these tables

The importance of developing a highly trained workforce and promoting a state-sponsored applied energy research agenda are vital themes touched on in the UCAP "ACCELERATING UTAH'S ENERGY INDUSTRY" report, the Strategic Energy Plan and the Uintah Basin Energy and Transportation Study. The ERT provides a pathway to operationalize the visions they have

previously outlined. It offers an opportunity to simultaneously invest in developing future leaders in Utah's knowledge economy, promote energy development vital to rural Utah and address major challenges the state faces with energy security, resource management, public health and environmental quality.

II. Project Outcomes

The primary outcome from the ERT proposal will be applied research projects: three by Principle Investigators and four by student-level Energy Leadership Scholars. These projects will be selected on the likelihood of their potential to improve the welfare and quality of life for Utah citizens with potential commercially deployable technology. Potentially, each university could lead one principle project and one scholar project, with one scholar project reserved for a Utah Indian tribal member. Regardless of location and applicant, these research projects will be judged on merit and be matched with industry interests. The universities will leverage their commercialization capabilities to roll out promising technology.

By focusing on a project-based initiative, the ERT will promote new capacity for certificate and degree programs in two ways. First, these projects will fund PIs, who in turn will hire post-doctorate scientists and engineers, Ph.D. and M.S. candidates, and undergraduates to assist in their research. These expanded opportunities for students in the STEM fields will be bolstered by the Governor's Energy Leadership Scholar program specifically designed to get resources to promising students who will in turn focus on energy topics. These opportunities will expand university research capacity and throughput in critical areas and in turn produce applied research solutions to serious issues and qualified graduates for the professional world.

The second way in which the Energy Research Triangle will promote University capacity is perhaps even more impactful. By promoting university collaboration, the ERT will draw on the complementary and unique resources at each of Utah's research universities. As we build this collaborative network, this cross-university synergy will become more and more common. This will expand the possibilities both for students and researchers and provides a strong foundation for Utah's knowledge economy.

These projects will be reviewed on a semi-annual basis by the Executive Director of the Energy Research Triangle under the guidance of the Governor's Energy Advisor. Applicants will be required to provide tangible milestones for their research and follow-on funding in future years will be dependent on meeting those milestones. The universities will track projects and any commercialization associated with ERT projects will be captured by the respective university.

III. Matching Funds

The ERT has identified matching funds that will leverage UCAP support. USTAR has proposed $200,000 to support the Tier 1, Principle Energy Issues program. In addition, USTAR is providing $87,000 in in-kind support with overhead of program management and administrative support. This includes 33% FTE for an Executive Director at $49,000, 50% FTE for an Analyst at $28,000, and Finance/Administrative Support at approximately $10,000.

ERT has also secured $45,000 from OED, designed to be used to fund three of the Governor's Energy Leadership Scholars. This comes to $245,000 in resource support and an additional

$87,000 of in-kind support, totaling $332,000 in support of UCAP's $265,000 investment. This is a 1.25:1 ratio of matching funds to UCAP funds.

IV. Budget

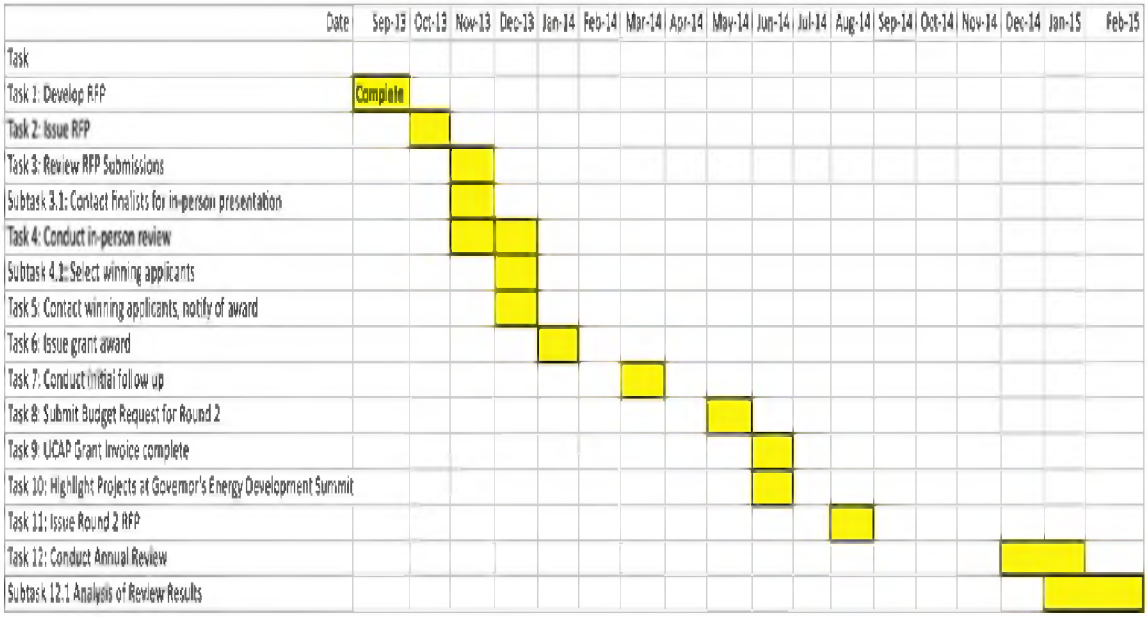
Leveraging UCAP Funding

An investment in the Energy Research Triangle by UCAP offers the opportunity for significant leveraging. The ERT request from UCAP of $265,000 will be matched with a $45,000 from OED, a proposed $200,000 by USTAR and an $87,000 in-kind participation by USTAR for a total of $332,000 in support for the ERT. The ERT has also been pursuing industry support and has submitted a request for Gov. Herbert's FY2015 budget. This gives the ERT the potential both to be highly impactful and sustainable beyond the initial UCAP investment.

Program Utah Energy Research Triangle			USTAR (Utah Science Technology and Research)	OED (Office of Energy Development)	UCAP (Utah Cluster Acceleration Partnership)
Tier 1: Principle Research	Project 1	$ 150,000	100000		50000
Tier 1: Principle Research	Project 2	$ 150,000	100000		50000
Tier 1: Principle Research	Project 3	$ 150,000			150000
Tier 2: Governor's Energy Leadership Scholar	Brigham Young University	$ 15,000		15000	
Tier 2: Governor's Energy Leadership Scholar	Utah State University	$ 15,000		15000	
Tier 2: Governor's Energy Leadership Scholar	University of Utah	$ 15,000		15000	
Tier 2: Governor's Energy Leadership Scholar	Utah Tribal Member	$ 15,000		0	15000
In-Kind, 33% ERT Ex Director	USTAR	$ 49,000	49000		
In-Kind, 50% ERT Analyst	USTAR	$ 28,000	28000		
In-Kind, Finance and Administrative Support	USTAR	$ 10,000	10000		
		$ 597,000	$ 287,000	$ 45,000	$ 265,000
			48%	8%	44%

V. Timeline

The graphic below shows the logical sequence of program elements.



The first step of developing the RFP criteria is modeled after the existing GOED TCIP program. The Request for Proposal (RFP) would be issued upon award of the grant and the final step in FY 14 would be highlighting the research at the Governor's Energy Summit. It is understood that all grant funds must be invoiced by June 30, 2014, with extensions granted by the Governing Board on an exceptional basis.

VI. Supporting Documentation

Links to supporting documentation are included in the narrative above and in the following Appendix A. The impetus for numerous energy industry acceleration initiatives, including the Utah Energy Research Triangle began with work by Utah Cluster Acceleration Partnership for energy in 2009 and was followed shortly by formation of the Governor's Energy Task Force. Many of the members of the UCAP effort served concurrently on the UCAP Steering Committee, the Governor's Energy Task Force, and subcommittees of the Energy Task Force. Two important documents, the UCAP fall 2010 report entitled "ACCELERATING UTAH'S ENERGY INDUSTRY" and the March 2011 Energy Task Force report entitled "ENERGY INITIATIVES & IMPERATIVES, *Utah's 10-Year Strategic Energy Plan"* enumerated strategies and recommended activates to accelerate Utah's energy industry. These reports list the proponents by name and company or agency that participated and contributed to these reports.

The UCAP focus on energy issues has continued with the Energy Cluster Acceleration Partnership (ECAP) and a second published report in January 2013 entitled "ACCELERATING UTAH'S ENERGY INDUSTRY". In the Executive Summary a major highlighted outcome is "Collaborated with the Utah Energy Research Triangle…" and a key recommendation for moving forward is to, "Support research collaboration opportunities."

VII. Conclusion

This proposal requests UCAP support to supplement Energy Research Triangle funding with $265,000 to enhance $332,000 from other agencies, such that OED and USTAR can operationalize Governor Herbert's vision and the UCAP Energy Cluster's key supporting strategies by launching the Utah Energy Research Triangle to develop solutions to Utah's most serious energy issues.

Appendix A

Utah Cluster Acceleration Program, Accelerating Utah's Energy Industry: http://www.growutahventures.com/wp-content/uploads/Energy-Final_Report.pdf – Key Supporting Strategies

Governor Herbert's 10-Year strategic Energy Plan: http://www.utah.gov/governor/docs/10year-strategic-energy.pdf. See Section VII for Energy Research Triangle

Uintah Basin Energy and Transportation Study (UBETS), Utah Department of Transportation http://www.udot.utah.gov/main/uconowner.gf?n=3975604202569320 Outlines the $1B/year opportunity cost and threat to 26,802 long-term jobs

The figure and table below are sourced from the UBETS and forecast production growth and transportation constraints and resultant lost revenue and long-term job opportunities:

Figure 6: Estimated Production Gap Due to Transportation Constraints

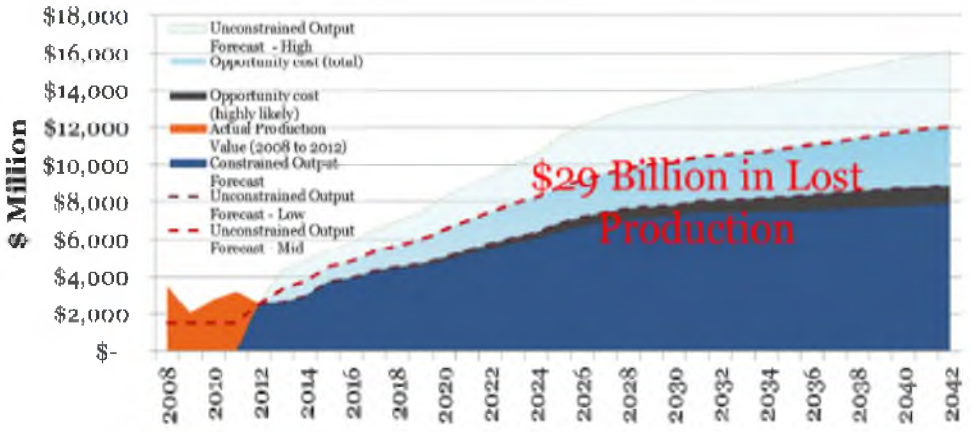


Table 3: The Opportunity Cost of Constrained Oil and Gas Transportation Capacity in the Uinta Basin, Present Value[a] (over 30 Years)

Revenues and User Cost Savings ($ Million)		Environmental and Social Costs ($Million)		Macroeconomic Impact	
Profit, rents, dividends, and private royalties[b]	$3,784	Site emissions and ecological impacts	($1,246)	Total regional output, $ Million	$34,794
State and local tax revenue	$2,756	Vehicle emissions	($24)	Total labor income, $ Million	$11,791
User cost savings	$4,943	Safety impacts	($101)	Long-term jobs[c]	26,802
Total	**$11,483**	**Total**	**($1,371)**		

Note: Does not account for costs of added transportation investment, but rather provides a basis against which to evaluate whether the cost of additional transportation investment is justified.

[a] 3% discount rate.

[b] Represents the portion of total macroeconomic output that is additional private citizen/corporate profit net of expenses and resource depletion.

[c] Full-time equivalent (FTE). Assumes a 10-year term of employment.

APPENDIX I

ENERGY RESEARCH TRIANGLE PROPOSAL FOR USTAR GOVERNING AUTHORITY

Strategic Initiative Funding Request

USTAR Governing Authority,
December 5th, 2013

Strategic Initiative - SCOPE

- Three documents laid out principle need
  - **UCAP "Accelerating Utah's Energy Industry" 2010**
  - **Governor Herbert's "10-Year Strategic Energy Plan" 2011**
  - **UCAP "Accelerating Utah's Energy Industry" 2013**
    - **Awarded $200,000 in funding from UCAP in FY 2014, conditioned on matching funds**
    - **Approved $45,000 from Governor's Office of Energy Development (OED) in FY 2014**
    - **USTAR contribution of $200,000 has $245,000 match**
- Multi-tiered approach to address energy innovation
  - **Tier 1, Principle Energy Issues –** Designed for University Principal Investigators to address Utah's principle energy challenges. USTAR funds will potentially grant one at USU and one at the UofU.
  - **Tier 2, Governor's Energy Leadership Scholars –** Designed to cultivate the next generation of energy innovators.

Overview of Program

- Governor's **10-Year Strategic Energy Plan** has proposed the Energy Research Triangle to unlock the potential of Utah's energy resources
  - Governor's budget proposal includes $510,000 for FY15
- The Energy Research Triangle is designed to:
  - Fund energy research relevant to Utah
  - Spark a greater level of collaboration between Utah's research universities
  - Targeted research on infrastructure/transportation, air quality, and water management
  - Strengthen Utah's research capacity through opportunities for advanced degree candidates
- Align Governor's top priorities
  - **Education** – Increasing revenues to raise new funding for education
  - **Sustainable Energy Development**– Promote Utah as a National thought leader in practical and applied energy innovation
  - **Jobs** – Energy jobs are high-paying, have a large benefit to rural economies
  - **Self-determination** – Shows Utah's independence of support from Federal government
- Industry Driven and Competitively Selected Research: Research projects would be selected through competition by panel of state energy experts

Office of Energy Development USTAR UtahState University

Program Outcomes

- Through Principle Energy Issues Program, contribute to:
  - Rural economic development
  - Energy security
  - Resource management
  - Public health
  - Environmental quality

- Through Energy Leadership Scholars, increase opportunities for next generation of researchers in STEM fields
- Build a new, cross-cutting partnership at Utah's research Universities
  - Creates a foundation for greater collaborative research focused on Utah-specific challenges
  - Foster a culture of self-determination through research

Office of Energy Development USTAR UtahState University

Approved UCAP Request

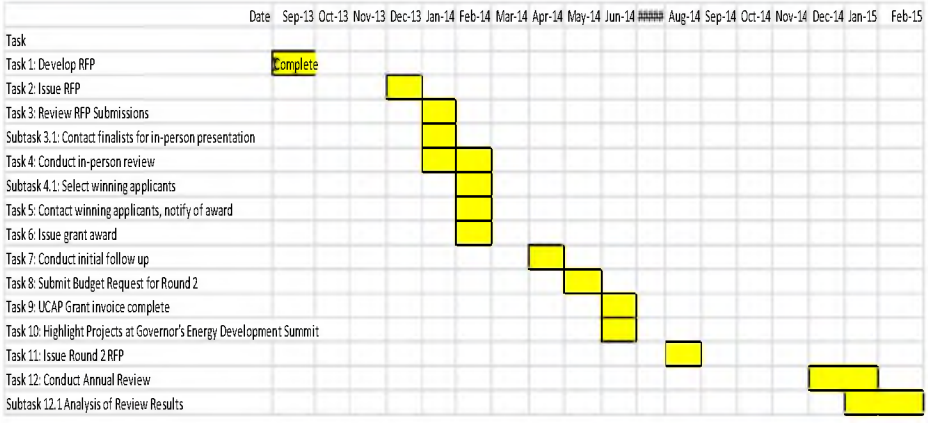
- Request for $265k from UCAP, awarded $200k
  - Supplemented by $200K by USTAR, $45K by OED
  - UCAP funding dependent upon matching funds

Utah Energy Research Triangle			USTAR (Utah Science Technology and Research)	OED (Office of Energy Development)	UCAP (Utah Cluster Acceleration Partnership)
Tier 1: Principle Research	Project 1	$ 128,333	$ 100,000		$ 28,333
Tier 1: Principle Research	Project 2	$ 128,333	$ 100,000		$ 28,333
Tier 1: Principle Research	Project 3	$ 128,333			$ 128,333
Tier 2: Governor's Energy Leadership Scholar	Brigham Young University	$ 15,000		$ 15,000	
Tier 2: Governor's Energy Leadership Scholar	Utah State University	$ 15,000		$ 15,000	
Tier 2: Governor's Energy Leadership Scholar	University of Utah	$ 15,000		$ 15,000	
Tier 2: Governor's Energy Leadership Scholar	Utah Tribal Member	$ 15,000		$ -	$ 15,000
		$ 445,000	$ 200,000	$ 45,000	$ 200,000
			45%	10%	45%

Note: Program administration will be contracted through Office of Energy Development.

Office of Energy Development USTAR UtahState University

Project Timeline



Office of Energy Development USTAR UtahState University

APPENDIX J

GRANT AGREEMENT WITH UTAH CLUSTER ACCELERATION PARTNERSHIP

141664

Department of Workforce Services

GRANT AGREEMENT

UTAH CLUSTER ACCELERATION PARTNERSHIP

This Grant Agreement is entered into by and between the **Utah Department of Workforce Services**, 140 East 300 South, Salt Lake City, UT 84111, hereinafter referred to as the **Department** or **DWS** and the **OFFICE OF ENERGY DEVELOPMENT, 60 EAST SOUTH TEMPLE, 3RD FLOOR, SALT LAKE CITY, UTAH 84111,** hereinafter referred to as the **Grantee, Contractor or OED.**

Vendor Number: *VC0000180907* Commodity Code: 99999

Contractor Type: *Governmental*

Grantee Program Name: *Utah Energy Research Triangle*

Funding Source: *Job Growth Funds*

PURPOSE

The Utah Cluster Acceleration Partnership (UCAP) is a collaborative partnership between the Department of Workforce Services (DWS), the Utah System of Higher Education (USHE) and the Governor's Office of Economic Development (GOED). The primary functions for UCAP are to accelerate industry clusters in Utah and to strengthen the alignment between industry and education. The UCAP program provides funding to public educational institutions to develop, implement or enhance educational programs that are responsive to regional and statewide industry needs. Specifically UCAP was created to address the following four opportunities and concerns: Goal #1 Increase Economic Cluster Connectivity and Educational Alignment; Goal #2 Respond to Skill Gaps; Goal #3 Enhance the Role of the Regional Institutions in Economic Development; and Goal #4 Promote Regional Stewardship.

PERIOD OF PERFORMANCE

This Agreement shall be effective **October 1, 2013** through **June 30, 2014**. This Agreement shall remain in effect unless terminated sooner in accordance with the terms and conditions herein.

CONTRACT COSTS

The **Grantee** shall be paid up to a maximum of **$200,000.00** for costs authorized under this Grant Agreement. All expenditures and activities must be in accordance with all Attachments herein and must occur within the grant period. Funding may not be used for purposes contrary to applicable federal, state, and local laws.

ATTACHMENTS

Attachment A: Interagency Standard Terms and Conditions
Attachment B: Grantee Performance Requirements
Attachment C: Budget
Attachment D: Grant Proposal

RATIFICATION

It is understood and agreed that the effective date of this Agreement is the date of commencement of services as provided in the Period of Performance paragraph above, and that any and all appropriate costs within budget incurred by the Grantee between said effective date and the date on which this Agreement is fully executed are hereby approved and ratified for payment.

141664

CONTACTS

DWS
Ben Hart
Employer Initiative Director
Utah Department of Workforce Services
140 East 300 South
Salt Lake City, UT 84111
801-649-9041
benhart@utah.gov

Melisa Stark, Program Manager
Utah Cluster Acceleration Partnership
801-628-4051
mstark@utah.gov

Linetta Moyes, Financial Manager
Administrative Support, Budget
Utah Department of Workforce Services
140 East 300 South. 5th Floor
Salt Lake City, UT 84111
(801) 526-4307 (Mon-Fri. 8-4:30)
(801) 526-9698 (fax)
lmoyes@utah.gov

GRANTEE
Samantha Julian, Executive Director
Office of Energy Development
60 East South Temple, 3rd Floor
Salt Lake City, UT 84111

Michelle Pasker
Budget & Accounting Officer
801-538-8727

Principal Investigator
Alan J. Walker, Director
Utah Energy Research Triangle
University of Utah Energy & Geoscience Institute
423 Wakara Way, Suite 300
Salt Lake City, UT 84108

ATTEST: **OFFICE OF ENERGY DEVELOPMENT**

Samantha Julian, Executive Director — Dec 10, 2013 — Date

ATTEST: **UTAH DEPARTMENT OF WORKFORCE SERVICES**

Jon Pierpont, Executive Director — 12/17/13 — Date

CONTRACT RECEIVED AND PROCESSED BY DIVISION OF FINANCE — DEC 17 2013

UTAH DEPARTMENT OF FINANCE

ATTACHMENT A

INTERAGENCY STANDARD TERMS AND CONDITIONS

1. **AUTHORITY:** Provisions of this contract are pursuant to the authority set forth in Sections 63G-6a-105 and 35A-1-104 of the Utah Code, 1953 as amended, Utah State Procurement Regulations (Utah Admin. Code Section R33), and related statutes that permit the State to purchase certain specified services, and other approved purchases for DEPARTMENT.

2. **CITING DEPARTMENT IN ADVERTISING:** CONTRACTOR agrees to give credit to DEPARTMENT for funding in all written and verbal advertising or discussion of this program such as brochures, flyers, informational materials, talk shows, etc. All formal advertising or public information programs will be coordinated with Public Information Officer for DEPARTMENT.

3. **IMPOSITION OF FEES:** CONTRACTOR will not impose any fees upon clients provided services under this Contract except as authorized by DEPARTMENT.

4. **CODE OF CONDUCT (Attached if Applicable):** CONTRACTOR agrees to follow and enforce DEPARTMENT'S Code of Conduct, Utah Administrative Code R982-601-101 et seq. CONTRACTOR agrees that each of its employees or volunteers receive a copy of the Code of Conduct. A signed statement by each employee or volunteer to this effect must be in employee's/volunteer's file subject to inspection and review by DEPARTMENT monitors.

5. **HUMAN SUBJECTS RESEARCH:** CONTRACTOR shall not conduct research involving employees of DEPARTMENT or individuals receiving services (whether direct or contracted) without prior approval from the DEPARTMENT. If approval is given, CONTRACTOR will obtain institutional review board (IRB) approval prior to engaging in human subjects research activities. CONTRACTOR will provide certification of IRB approval upon request.

6. **DRUG-FREE WORKPLACE:** CONTRACTOR agrees to abide by DEPARTMENT'S drug-free workplace policies while performing services under this contract.

7. **INDEMNITY CLAUSE:** Both parties to this Contract are governmental entities as defined by the Utah Governmental Immunity Act, Utah Code Ann. §§ 63 G-7-101 to -904 (2013). Consistent with the terms of this Act, it is mutually agreed that each party is responsible and liable for its own wrongful or negligent acts that it commits or which are committed by its agents, officials, or employees. Neither party waives any defenses otherwise available under the Governmental Immunity Act.

8. **LICENSING AND STANDARD COMPLIANCE:** By signing this agreement CONTRACTOR acknowledges that it currently meets all applicable licensing or other standards required by federal and state laws or regulations and ordinances of the city/county in which services and/or care is provided and will continue to comply with such licensing or other applicable standards and ordinances for the duration of this contract period. Failure to secure or maintain a license shall support a basis for

cancellation of this Contract. CONTRACTOR acknowledges that it is responsible for familiarizing itself with these laws and regulations, and complying with all of them.

9. **COMPLIANCE WITH GENERALLY APPLICABLE STATE AND FEDERAL LAWS:**

a. As noted in this Contract, CONTRACTOR is required to comply with all anti-discrimination and drug-free workplace laws, and all laws governing research involving human subjects. If CONTRACTOR is receiving federal funds under this Contract the following federal laws may apply: Equal Opportunity Employer Executive Order, the Davis-Bacon Act, the Hatch Act, the Copeland "Anti-Kickback" Act, the Fair Labor Standards Act, the Contract Work Hours and Safety Standards Act, the Clean Air Act, the Federal Water Pollution Control Act, the Byrd Anti-Lobbying Amendment, and the Debarment and Suspension Executive Orders. CONTRACTOR shall comply with these laws and regulations to the extent they apply to the subject matter of this Contract.

b. **Equal Opportunity Clause.** CONTRACTOR agrees to abide by the Equal Opportunity provisions of Section 188 of the Workforce Investment Act of 1998 (WIA) 29 CFR Part 37, which prohibits discrimination against all individuals in the United States on the basis of race, color, religion, sex, national origin, age, disability, political affiliation or belief, and against beneficiaries on the basis of either citizenship/status as a lawfully admitted immigrant authorized to work in the United States or participation in any WIA Title I-financially assisted program or activity:

Title VII of the Civil Rights Act of 1964, as amended, which prohibits discrimination on the basis of race, color, and national origin;

Section 504 of the Rehabilitation Act of 1973, as amended, which prohibits discrimination against qualified individuals with disabilities;

The Age Discrimination Act of 1975, as amended, which prohibits discrimination on the basis of age;

And Title IX of the Education Amendments of 1972, as amended, which prohibits discrimination on the basis of sex in education programs.

If applicable, CONTRACTOR will provide an explanation of the client's rights and protections under 29 CFR Part 37. CONTRACTOR will also provide a copy of DEPARTMENT'S Equal Opportunity Notice (English or Spanish version, DWS 09-15E-0900NCR or 09-15S-0201 respectively) to the client and maintain a copy in the client file.

10. **SEPARABILITY CLAUSE:** A declaration by any court, or other binding legal source, that any provision of this agreement is illegal and void shall not affect the legality and enforceability of any other provisions of this agreement, unless said provisions are mutually dependent.

11. **RECORDS ADMINISTRATION:** CONTRACTOR shall maintain, or supervise the maintenance of all records necessary to properly account for the payments made to CONTRACTOR for costs authorized by this contract. These records shall be retained by CONTRACTOR for at least four years after the contract terminates, or until all audits initiated within the four years, have been completed, whichever is later. CONTRACTOR shall maintain books, records, documents and other evidence.

12. **CONTRACTOR ASSIGNMENT AND SUBCONTRACTORS:**

a. **Assignment.** Notwithstanding DEPARTMENT'S right to assign the rights or duties hereunder, CONTRACTOR agrees and understands that this Contract is based on the reputation of CONTRACTOR, and this Contract may not be assigned by CONTRACTOR without the written consent of DEPARTMENT. Any assignment by CONTRACTOR without DEPARTMENT'S written consent shall be wholly void.

b. **Subcontractors.** As used in this Contract, the term "subcontractor" means an individual or entity that has entered into an agreement with the original CONTRACTOR to perform services or provide goods, which the original CONTRACTOR is responsible for under the terms of this Contract. Additionally, the term "subcontractor" also refers to individuals or entities that have entered into agreements with any subcontractor if: (1) those individuals or entities have agreed to perform all or most of the subcontractor's duties under this Contract; or (2) federal law requires this Contract to apply to such individuals or entities. If CONTRACTOR enters into subcontracts the following provisions apply:

(1) Duties of Subcontractors: Regardless of whether a particular provision in this Contract mentions subcontractors, a subcontractor must comply with all provisions of this Contract including the state procurement requirements, insurance requirements and the fiscal and program requirements. CONTRACTOR retains full responsibility for Contract compliance, whether the services are provided directly or by a subcontractor.

(2) Provisions Required in Subcontracts: If CONTRACTOR enters into any subcontracts with other individuals or entities and pays those individuals or entities for such goods or services with federal or state funds, CONTRACTOR must include provisions in its subcontracts regarding the federal and state laws identified in this Contract, if applicable ("Contractor's Compliance with Applicable Laws; Cost Accounting Principles and Financial Reports,") as well as other laws and contract provisions identified in 45 C.F.R. §92.36(i).

13. **MONITORING:** DEPARTMENT shall have the right to monitor CONTRACTOR'S performance regarding all services purchased under this Contract. Monitoring of CONTRACTOR'S performance shall be at the complete discretion of DEPARTMENT which will rely on the criteria set forth in this Contract, including the goals, service objectives and methods described in "Scope of Work" and any special conditions and "Performance Measures" and CONTRACTOR'S fiscal operations. Monitoring may include both announced and unannounced visits. Monitoring will take place during normal business hours.

Client or Contract Staff Satisfaction Surveys. CONTRACTOR understands that DEPARTMENT is committed to providing customer-oriented services, and that DEPARTMENT often conducts customer-satisfaction surveys as a part of monitoring. CONTRACTOR therefore agrees to cooperate with all DEPARTMENT-initiated customer feedback.

14. **CONTRACT RENEWAL:** Renewal of contract will be solely at the discretion of DEPARTMENT.

15. **RENEGOTIATION OR MODIFICATIONS:** This contract may be amended, modified, or supplemented only by written amendment executed by the parties hereto, and attached to the original signed copy of the contract.

16. **CONTRACT TERMINATION:**

a. **Termination for Cause.** This contract may be terminated, with cause by either party, in advance of the specified termination date, upon written notice being given by the other party. The party in violation will be given ten (10) working days after notification to correct and cease the violations, after which the contract may be terminated for cause. The DEPARTMENT will give the CONTRACTOR only one opportunity to correct and cease the violations.

b. **Immediate Termination.** If CONTRACTOR creates or is likely to create a risk of harm to the clients served under this Contract, or if any other provision of this Contract (including any provision in the attachments) allows DEPARTMENT to terminate the Contract immediately for a violation of that provision, DEPARTMENT may terminate this Contract immediately by notifying CONTRACTOR in writing. The DEPARTMENT may also terminate this contract immediately for fraud, misrepresentation, misappropriation, and/or mismanagement as determined by the DEPARTMENT.

c. **No Cause Termination.** This Contract may be terminated without cause, in advance of the specified expiration date, by either party, upon sixty (60) days prior written notice being given the other party. Upon termination of this Contract, all accounts and payments will be processed according to the financial arrangements set forth herein for approved services rendered to date of termination.

d. **Termination Fund-out.** CONTRACTOR acknowledges that DEPARTMENT cannot contract for the payment of funds not yet provided by the Federal Government or appropriated by the Utah State Legislature and DEPARTMENT cannot guarantee funding under this Contract since it may be altered by an act of the Federal Government or the Utah State Legislature occurring before the expiration of this Contract. Therefore, in the event that DEPARTMENT fails to receive appropriations then DEPARTMENT may, by giving at least 30 days advance written notice, terminate this Contract. DEPARTMENT will reimburse CONTRACTOR for services performed up through the date of cancellation.

e. **Attorneys' Fees and Costs.** If either party seeks to enforce this Contract upon a breach by the other party, or if one party seeks to defend itself against liability arising from the negligence of the other party, the prevailing party shall receive from the unsuccessful party all court costs and its reasonable attorneys' fees, regardless of whether such fees are incurred in connection with litigation.

f. **Remedies for Contractor's Violation.**

1. In the event this Contract is terminated as a result of a default by CONTRACTOR, DEPARTMENT may procure or otherwise obtain, upon such terms and conditions as DEPARTMENT deems appropriate, services similar to those terminated, and CONTRACTOR shall be liable to DEPARTMENT for any damages arising there from, including attorneys' fees and excess costs incurred by DEPARTMENT in obtaining similar services.

2. CONTRACTOR acknowledges that if CONTRACTOR violates the terms of this Contract, DEPARTMENT is entitled to avail itself of all available legal, equitable and statutory remedies including, but not limited to, money damages, injunctive relief and debarment as allowed by state and federal law.

17. **BILLINGS AND PAYMENTS:** Payments to CONTRACTOR will be made by DEPARTMENT upon receipt of an itemized billing for authorized service(s) provided and supported by information contained in reimbursement forms supplied by DEPARTMENT. Billings and claims for services must be received within thirty (30) days after the last date of service for the period billed or at the contract's date of termination or payment may be delayed or denied. DEPARTMENT must receive billings for services through the month of June no later than July 15th due to the DEPARTMENT'S fiscal year end. Billings submitted after this date may be denied.

    DEPARTMENT will not allow claims for services furnished by CONTRACTOR, which are not specifically authorized by this contract.

18. **PAYMENT RATES (Does Not Apply to Contracts With Department Of Workforce Services Set Rates):** Initial payment rates for negotiated contracts may be calculated based on actual expenditures for prior period, available budget and changes in the type or quality of service. The rates may be adjusted up or down during the Contract term in accordance with prior paid actual costs or a review of current costs verified by audit or fiscal review. Such a rate adjustment may be retroactive to the beginning of the Contract. Rates for contracts awarded as a result of the competitive bidding process will not be changed during the Contract term.

19. **PAYMENT WITHHOLDING:** CONTRACTOR agrees that the reporting and record keeping requirements specified in this Contract are a material element of performance and that if, in the opinion of DEPARTMENT, CONTRACTOR'S record keeping practices and/or reporting to DEPARTMENT are not conducted in a timely and satisfactory manner, DEPARTMENT may withhold part or all payments under this or any other Contract until such deficiencies have been remedied. In the event of the payment(s) being withheld, DEPARTMENT agrees to notify CONTRACTOR of the deficiencies that must be corrected in order to bring about the release of withheld payment.

20. **OVERPAYMENT/AUDIT EXCEPTIONS/DISALLOWANCES:** CONTRACTOR agrees that if during or subsequent to the Contract CPA audit or DEPARTMENT determines that payments were incorrectly reported or paid, DEPARTMENT may amend the Contract and adjust the payments. In Contracts, which include a budget, CONTRACTOR expenditures to be eligible for reimbursement must be adequately documented. CONTRACTOR will, upon written request, immediately refund any overpayments determined by audit and for which payment has been made to CONTRACTOR, to DEPARTMENT. CONTRACTOR further agrees that DEPARTMENT shall have the right to withhold any or all subsequent payments under this or other contracts with CONTRACTOR until recoupment of overpayment is made.

21. **REDUCTION OF FUNDS:** The maximum amount authorized by this Contract shall be reduced or Contract terminated if required by federal/state law, regulation, action or if there is significant under-utilization of funds, provided CONTRACTOR shall be reimbursed for all services performed in accordance with this Contract prior to date of reduction or termination. If funds are reduced, there will be a comparable reduction in amount of the services to be given by CONTRACTOR. The DEPARTMENT will give CONTRACTOR thirty (30) days notice of reduction.

22. **PRICE REDUCTION FOR INCORRECT PRICING DATA:** If any price, including profit or fee, negotiated in connection with this Contract, or any cost reimbursable under this Contract was increased by any significant sum because CONTRACTOR furnished

cost or pricing data (e.g., salary schedules, reports of prior period costs, etc.) which was not accurate, complete and current, the price or cost shall be reduced accordingly. The Contract may be modified in writing as necessary to reflect such reduction, and amounts overpaid shall be subjected to overpayment assessments. Any action DEPARTMENT may take in reference to such price reduction shall be independent of, and not be prejudicial to, DEPARTMENT'S right to terminate this Contract.

23. **GRIEVANCE PROCEDURE:** In the event of a discrimination complaint or grievance, CONTRACTOR will instruct recipients to contact DEPARTMENT'S Equal Opportunity Officer/Customer Relations office at (801) 526-4390 or 1-800-331-4341, or in writing to DEPARTMENT at:

Equal Opportunity/Customer Relations
Department of Workforce Services
P.O. Box 45249
Salt Lake City, UT 84145-0249

Individuals with speech and/or hearing impairments may call: State Relay @ 1-800-346-4128.

For all other grievances CONTRACTOR agrees to establish a system in which recipients of the purchased services may present grievances about the operation of the program as it pertains to and affects said recipient. CONTRACTOR will advise recipients of their right to present grievances concerning denial or exclusion from the program, or operation of the program, and of their right to a review of the instance by DEPARTMENT. CONTRACTOR will advise applicants in writing of rights and procedures to appeal. In the event of a grievance, CONTRACTOR will notify DEPARTMENT of the grievance and it's disposition of the matter. If no resolution is reached with CONTRACTOR, the grievance will be forwarded to DEPARTMENT for processing through DEPARTMENT'S Administrative Process.

24. **PROTECTION AND USE OF CLIENT RECORDS:** The use or disclosure by any party of any information concerning a client for any purpose not directly connected with the administration of DEPARTMENT'S or CONTRACTOR'S responsibilities with respect to services purchased under this agreement is prohibited except on written consent of the client, their attorney, or responsible parent or guardian. CONTRACTOR will be required to sign DEPARTMENT'S disclosure statement.

25. **DEPARTMENT COST PRINCIPLES FOR COST REIMBURSEMENT CONTRACTS:**

a. Federal Cost Principles determine allowable costs in DEPARTMENT contracts. They can be found in circulars published by the Federal Office of Management and Budgets ("OMB"). CONTRACTOR may locate the Federal Cost Principles applicable to its organization at the Internet web site:

OMB Circulars: http://www.whitehouse.gov/omb/circulars/index.html

b. Additional Cost Principles.

Compensation For Personal Services:

(1) In addition to the cost principles in the federal circulars concerning compensation for personal services, the following cost principles also apply:

(a) The portion of time a person devotes to a program should be disclosed in the budget as a percent of 40 hours per week.

(b) Employees who are compensated from one or more contracts, or from programmatic functions must maintain time reports, which reflect the distribution of their activities.

(c) For persons occupying any managerial position (administration or program management), total work time from all work, including outside employment and participation in other entities, must be disclosed. If total work time exceeds 40 hours and CONTRACTOR wants reimbursement for the time devoted to DEPARTMENT programs over 40 hours, the following two conditions must be met:

(i) A perpetual time record must be maintained, and

(ii) Prior written approval must be obtained from DEPARTMENT'S Finance-Contracting Division

(2) Compensation for Personal Expenses: DEPARTMENT will not reimburse CONTRACTOR for personal expenses. For example, spouse travel when the travel costs of the spouse are unrelated to the business activity, telecommunications and cell phones for personal use, undocumented car allowances, payments for both actual costs of meals and payments for per diem on the same day, and business lunches (not connected with training).

(3) **Third-Party Reimbursement And Program Income.** CONTRACTOR is required to pursue reimbursement from all other sources of funding available for services performed under this Contract. Other sources of funding include, but are not limited to, third party reimbursements and program income. In no instance shall any combination of other sources of funding and billings to DEPARTMENT be greater than "necessary and reasonable costs to perform the services" as supported by audited financial records. Collections over and above audited costs shall be refunded to Department Of Workforce Services.

26. **ADMINISTRATIVE EXPENDITURES:** DEPARTMENT will reimburse CONTRACTOR for actual administrative or indirect costs (Category I) up to 10% of the total program and capital (Category III & II) costs as negotiated in the attached budget.

APPENDIX K

REQUEST FOR PROPOSAL

December 18, 2013

Dr. Behunin, Dr. Harker, and Dr. Parks,

I am deliberately sending this open letter to you jointly, as the nature of the Utah Energy Research Triangle is to encourage collaborative energy research on a level playing field. The first round is open now and will close at noon on January 13, 2014. A second round, if needed, will open early next year.

I am pleased to release the first round of the Utah Energy Research Triangle request for proposal (RFP) today. We initially discussed this in your offices separately last spring, but it has taken considerable time to make revisions to the program and secure continued funding for the program. For the initial year, we have secured funding of $200,000 from the Utah Cluster Acceleration Program (UCAP), $200,000 from USTAR, and $45,000 from the Office of Energy Development (OED), to provide $445,000 for collaborative energy research commitments prior to July 1, 2014. We are pleased that Governor Herbert has prioritized the Utah Energy Research Triangle in his budget recommendation on a continuing basis at $515,000 per year through OED, which will fund collaborative energy research in future years.

As previously described, the program will have two tiers. Tier 1 will fund the Principal Energy Issues program at your universities for collaborative energy research by your principal investigators (PI) with potentially three grants being awarded for up to $128,333 each. Tier 2 will fund the Governor's Energy Leadership Scholars program with up to four grants of $15,000 each for your faculty-mentored students. Each university is eligible for one of the Tier 2 grants and a fourth grant is set aside for a Native American matriculated at one of your universities. Winners will be required to present their initial research at the Governor's Energy Summit on June 3-4, 2014 and attend an awards presentation during the Energy Summit.

The program description and application are online at http://energy.utah.gov/utah-energy-research-triangle/. Please distribute this information as appropriate at your university. If you have questions, please contact me (801-864-5960, alanjwalker@utah.gov) or Ryan Streams (435-503-5392, rstreams@utah.gov). Our best to you during this holiday season.

Warm Regards,

Alan J. Walker

Alan J. Walker
Executive Director, Utah Energy Research Triangle

Cc: Dr. Conrad Monson, Dr. Eric Eddings, Dr. Tom Fletcher, Curt Roberts

December 23, 2013

Dear Mr. Arce,

I am pleased to release the first round of the Utah Energy Research Triangle request for proposal (RFP). The first round is open now and will close at noon on January 13, 2014. A second round, if needed, will open early next year. We initially discussed this in your office last spring with periodic updates when we crossed paths. The program will have two tiers, and Tier 2 should be of particular interest to you.

Tier 2 will fund the Governor's Energy Leadership Scholars program with up to four grants of $15,000 each for faculty-mentored students at Brigham Young University (BYU), Utah State University (USU), and the University of Utah (UofU). Each university is eligible for one of the Tier 2 grants and a fourth grant is set aside for a matriculated Native American from Utah. Winners will be required to present their initial research at the Governor's Energy Summit on June 3-4, 2014 and attend an awards presentation during the Energy Summit. Tier 1 will fund the Principal Energy Issues program at BYU, USU, or the UofU for collaborative energy research by principal investigators (PI) with potentially three grants.

It has taken considerable time to make revisions to the program and secure continued funding for the program. We have secured funding for the initial year and are pleased that Governor Herbert has prioritized the Utah Energy Research Triangle in his budget recommendation on a continuing basis through the Office of Energy Development. This will fund collaborative energy research and research leadership development in future years.

The program description and application are online at http://energy.utah.gov/utah-energy-research-triangle/. Please distribute this information as appropriate. If you have questions, please contact me (801-864-5960, alanjwalker@utah.gov) or Ryan Streams (435-503-5392, rstreams@utah.gov). Our best to you during this holiday season.

Warm Regards,

Alan J. Walker
Executive Director, Utah Energy Research Triangle

Cc: Ryan Streams, Cameron Cuch

APPENDIX L

PROPOSED AGENDA FOR RFP CONSIDERATION

Proposed Agenda

10:00 Intro

10:15 Process and scoring

PRINCIPLE ENERGY ISSUES

10:25 PEI – Mansfield, USU

10:30 PEI – Hansen, BYU

10:35 PEI – Fletcher, BYU

10:40 PEI – Smith, UofU

10:45 PEI – Burian, UofU

10:50 PEI – Roehner, UofU

10:55 PEI – Saouma, UofU

11:00 PEI – Sparks, UofU

11:05 PEI – Tiwari, UofU

11:10 PEI recommendation

11:20 PEI discussion

11:45 PEI Decision

12:00 lunch break

GOVERNOR'S ENERGY LEADERSHIP SCHOLARS

12:15 GES – Erickson, BYU

12:20 GES - Smallwood BYU/UofU – **DECIDE on BYU**

12:25 GES - Huynh, UofU

12:30 GES – Dobson-Jones, UofU

12:35 GES - Meuller, UofU

12:40 GES – Shrimali, UofU

12:45 – Ghadeigi, UofU

12:50 GES – Judge, UofU

12:55 GES – Tseng, UofU **– DECIDE ON UofU**

1:00 GES – Overbeck, USU

1:05 GES – Thomas, USU

1:10 GES – Jiang, USU

1:15 GES – Robertson/Olson, USU

1:20 GES – O'Neil, USU - **DECIDE ON USU**

APPENDIX M

ENERGY RESEARCH TRIANGLE – PROJECT RECOMMENDATIONS

Energy Research Triangle – Project Recommendations

Governor's Energy Taskforce

January 17th, 2014

Al Walker and Ryan Streams

Proposal Review Process

- Review Panel consisting of:
  - Cody Stewart
  - Al Walker
  - Sarah Wright (Utah Clean Energy)
  - Ian Andrews (PacifiCorp Energy)
- Proposals reviewed on the basis of:
  - Collaboration (for Principle Energy Issues proposals)
  - Relevance to Utah
  - Feasibility/Efficacy

Total requests: $1,230,793

PIs - $1.1M for $380k available

Students - $ 210k for $60k available

Project Timeline

- **Nov 2012 –** Retooled Energy Research Triangle proposed to Governor's Energy Taskforce
- **Jan 11, 2013 –** First Presented at Governor's Energy Development Summit
- **Apr 4, 2013** - First funding request to USTAR Governing Authority denied
- **Oct 15, 2013** - $200k UCAP funding awarded
- **Dec 5, 2013** - $200k USTAR funding awarded
- **Dec 13, 2013** – Final draft application and guidelines to OED AG for review
- **Dec 18, 2013** – Receive AG approval, build ERT webpage, Issue RFP
- **Jan 13, 2014** – Energy Research Triangle Proposals due by noon
- **Jan 15, 2014** – Initial review of proposals complete by ERT selection panel
- **Jan 17, 2014** – Presentation of recommendations to Gov. Herbert
- **Jan 21, 2014** – Contact awardees to begin contracting process
- **June 4, 2014** – Energy Research Triangle presentations at Governor's Energy Development Summit

Review of 8 Principle Energy Issues

Project Title	PI/Univ	BYU Share	USU Share	UofU Share
Computer Modeling of Winter Ozone Formation in the Uintah Basin **(Uintah Basin Air Quality)**	Mansfield/ USU	$ -	$ 64,142	$ 64,000
Using Anaerobic Digestion to Create Glucose Fuel-Cell Feedstocks from Lignocellulosic Biomass **(Biomass to Biofuels)**	Hansen/ BYU	$ 63,733	$ 38,000	
A Low Cost, High Efficiency, Low Water Consumption Oil Shale Retort **(Oil Shale)**	Fletcher/ BYU	$ 68,439	$ -	$ 56,620
Demonstration and Feasibility of Hydroelectric Power Generation from Pressure Retarded Osmosis **(Hydroelectric Power)**	A. Smith/UU	$ 50,000	$ -	$ 78,011
Integrated Water-Energy Management for Utah's Energy Future **(Water Management)**	Burian/UU	$ 34,294	$ 33,851	$ 60,607
Characterization of Waxy Crude Deposition in Pipelines **(UB Crude Flow Assurance)**	Roehner/UU	$ 19,500	$ 19,500	$ 89,333
Catalytic Conversion of Carbon Dioxide to Carbon Monoxide and Methanol **(CO2 to Methanol)**	Saouma/UU	$ 40,277	$ 42,776	$ 42,777
Optimization of Thermoelectric Power Harvesting Systems with Tunable Thermoeletric Generator **(Waste heat to Electricity)**	Sparks/UU	$ 42,641	$ 42,133	$ 43,559
Manufacturing High-Efficiency, Low Cost ZnO Nanoplant-based Solar Cells **(Next-gen Solar)**	Tiwari/UU	$ 24,000	$ 24,000	$ 80,333

Process

- ✓ Identified top proposals based on reviewed criteria
- ✓ Discussed topic balance
- ✓ Discussed University balance
- ✓ Recommend three projects for funding (with only one unanimous selection)

Concerns

- ✓ No BYU-led proposal
- ✓ No BYU component to USU Air Quality

Review of Governor's Energy Leadership Scholars

Materials study for future layered photovoltaics using protein enclosed nanocrystals **(Solar Power Design)**	Erickson	BYU
Axial dispersion measurement of CO2 on adsorbent beds and novel low-cost process design **(CO2 Capture)**	Smallwood	BYU/ USU
Design and fabricate the single cell BHJ OPV with power conversion efficiency exceeding 10% **(Nex-gen Solar)**	Huynh	UU
Synthesis of Novel Bimetallic Complexes for Selective Reduction of CO2 to CO **(CO2 to CO Conversion)**	Dobson-Jones	UU
Redox Non-innocant Ligand Scaifolds for CO2 Electrocatalysis **(CO2 to CO Conversion)**	Meuller	UU
Novel Catalysts for the Conversion of CO2 to Methanol **(CO2 to Methanol Conversion)**	Shrimali	UU
Evaluation of cold temperature performance of PCM Based TMS in Hybrid Electric vehicles **(Electric Vehicle Batteries)**	Ghadbeigi	UU
High performance Mg2Si nanostructures thermoelectric materials **(Waste Heat to Electricity)**	Judge	UU
Characterization of Waxy Crude Crystallization **(Uintah Basin Crude Oil)**	Tseng	UU
Application of lactic acid bacteria in a biorefinery approach to produce valuable co-products from wast algal cake **(Algae to Biodiesel)**	Overbeck	USU
CO2-based Geothermal Opportunities in Northern Utah **(Geothermal Power)**	Thomas	USU
Developing Hydrogen Evolution Catalysts Using First-Row Transition Metal Chalcogenides **(Hydrogen Fuel Cells)**	Jiang	USU
Blocks and Barriers, Openings and Opportunities for Renewable Energy Development in Utah **(Renewable Energy Policy Analysis)**	Robertson/ Olson	USU
Measurement of ozone precursor emissions from oil and gas well sites **(Uintah Basin Air Quality)**	O'Neil	USU

Process

- ✓ Followed same decision-making framework for students
- ✓ Considered level of education (Bachelor's vs. Master's vs. Ph.D.
- ✓ Discussion of Tribal issues
- ✓ Selection of alternate project

Concerns

- ✓ No Tribal proposal

Summary of Recommendations – Principle Energy Issues

- **USU –** Air Quality Study in Uinta Basin
- **U of U –** Waxy Crude Flow Assurance
- **Alternatives**
  - Round 2 of Proposals for BYU
  - U of U – Catalytic Conversion of CO2 to CO and Methanol

Summary of Recommendations – Governor's Energy Leadership Scholars

- **BYU –** B.S. Student Study of Photovoltaic Production Process Improvements
- **U of U –** Ph.D. Student Study of Hybrid Electric Vehicle Battery Performance in Cold Climate
- **USU –** Ph.D. Student Study of Hydrogen Fuel Cell Production from Solar Power
- **Tribal –** No proposal, Round 2
- **Alternate –** U of U B.S. Student Study of High Performance Thermoelectric nanomaterials

APPENDIX N

NOTICE OF GRANT AWARD

Feb 18, 2014

Dear Dr. Daniel Ess,

Congratulations! Governor Gary R. Herbert's Energy Advisor and the Utah Energy Research Triangle are pleased to announce that your proposal entitled, *"Catalytic Conversion of Carbon Dioxide to Carbon Monoxide and Methanol"* has been selected for the Principle Energy Issues Program. The $128,333 grant may be used for research-related costs such as research team salary, laboratory costs and supplies. Funds must be administered by awardee's academic institution.

The project period is one year from date of award.

A contract detailing award terms and conditions will be sent to your University's Office of Sponsored Projects and must be signed by an appropriate authority on behalf of the institution. We will activate the award upon receipt of the signed contract. Your University's OSP will coordinate access to award funds and can answer any questions you may have regarding this process.

As a reminder, you are responsible to follow the Terms and Conditions laid out in our program guidelines. They can be found online at: http://energy.utah.gov/utah-energy-research-triangle/.

We look forward to working with you in the coming year to positively impact energy development in Utah. If you have any questions or concerns, please do not hesitate to contact me by phone at (801) 864-5960 or by email at alanjwalker@utah.gov.

Warm Regards,

Alan J. Walker

Executive Director, Utah Energy Research Triangle

Utah Energy Research Triangle
423 Wakara Way, Suite 300
Salt Lake City, UT 84108

Feb 18, 2014

Dear Ms. Leila Ghadbeigi,

Cc: Dr. Taylor Sparks

Congratulations! Governor Gary R. Herbert's Energy Advisor and the Utah Energy Research Triangle are pleased to announce that your proposal entitled, *"Evaluation of cold temperature performance of PCM Based TMS in Hybrid Electric Vehicles"* has been selected for the Governor's Energy Leadership Scholars Grant. The $15,000 grant may be used for research-related costs such as student salary, laboratory costs and supplies. Funds must be administered by awardee's academic institution. Funds may not be used to pay faculty mentor salary and/or benefits.

The project period is one year from date of award.

A contract detailing award terms and conditions will be sent to your University's Office of Sponsored Projects and must be signed by an appropriate authority on behalf of the institution. We will activate the award upon receipt of the signed contract. Your University's OSP will coordinate access to award funds and can answer any questions you or your faculty mentor may have regarding this process.

As a reminder, you are responsible to follow the Terms and Conditions laid out in our program guidelines. They can be found online at: http://energy.utah.gov/utah-energy-research-triangle/.

We look forward to working with you in the coming year to positively impact energy development in Utah. If you have any questions or concerns, please do not hesitate to contact me by phone at (801) 864-5960 or by email at alanjwalker@utah.gov.

Warm Regards,

Alan J. Walker

Executive Director, Utah Energy Research Triangle

Utah Energy Research Triangle
423 Wakara Way, Suite 300
Salt Lake City, UT 84108

APPENDIX O

GOVERNOR'S ENERGY DEVELOPMENT SUMMIT PRINCIPLE ISSUES

Utah Energy Research Triangle
(Utah ERT)

Ryan Streams and Alan Walker

In Partnership With:

- **UNPRECEDENTED PARTNERSHIP**

- Office of Energy Development (OED)
- Office of Economic Development (GOED)
- Department of Workforce Services (DWS)
- Utah Science Technology and Research (USTAR)
- Utah Cluster Acceleration Program (UCAP)

- Brigham Young University (BYU)
- Utah State University (USU)
- University of Utah (UofU)

Agenda

- **Overview of Utah ERT**: Al Walker
- **PI Presentation:** Dr. Daniel Ess

- **PI Presentation:** Dr. Marc Mansfield

- **PI Presentation:** Dr. Michael Hoepfner (on behalf of Dr. Richard Roehner)

- Discussion/question and answers

Impact on Utah Energy Issues

- Three Utah research universities collaborate to solve Utah energy issues
  - Improves the welfare and quality of life for Utah citizens
  - Develops potential commercially deployable technologies
- Build a new, cross-cutting partnership at Utah's research Universities
  - Creates a foundation for future collaborative research focused on Utah-specific challenges
  - Foster a culture of self-determination through research
- Total of 25 Researchers including:
  - Undergraduates through senior research faculty with 20+ years of experience

Proposal Review Process

- Review Panel consisting of:
  - Cody Stewart, Governor's Energy Advisor
  - Al Walker, Executive Director, Utah ERT
  - Sarah Wright, CEO, Utah Clean Energy
  - Ian Andrews, Director, PacifiCorp Energy
- Proposals reviewed on the basis of:
  - Collaboration (for Principle Energy Issues proposals)
  - Relevance to Utah
  - Feasibility/Efficacy

Total requests: $1,230,793
PIs - $1.1M for $385k available
Students - $130k for $60k available

TIER 1: Principle Energy Issues Program

- Tier 1: Principle Energy Issues Program
  - Engaged 18 researchers across 3 projects
  - Merit-based selection process
  - Connect science and industry where need is greatest and impact is plausible
- Through Principle Energy Issues Program, contribute to:
  - Rural economic development
  - Energy security
  - Resource management
  - Public health
  - Environmental quality

Review of 8 Principle Energy Issues

Project Title	PI/Univ	BYU Share	USU Share	UofU Share
Computer Modeling of Winter Ozone Formation in the Uintah Basin **(Uintah Basin Air Quality)**	Mansfield/ USU	$ 10,000	$ 59,142	$ 59,000
Using Anaerobic Digestion to Create Glucose Fuel-Cell Feedstocks from Lignocellulosic Biomass **(Biomass to Biofuels)**	BYU	$ 63,733	$ 38,000	$ -
A Low Cost, High Efficiency, Low Water Consumption Oil Shale Retort **(Oil Shale)**	BYU	$ 68,439	$ -	$ 56,620
Demonstration and Feasibility of Hydroelectric Power Generation from Pressure Retarded Osmosis **(Hydroelectric Power)**	UU	$ 50,000	$ -	$ 78,011
Integrated Water-Energy Management for Utah's Energy Future **(Water Management)**	UU	$ 34,294	$ 33,851	$ 60,607
Characterization of Waxy Crude Deposition in Pipelines **(Uinta Basin Crude Oil)**	Roehner/UU	$ 19,500	$ 19,500	$ 89,333
Catalytic Conversion of Carbon Dioxide to Carbon Monoxide and Methanol **(CO2 to Methanol)**	Ess/BYU	$ 40,277	$ 42,776	$ 42,777
Optimization of Thermoelectric Power Harvesting Systems with Tunable Thermoeletric Generator **(Waste heat to electricity)**	UU	$ 42,641	$ 42,133	$ 43,559
Manufacturing High-Efficiency, Low Cost ZnO Nanoplant-based Solar Cells **(Next-gen Solar)**	UU	$ 24,000	$ 24,000	$ 80,333

Process

- ✓ Identified top proposals based on reviewed criteria
- ✓ Discussed topic balance
- ✓ Discussed University balance
- ✓ Recommend three projects for funding (with only one unanimous selection)

Summary of Awards - Principle Energy Issues

- **Project 1 –** Air quality/ ozone study to mitigate non-attainment in the Uinta Basin and Wasatch Front

PIs: Dr. Mansfield, Dr. Lyman, Dr. Horel, Dr. Hansen

- **Project 2 –** Waxy crude oil characterization to improve transportation and increase value

PIs: Dr. Roehner, Dr. HIll, Dr. Hedengren

- **Project 3 –** Catalytic conversion of CO_2 to synthetic gas and liquid fuel

PIs: Dr. Saouma, Dr. Ess, Dr. Sun

TIER 2: Governor's Energy Leadership Scholars

- Tier 2: Governor's Energy Leadership Scholars
  - Engaged 7 scholars across 4 projects
- Increase opportunities for next generation of researchers in STEM fields

Review of Governor's Energy Leadership Scholars

Materials study for future layered photovoltaics using protein enclosed nanocrystals **(Solar Power Design)**	Erickson	BYU
Axial dispersion measurement of CO2 on adsorbent beds and novel low-cost process design **(CO2 Capture)**		BYU/ USU
Design and fabricate the single cell BHJ OPV with power conversion efficiency exceeding 10% **(Next-gen Solar)**		UU
Synthesis of Novel Bimetallic Complexes for Selective Reduction of CO2 to CO **(CO2 to CO Conversion)**		UU
Redox Non-innocant Ligand Scaifolds for CO2 Electrocatalysis **(CO2 to CO Conversion)**		UU
Novel Catalysts for the Conversion of CO2 to Methanol **(CO2 to Methanol Conversion)**		UU
Evaluation of cold temperature performance of PCM Based TMS in Hybrid Electric vehicles **(Electric Vehicle Batteries)**	Ghadbeigi	UU
High performance Mg2Si nanostructures thermoelectric materials **(Waste Heat to Electricity)**	Judge	UU
Characterization of Waxy Crude Crystallization **(Uintah Basin Crude Oil)**		UU
Application of lactic acid bacteria in a biorefinery approach to produce valuable co-products from waste algal cake **(Algae to Biodiesel)**		USU
CO2-based Geothermal Opportunities in Northern Utah **(Geothermal Power)**		USU
Developing Hydrogen Evolution Catalysts Using First-Row Transition Metal Chalcogenides **(Hydrogen Fuel Cells)**	Jiang	USU
Blocks and Barriers, Openings and Opportunities for Renewable Energy Development in Utah **(Renewable Energy Policy Analysis)**		USU
Measurement of ozone precursor emissions from oil and gas well sites **(Uintah Basin Air Quality)**		USU

Process

- ✓ Followed same decision-making framework for students
- ✓ Considered level of education (Bachelor's vs. Master's vs. Ph.D.

Summary of Recommendations – Governor's Energy Leadership Scholars

- **BYU –** B.S. Student Study of Photovoltaic Production Process Improvements

Stephen Erickson

- **U of U –** Ph.D. Student Study of Hybrid Electric Vehicle Battery Performance in Cold Climate

Leila Ghadbeigi

- **USU –** Ph.D. Student Study of Hydrogen Fuel Cell Production from Solar Power

Nan Jiang

- **"Jump Ball" –** U of U B.S. Student Study of High Performance Thermoelectric nanomaterials

Matthew Judge

Agenda

- **Overview of Utah ERT**: Al Walker

- **PI Presentation:** Dr. Daniel Ess

- **PI Presentation:** Dr. Marc Mansfield

- **PI Presentation:** Dr. Michael Hoepfner (on behalf of Dr. Richard Roehner)
- Discussion/question and answers

APPENDIX P

GOVERNOR'S ENERGY SUMMIT BREAKFAST PRESENTATION

Energy Research Triangle – Breakfast Presentation Script

0:00-1:00 Thanks and Program Thumbnail

"Thank you all for being here this morning, my name is Alan Walker and I am the Executive Director of the Utah Energy Research Triangle. I would like to take a moment to recognize four impressive young people who are participants in an exciting new program called the Governor's Energy Leadership Scholars. During our afternoon breakout session at 3:00pm, I will discuss the program in more detail but I would like to take a moment to give you a brief overview. The Governor's Energy Leadership Scholars is designed to fund student-led applied energy research on Utah-specific topics. These students represent just a portion of the future leaders in energy research within our state. This program is designed to foster those students while tackling unique energy challenges. I will recognize each student in turn and I ask that you hold your applause until the end."

1:00-1:30 Stephen Erickson from BYU

Our first scholar is Stephen Erickson who is currently pursuing his B.S. in Physics from Brigham Young University. Stephen's research is on high-efficiency photovoltaics.

1:30-2:00 Nan Jiang (phonetically – N-ah-n Jong) from USU

Our next scholar is Nan Jiang from Utah State University. Nan is currently pursuing her Ph.D. in Inorganic Chemistry. Her research is examining the production of Hydrogen for fuel cells through the use of catalysts made of earth-abundant materials.

2:00-2:30 Leila Ghadbeigi (phonetically G-ah-d b-ay-gi) from UofU

Our third scholar is Leila Ghadbeigi from the University of Utah. Leila is pursuing her Ph.D. in Materials Science and Engineering. Her research addresses the performance of hybrid electric vehicle batteries in cold temperatures through the study of phase change materials.

2:30-3:00 Matthew Judge from UofU

Our final scholar is Matthew Judge. Matthew is pursuing his B.S. in Materials Science and Engineering. He is researching thermoelectric materials that utilize Magnesium, an important Utah commodity.

3:00-3:30 Ask for applause and invite audience to visit student poster session and attend ERT panel discussion

I encourage all of you to visit with theses scholars during the breaks between sessions. They will have posters set up and are looking forward to discussing their research. To learn more about the Energy Research Triangle and our faculty-led research projects, please join us at 3:00pm for our breakout session. Thank you and please give the Governor's Energy Research Scholars a round of applause.

APPENDIX Q

TIER 2: ENERGY LEADERSHIP SCHOLARS POSTERS

Evaluation of cold temperature performance of PCM Based Thermal Management System in Hybrid Electric vehicles

Leila Ghadbeigi, Taylor D. Sparks
Department of Materials Science and Engineering
University of Utah

BACKGROUND

Improving the performance and cycle life of Li-ion batteries is a key factor for electric vehicle (EV) viability. Li-ion batteries operate most efficiently in a temperature range of 20-40°C. Higher temperatures must be avoided to prevent thermal runaway and low temperatures lead to high internal resistance. Given these temperature impacts on battery performance, thermal management systems (TMS) in battery packs in EVs are critical.

Figure 1. (left) Conventional TMS rely on air or liquid, but are too expensive, heavy, and complex in terms of blower, fans, pumps, pipes and other accessories. (right) Another option described in this proposal is to use phase change materials (PCM) that absorb heat through their latent heat during melting. Ref. Khateeb et al 2005.

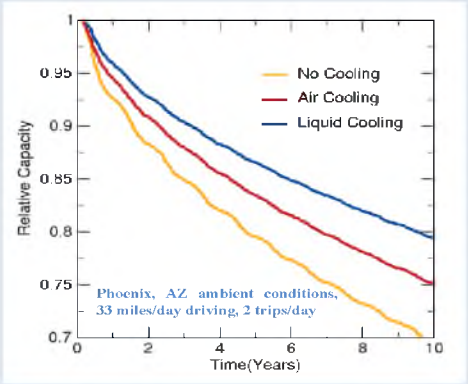


Figure 2. Critical role of battery thermal management system on battery life. Ref. NREL.

RESEARCH OBJECTIVE

In this project the performance of PCM based TMS in *cold* ambient temperature will be assessed to determine the net benefit.

- **Advantages:** once the PCM is melted it will keep the battery package warm during short stops by solidifying and giving off heat.
- **Drawbacks:** the cold PCM will delay battery warming after a long cold soak by absorbing a portion of the heat intended for the battery.
- **Hypothesis:** It is anticipated that the net impact, either positive or negative, of PCM based TMS will likely be a function of the duration of short vehicle stops. This study aims to determine this time dependence and to quantify the effect of these time intervals on battery temperature and capacity.

METHODS

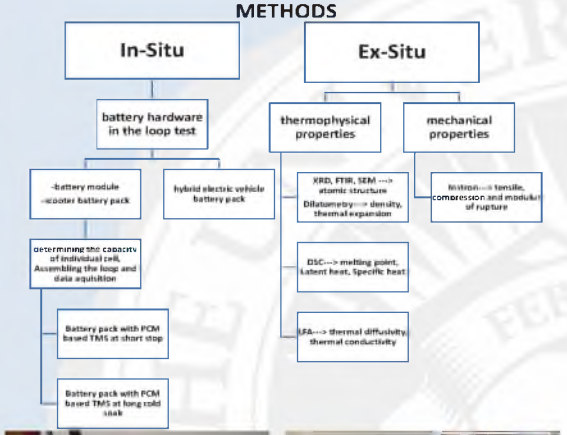


Figure 3. Two options for BHDIL test. (left) Real time test using scooter. (right) battery module with constant current profile. Ref. Khateeb et al 2005. Goli et al 2014.

PRELIMINARY RESULTS

- PCM requirements: Suitable melting temperature, high melting enthalpy, high specific heat, low volume change due to the phase change, high thermal conductivity, low density, little or no supercooling, low price.
- We measured thermal diffusivity of pure materials (paraffin wax) and composites (paraffin + graphite) at different temperature using laser flash method (ASTM-E146).

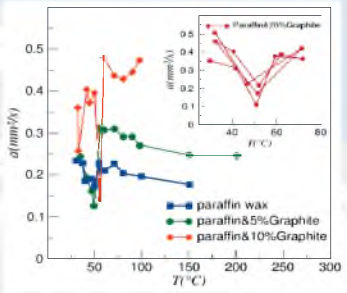


Figure 4. Thermal diffusivity can be increased by increasing graphite weight fraction in PCM composite.

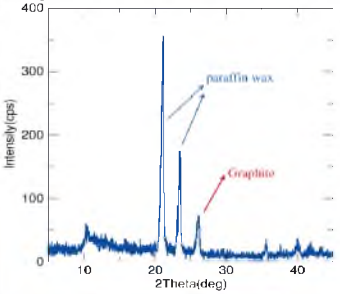


Figure 5. XRD pattern of partially crystalline paraffin with 10wt% graphite. A polymer with a highly crystalline and ordered structure will have a greater conductivity than the equivalent amorphous material. We will investigate the tuning thermal conductivity of paraffin by changing its crystal structure.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the Utah Energy Research Triangle and Governor's Energy Leadership Scholars Program for funding and support.

Electrodeposited Nickel-Sulfide Films as Competent Hydrogen Evolution Catalysts in Neutral Water

Nan Jiang, Lia Bogoev, and Yujie Sun*

Department of Chemistry and Biochemistry, Utah State University, Logan, Utah 84322

1: Introduction

The growing global energy demands and depletion of fossil fuel reserves have urged the exploration of renewable energy resources. Solar energy is a promising candidate owing to its gigantic capacity. In this respect, solar-driven water splitting to produce hydrogen and oxygen is an attractive approach to store solar energy in chemical forms. Significant efforts have been devoted to developing efficient catalysts for the hydrogen evolution reaction (HER).

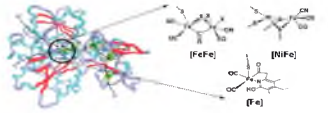
Nature uses hydrogenase enzymes to carry out the conversion between proton and hydrogen with earth-abundant elements at remarkable rates under benign conditions. The active sites of hydrogenase enzymes with [Fe-Ni], [Fe-Fe], and [Fe]-cofactors have inspired the development of various molecular HER catalysts, however they usually suffer from low stability in aqueous media and/or large overpotential.

Water-splitting reactions

$O_2 + 4H^+ + 4e^- \rightleftharpoons 2H_2O$ $\quad E_{anodic} = 1.23\ V - 0.059\ (pH)\ V$ vs NHE

$4H^+ + 4e^- \rightleftharpoons 2H_2$ $\quad E_{cathodic} = 0\ V - 0.059\ (pH)\ V$ vs NHE

$2H_2O \longrightarrow 2H_2 + O_2$ $\quad E_{cell} = -1.23\ V$

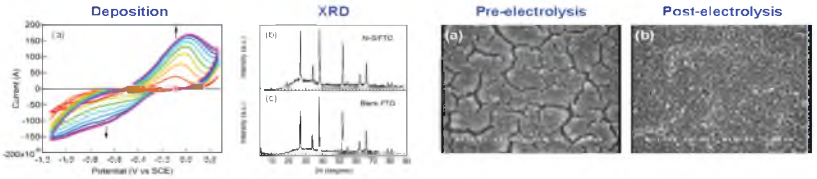


Recent years have witnessed the emergence of several promising solid-state HER catalysts composed of non-precious elements. For example, MoS_2, MoB, Mo_2C, Cu_3MoS_4, H_2-CoCat, MS_2 (M = Fe, Co, Ni), etc, were published showing good to excellent HER catalysis in acidic media.[1-2] These catalysts are usually studied in strong acidic media and some of them required toxic gas treatment at elevated temperature. In order to minimize environmental impact and increase biocompatibility, it is very desirable to conduct HER in neutral water.[3] Herein, we demonstrate that amorphous nickel-sulfide (Ni-S) films prepared via potentiodynamic deposition are competent HER catalysts under various conditions

2: Preparation of Ni-S films via potentiodynamic deposition

The potentiodynamic deposition was conducted in deoxygenated 5 mM $NiSO_4$ and 0.5 M thiourea in water. Linear voltammetry scans in the range of −1.2 to 0.2 V vs SCE were cycled at 5 mV/s (Figure a). X-ray diffraction (XRD) analysis of Ni-S/FTO is compared to that of a blank FTO in Figures b and c. All the XRD peaks are due to the presence of FTO, demonstrating the amorphous nature of the Ni-S films.

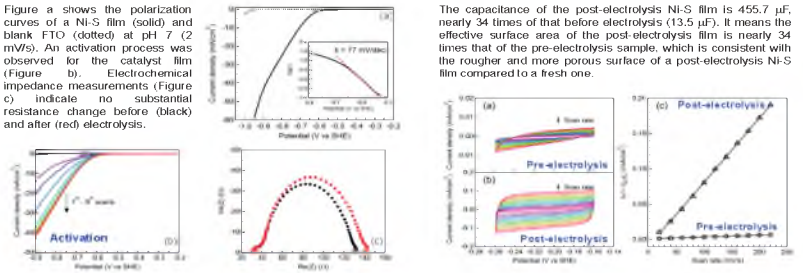
The scanning electron microscopy images of Ni-S films before (a) and after (b) electrolysis are shown in Figures a and b, respectively. No regular crystalline particles or aggregates were observed. The cracks are likely attributed to the annealing process. The post-electrolysis Ni-S film displays a rougher and more porous surface than that of the pre-electrolysis counterpart.



3: Polarization, electrochemical impedance, and capacitance studies

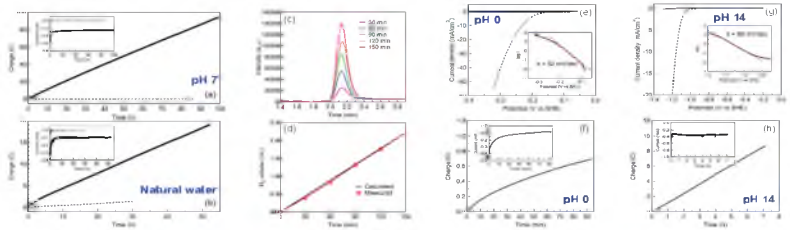
Figure a shows the polarization curves of a Ni-S film (solid) and blank FTO (dotted) at pH 7 (2 mV/s). An activation process was observed for the catalyst film (Figure b). Electrochemical impedance measurements (Figure c) indicate no substantial resistance change before (black) and after (red) electrolysis.

The capacitance of the post-electrolysis Ni-S film is 455.7 μF, nearly 34 times of that before electrolysis (13.5 μF). It means the effective surface area of the post-electrolysis film is nearly 34 times that of the pre-electrolysis sample, which is consistent with the rougher and more porous surface of a post-electrolysis Ni-S film compared to a fresh one.



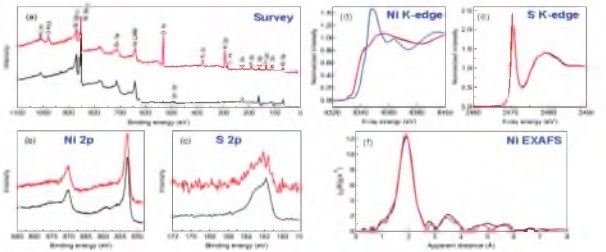
4: Faradaic efficiency and electrolysis under various conditions

Long-term electrolysis of Ni-S/FTO at −0.7 V vs SHE at pH 7 and at −0.959 V vs SHE in the Great Salt Lake water are included in Figures a and b, respectively. A Faradaic efficiency of 100% was confirmed by gas chromatography (Figures c-d). Figures e-f display the polarization and electrolysis data at pH 0 with a Tafel slope of 52 mV/dec, while Figures g-h show the data collected at pH 14 with a Tafel slope of 88 mV/dec.



5: X-ray photoelectron spectroscopy (XPS) and X-ray absorption spectroscopy (XAS)

XPS and XAS were conducted on Ni-S films. Figures a, b, and c show the XPS survey, high-resolution Ni 2p, and S 2p regions, respectively, of the Ni-S films before (black) and after (red) electrolysis, implying a Ni/S ratio of 1.65. Figures d, e, and f present the Ni K-edge, S K-edge X-ray atomic near edge structure spectra (XANES), and Ni extended X-ray atomic fine structure (EXAFS) of the Ni-S films before (black) and after (red) electrolysis. Blue curve in Figure d is the Ni K-edge XANES spectrum of $Ni(OH)_2$. The Ni K-edge XANES spectrum of the Ni-S film resembles that of Ni_3S_2 very well, which is further supported by the Ni EXAFS spectra.



6: Conclusions, references, and acknowledgements

Conclusions:

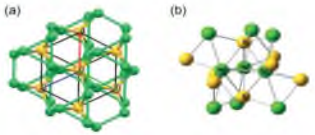
a) Amorphous Ni-S films can be prepared by potentiodynamic deposition.
b) The Ni-S films show competent HER catalysis under various conditions.
c) An activation process was observed and likely due to the enhanced surface area under electrochemical conditions.
d) A suite of characterization techniques reveal the major composition of the Ni-S film as Ni_3S_2.

References:

(1) Sun, Y.; Liu, C.; Grauer, D. C.; Yano, J.; Long, J. R.; Yang, P.; Chang, C. J. *J. Am. Chem. Soc.* **2013**, *135*, 17699.
(2) Morales-Guio, C. G.; Stern, L.-A.; Hu, X. *Chem. Soc. Rev.* **2014**.
(3) Thoi, V. S.; Sun, Y.; Long, J. R.; Chang, C. J. *Chem. Soc. Rev.* **2013**, *42*, 2388.
(4) Metcalf, P. A.; Fanwick, P.; Rajkovic, Z.; Honig, J. M. *J. Solid State Chem.* **1993**, *104*, 81.

Acknowledgements:

N.J. acknowledges the Governor's Energy Leadership Scholars grant program of the State of Utah. L.B. is supported by the URCO and SURCO programs of Utah State University (USU). Y.S. acknowledges the financial support and Research Catalyst grant from USU and the Principle Energy Issues Program of the State of Utah.



Ni_3S_2 (heazlewoodite) is one of the stable forms of nickel sulfides. Each nickel atom in crystalline Ni_3S_2 occupies a pseudotetrahedral site in an approximately body-centered cubic sulfur lattice.[4] The Ni_3S_2 units are interconnected through short Ni-S and Ni-Ni distances, 2.2914(5) and 2.5319(9) Å, respectively, within the Ni_3S_2 unit. Figure a displays the crystal structure of Ni_3S_2 viewed through the body diagonal direction and Figure b highlights the trigonal bipyramidal core of Ni_3S_2 (green: Ni; yellow: S).

Materials study for 3rd generation solar cells using protein enclosed nanocrystals

Stephen Erickson[1], Trevor Smith[2], Cameron Olsen[1], Dr. John Colton[1], Dr. Richard Watt[2]
1: Department of Physics and Astronomy, Brigham Young University 2: Department of Chemistry and Biochemistry, Brigham Young University

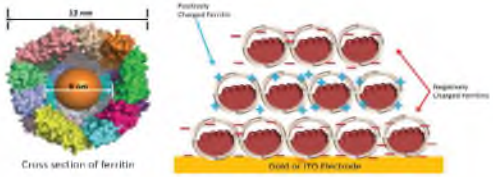
INTRODUCTION

- Traditional monocrystalline solar cells are limited by the Shockley-Queisser limit of 33.7% efficiency
- Multi-junction cells have been shown to surpass this limit and have higher theoretical efficiency limits
  - This introduces a number of new problems, particularly with lattice matching, which severely limit the number of compatible materials
- We are studying ferritin, a spherical protein shell, as a template for nanocrystal growth for use in multi-junction bio-inorganic solar cells, which offer a number of key advantages

BACKGROUND

Ferritin:

- 12 nm spherical protein with an 8 nm hollow interior (see below)
- Naturally contains an iron oxide (FeOOH) nanocrystal core.
- Very durable, withstanding temperatures up to 85° C and pH 4-12.



Cross section of ferritin

Advantages to using ferritin:

- Template for self assembling nanocrystals
- Wide range of nanocrystals allows for a wide range of band gaps
- Can be arranged through adsorption of various chemical compounds to the outer surface, allowing for layered deposition
- Eliminates problem with lattice matching
- Protects against harmful effects of photo-corrosion

Multi-junction solar cells:

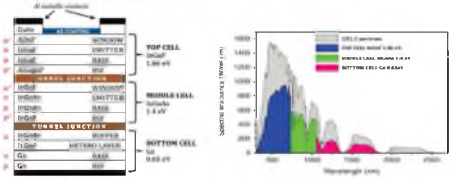
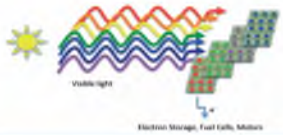


Image source: http://upload.wikimedia.org/wikipedia/commons/1/19/StructureMultispecies.png

OBJECTIVES

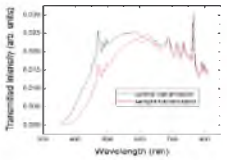
- Characterize a wide range of ferritin enclosed nanocrystals for use in future multi-junction solar cells
- Show band gap tunability by controlling the composition and size of the nanocrystals
- Select materials that give the optimum spread of band gaps for maximum efficiency
- Materials to test:
  - iron, cobalt, manganese, titanium, nickel, and chromium oxides.
  - II-VI (CdS, CdSe, PbS, etc) and III-V (GaAs, GaN, InAs, etc) semiconductors



METHODS

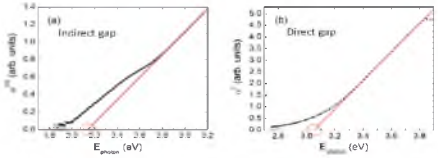
Optical absorption spectroscopy:

- Individual wavelengths are sent through the sample (in solution)
- Transmitted intensities are then compared to control intensities to get an absorption spectrum



Typical raw transmission spectrum. Sharp features come from the spectrum of our Xe arc lamp.

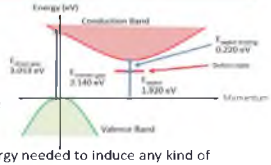
After converting wavelength to energy, the relative amplitudes from the above graph are then used to produce the following plots for (a) indirect gaps, and (b) direct gaps. A linear fit is extrapolated to the x-axis to find the band gap.



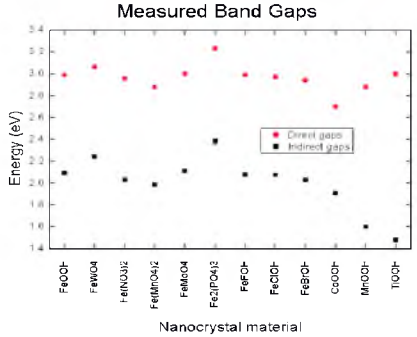
For more information on the methods: J S Colton *et al* 2014 *Nanotechnology* **25** 135703 doi: 10.1088/0957-4484/25/13/135703

RESULTS

Band structure model for FeOOH:



- Colored sections are allowable electron states
- Photons can induce vertical transitions, but horizontal movement requires the assistance of a phonon (vibration in crystal lattice) to conserve momentum
- The band gap is the minimum energy needed to induce any kind of transition between the valance band and conduction band.
- Direct transitions (vertical, no change in momentum) thus occur more readily because they do not require a phonon
- Indirect transitions, requiring a change in momentum, are less likely due to the intermediate phonon step
- Any additional photon energy beyond the band gap is lost as heat



- Error bars are not visible on this scale, most in the range of 0.01-0.02 eV
- All materials tested so far are indirect gap semiconductors, with band gaps ranging from **1.48 eV** (838 nm) to **2.38 eV** (521 nm)

FUTURE WORK

- Expand our collection of materials to include direct gap semiconductors
- Synthesize and characterize II-VI and III-V semiconductor nanocrystals, most of which are direct gap in the bulk state
- Continue developing ferritin as a model for 3rd generation solar cells as outlined in R K Watt *et al* 2013 *Catal. Sci. Technol.*, **3** 3103-3110 doi: 10.1039/C3CY00536D

High Performance Nanostructured Mg_2Si Thermoelectric Materials

Matthew A. Judge, Taylor D. Sparks
Department of Materials Science and Engineering
University of Utah

BACKGROUND

Magnesium silicide (Mg_2Si) is an attractive thermoelectric material due to it's compromise between moderate performance and excellent abundance and cost. This goal of this research is to improve efficiency of Mg_2Si while maintaining low cost and toxicity. The thermoelectric Figure of Merit is defined by equation (1). Where σ is the electrical conductivity, S is the Seebeck coefficient, T is the temperature, and λ is the thermal conductivity. In this project our goal will be to generate porous nanostructures that minimize the thermal conductivity without negatively impacting the electrical conductivity.

$$(1)\quad zT = \frac{\sigma S^2 T}{\lambda}$$

Figure 1. Thermoelectrics work by converting a temperature gradient to a voltage and vice versa. Both electronic carriers (electrons and holes) and lattice vibrations (phonons) carry heat across the device.

WHY DO WE CARE ABOUT THERMOELECTRICS?

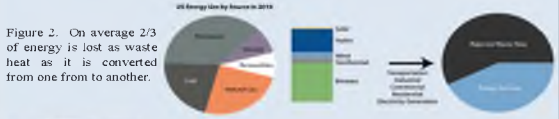


Figure 2. On average 2/3 of energy is lost as waste heat as it is converted from one from to another.

Figure 3. Many opportunities exist to improve energy efficiency by capturing waste heat and converting it back to useable electricity. For example, 70% of fuel energy in vehicles is lost as heat with 40% of that as high temperature waste heat in the exhaust. Thermoelectric efficiency must improve to better utilize this abundant waste heat resource.

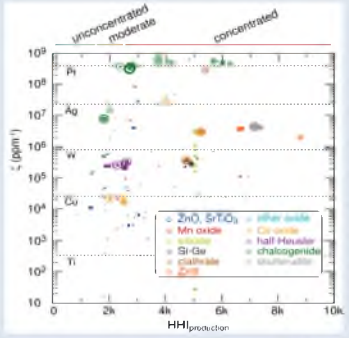


Figure 4. The scarcity (ς, inverse of crustal abundance) and $HHI_{production}$ (a measure of supply and demand) of a wide variety of thermoelectric materials is plotted. Marker size scales with thermoelectric efficiency (zT). State-of-the-art materials like chalcogenides, Zintls, and skutterudites are either too expensive because of reliance on critically scarce or low-abundance elements. Mg_2Si balances moderate thermoelectric and resource performance

RESEARCH OBJECTIVE

WHY MAGNESIUM SILICIDE?

Using Mg_2Si as a thermoelectric material allows for a compromise between performance and resource considerations. The highest zT in state-of-the-art materials is ~ 2 but these materials contain rare or toxic materials. Mg_2Si, however, contains neither rare, nor toxic materials. Both magnesium and silicon are abundant resources, and magnesium is an important domestic commodity produced entirely in Utah. The drawback of Mg_2Si is that it has a zT of only ~ 1.

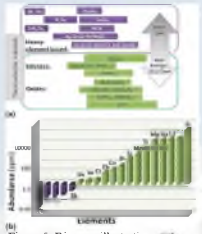


Figure 5. Diagram illustrating cost and toxicity in thermoelectrics.

APPROACH

In order to improve the zT of Mg_2Si we intend to use porosity to tailor the properties of the material. Pores within the material act as a scattering site to phonons and electrons but careful control of size, shape and distribution of pores can lead to optimal nanostructures for maximizing phonon scattering and minimizing electron scattering. In this way we decrease λ from equation (1), thus raising zT. In addition to porosity we will examine the grain size of the Mg_2Si and measure the effect of different grain sizes on the electrical and thermal properties.

NOVEL SYNTHESIS METHOD

Mg_2Si is often synthesized by vacuum melting, or spark plasma sintering. The difficulties in these techniques arise from the difference in melting temperature between magnesium and silicon, chemical reactivity, and high vapor pressure of magnesium. These lead to evaporation during heating, expensive equipment, non-stoichiometry and other problems. Most importantly, these approaches yield only fully dense Mg_2Si which leaves no possibility to use porosity to improve its properties. The method we have chosen to use is a combination of mechanical alloying with vacuum sintering. We will also be looking at microwave synthesis as another possible alternative.

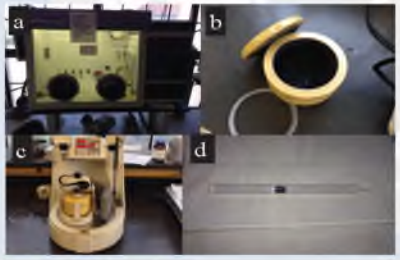


Figure 6. Materials are weighed and mixed in glove box (a) with a high purity argon atmosphere to remove oxygen that would cause oxidation during synthesis. Materials are transported in a sealed crucible filled with milling media (b) into a planetary mill (c) where they are mixed at high speeds until a mechanical alloying reaction produces pure Mg_2Si powder. This powder is then shaped and pressed into a pellet and sealed in a quartz ampoule (d) before final sintering under vacuum.

PRELIMINARY RESULTS

SYNTHESIS

We are using a mechanical alloying technique called ball milling which requires no liquids or other solvents, and no heat input (See Figure 6). A glove box is used to load the magnesium and silicon in an argon environment to ensure no oxidation during synthesis. Milling media are added to powders in the milling crucible where they are spun at a high rate using a planetary ball mill. The spinning allows the milling media to crush the aggregates into a fine powder, and the milling media also imparts the mechanical energy and friction necessary to begin the chemical reaction. Our goal is to get as close to phase pure (100% Mg_2Si) as possible during the milling process. Whatever reactants are left over, however, should react in the sintering process that will become the next focus of the project. After milling, the powder is pressed into pellets which can be loaded into quartz ampoules, sealed under vacuum, and heated for sintering.

CHARACTERIZATION

Rietveld refinement of X-ray diffraction data is shown below in Figure 7. These refinements offer two major advantages: (1) they allow for quantitative phase analysis (weight fraction of each phase) and (2) they allow us to determine the exact crystal structure details of each phase (lattice parameter, site occupancy etc)

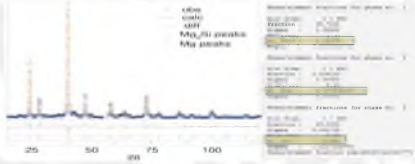


Figure 7. Rietveld refinement of each phase in the reacted mixture. Phase 1 (16%) is leftover Mg, phase 2 (<1%) is leftover Si, phase 3 (83%) is the desired Mg_2Si.

NEXT STEPS

After refinement our sample shows 83% by weight Mg_2Si, with A significant amount of unreacted Mg and Si and probably impurities from the milling crucible and media. We have decided to make some changes to the synthesis process going forward in order to improve upon the phase purity of the samples. Future samples will be milled in a tungsten carbide crucible approximately 1/10 the size of the current crucible. This should reduce the impurity content and improve the quality of the reaction. Additionally we have encountered the problem of Mg agglomeration on the bottom of the crucible. This is due to the difference in elastic modulus between Mg and Si. To address this problem Mg will be added in smaller increments and the milling will go in cycles. This technique has been shown to address that problem in other research. Lastly, we can form pellets with different nanostructured porosity and begin testing their electrical and thermal properties.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the Utah Energy Research Triangle and Governor's Energy Leadership Scholars Program for funding and support.

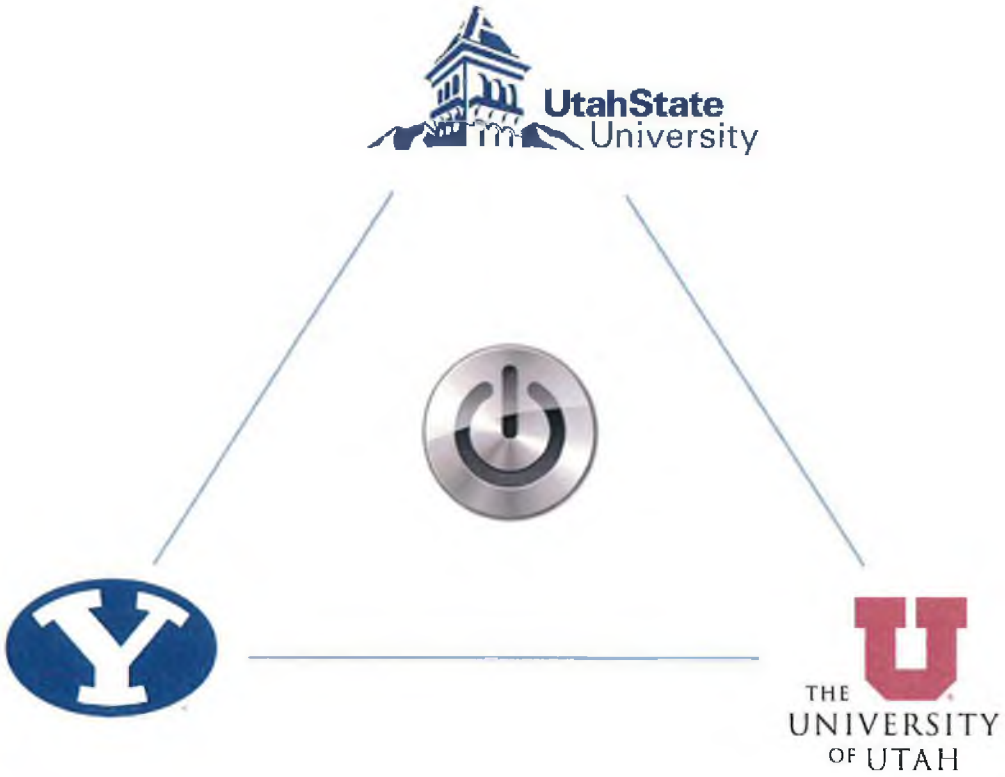
APPENDIX R

UTAH CLUSTER ACCELERATION PROGRAM, FINAL REPORT

Utah Energy Research Triangle

Final Report to the Utah Cluster Acceleration Partnership (UCAP)

June 20, 2014



Al Walker, Executive Director

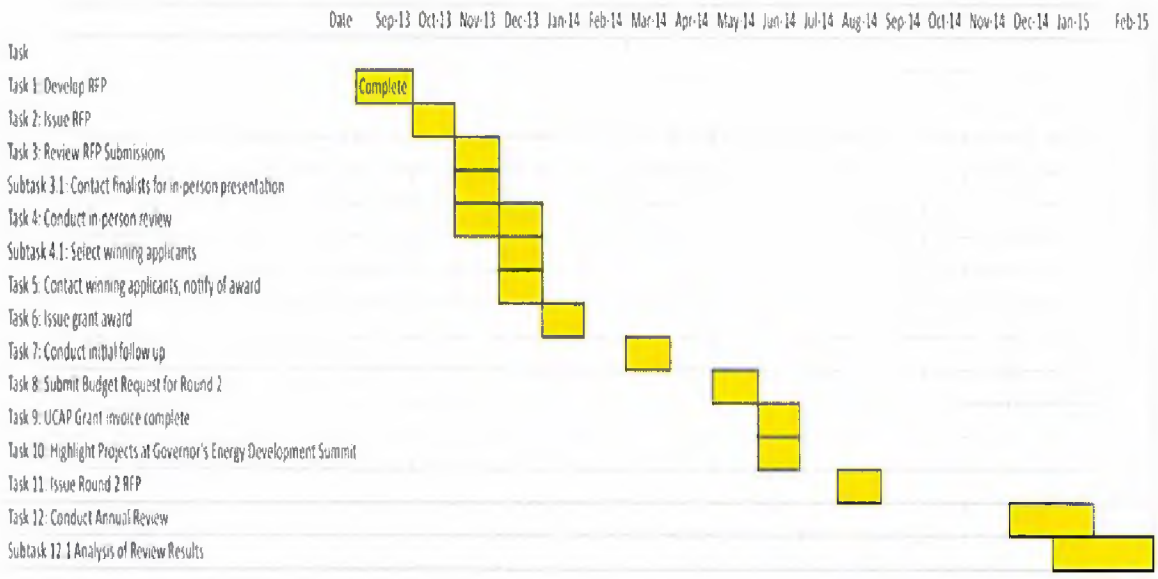
Ryan Streams, Analyst

CONTENTS

Overview

The Energy Research Triangle (ERT) successfully launched seven applied research projects during the 2014 Fiscal Year. This project was made possible by the Utah Cluster Acceleration Partnership (UCAP) contribution of $200,000 along with a $287,000 contribution in funding and in-kind support from USTAR and $45,000 from the Office of Energy Development (OED). The Energy Research Triangle sought additional funding during the 2014 Legislative Session, but was denied by the Utah State Legislature. However, based on initial program successes the Energy Research Triangle will continue to aggressively pursue alternative sources of funding. This will include the next round of UCAP grants and appropriations during the FY 2016 Legislative Session.

Below is the initial timetable as submitted to UCAP:



Due to delays in funding appropriations from matching sources, ERT was not able to issue its RFP until Dec 2013. However, by pursuing an aggressive timetable for the review process, ERT was able to screen over $1.2 million in proposals and provide recommendations to Gov. Herbert by January 2014. With the Governor's approval of the 7 selected research topics, we notified winners and issued grants by March of 2014. We were then able to successfully reach our remaining milestones at the Governor's Energy Development Summit on June 3rd and 4th, 2014.

Process

ERT advanced its mission, as described in Utah's 10-Year Strategic Energy Plan, along with UCAP's goals of supporting talent development, applied research and research and development. After issuing a RFP to the three Energy Research Triangle Universities, ERT staff conducted an initial screening of

applications. These were then taken to the ERT's selection committee, which was composed of four panel members:

Cody Stewart, Gov. Herbert's Energy Advisor

Ian Andrews, Manager of Resource Development for PacifiCorp

Sarah Wright, the Executive Director of Utah Clean Energy

Alan Walker, Executive Director of the Utah Energy Research Triangle

These four members reviewed projects for feasibility and efficacy, relevancy to Utah's economic and environmental concerns, and collaborative potential. Total requested funding was $1,230,793 for an available $445,000, indicating a strong need within the research community for additional funding for Utah-focused research and workforce development. The selection committee recommended 7 projects (3 faculty and 4 student) for funding, and these recommendations were taken to the Governor during his January 2014 Energy Taskforce meeting.

Working with our partners at the Office of Energy Development and Utah's Attorney General's office, we were able to establish contracts with the three research Universities and transfer funds to begin research. Prior to the Governor's Energy Development Summit, each award winner was required to submit an updated research abstract to ensure that they were making progress and remaining on-topic. During the Energy Development Summit on June 3rd and 4th, 2014, we received progress reports from our award winners. Students were recognized at the Summit breakfast and participated in poster sessions throughout the day. Faculty winners participated in an afternoon panel discussion moderated by Al Walker.

To date, the ongoing research done by these faculty and students represents major progress for the Energy Research Triangle. Additionally, because these are one-year projects, we will continue to work with each award winner over the course of the year. Award winners will continue to provide the Energy Research Triangle with periodic updates on progress as well as a detailed final report in March 2015. This report will be used to base decisions about continued funding or redirected funding. Each researcher and his or her team have specific milestones and research objectives to reach, as laid out in each of their applications (in the Appendix, sample applications are attached for review).

Progress on Budget

Budget expenditure to this point by research teams has allowed us to fully invoice UCAP for its $200,000 contribution, thereby fulfilling our requirement under the terms and conditions of the program in a highly effective manner. There are no cost-overruns for the program and we do not anticipate any significant budget issues moving forward. USTAR and OED will provide the rest of the funds for these grant programs using their continuing authorization of FY 2014 funds. To date, total disbursements for the Energy Research Triangle are $217,499.50.

Tier 2 – Governor's Energy Leadership Scholars

In total, four student projects were selected for funding at $15,000 each. These grants were provided for applied energy research across several technical areas.

From Utah State University, Ph.D. candidate Nan Jiang was selected for her proposal on *Developing Hydrogen Evolution Catalysts Using First-Row Transition Metal Chalcogenides,* or production of hydrogen fuel cells from solar power. Nan describes the importance of her research: "Solar-driven water splitting to produce hydrogen and oxygen is widely considered as a sustainable approach to meet the increasing global energy demand, in which hydrogen acts as a green energy carrier. The slow kinetics of hydrogen evolution reaction (HER) in water necessitates the development of novel HER catalysts. A great number of HER catalysts employing expensive metals, such as Platinum, have been reported, but the associated scarce and cost prohibit their wide application."

From Brigham Young University, B.S. Candidate Stephen Erickson was selected for his proposal *Materials Study for Future Layered Photovoltaics Using Protein Enclosed Nanocrystals* or photovoltaic production process improvements. Stephen describes his work: "The purpose of this project is to develop that collection of different materials, so that we can in the future develop our layered photovoltaic cells. I plan to test how

the band gap changes under the effects of nanocrystal size, doping, chemical composition, and aging."

This project has given Stephen the opportunity to pursue his educational goals in a new way. In his own words, "While my coursework has been of great worth and provides the basis for my understanding, nothing has taught me more about what it actually means to be a physicist than researching in Dr. Colton's lab. There is only so much you can learn from a book, and so much more that you can learn from hands on experience working on a meaningful project in your field."

From the University of Utah, Ph.D. candidate Leila Ghadbeigi was selected for her proposal *Evaluation of cold temperature performance of PCM Based TMS in Hybrid Electric Vehicles*, or the study of hybrid electric vehicle battery performance at cold temperatures.

Her abstract outlines the importance of her work: "A key barrier to Electric Vehicle (EV) implementation is their high cost for both manufactures and customers. The battery is one of the most expensive components of these vehicles. Therefore improving battery performance and cycle life is crucial. Temperature significantly affects battery performance and life expectancy. Whereas high temperatures reduce battery life and can cause thermal runaway, cell rupture or even explosion, likewise, low temperatures can decrease battery energy efficiency and life considerably. Accordingly, thermal management systems in EVs have been developed to mitigate the undesirable impact of temperature."

Our fourth project was designated for a Utah student resident from a North American Indian Tribe, but despite diligent outreach by ERT staff, no Tribal members applied for the grant. Therefore, our fourth and final student project was designated to be a "jump ball" for the best remaining project from any University. Matthew Judge, a B.S. Candidate at the University of Utah was selected for his research *High Performance Mg2Si Nanostructured Thermoelectric Materials* or molten salt research. Matthew's abstract outlines the importance of molten salts, or thermoelectric materials.

"Improving the efficiency with which energy is produced is one of the major challenges faced by Utah and our nation as a whole. The development of improved thermoelectric materials (TE's) has the potential to generate a significant improvement in the efficiency

with which we produce electrical power, thus addressing one of the major areas of pollution and waste... With current technologies we are forced either to use highly toxic and very expensive, scarce elements, such as bismuth, lead, and antimony; or we must settle for low efficiency. Magnesium silicide, Mg_2Si, is a material that balances moderate performance with good resource considerations."

As Matthew notes, Magnesium is a particularly important commodity to Utah's economy, with Utah being the major US producer of magnesium. His research is important to Utah's energy and minerals portfolios.

Tier 1 – Principle Energy Issues

From Utah State University, a project being led by Dr. Marc Mansfield with co-investigators of Dr. Seth Lyman, Dr. John Horel (University of Utah) and Dr. Jaron Hansen (BYU) will study *Computer Modeling of Winter Ozone Formation in the Uintah Basin.* This study addresses one of the most pressing challenges facing energy production in the Uintah Basin, valued at an estimated $2.5 billion annually (Source:UBETS)

Dr. Marc Mansfield

Dr. Mansfield and Dr. Lyman both have extensive experience working in the Uintah Basin and this proposal allow everage the meteorology capabilities of the University of Utah iospheric chemistry assets of Brigham Young University to further improve their air quality modeling efforts at Utah State University. The USU-led team also secured a letter of cooperation from the Utah Division of Air Quality to ensure that their modeling work would not simply remain an academic exercise. By connecting this valuable research with the State's regulatory arm, this ensures that all parties working to understand and mitigate Uintah Basin winter ozone formation are using the best quality tools available.

From Brigham Young University, a project being led by Dr. Daniel Ess, with co-investigators Dr. Caroline Saouma (University of Utah) and Dr. Yujie Sun (USU), will examine *Catalytic Conversion of Carbon Dioxide to Carbon Monoxide and Methanol.* This new but already accomplished team of researchers is exploring novel catalysis processes to produce high-quality transportation fuels from clean sources. Dr. Ess, who was recently published in the journal *Science* for his work on the catalysis of methane to alcohols, has connected his lab's expertise in catalyst design and prediction with the University of Utah's capabilities in electrocatalysts and Utah State University's capabilities in photocatalysts.

Dr. Daniel Ess

Dr. Richard Roehner

From the University of Utah, a project being led by Dr. Rich Roehner with co investigators Dr. Michael Hoepfner, Dr. Scott Hill (USU) and Dr. John

Hedengren (BYU) examines *Characterization of Waxy Crude Deposition in Pipelines*. Dr. Roehner brings 30 years of midstream and downstream oil and gas industry experience to this project focused on Utah's waxy crude oil transportation challenges. Current infrastructure shortfalls are expected to cost $29 billion in lost production over the next 30 years in Utah's Uintah Basin (Source: UBETS). This project will characterize the problems these waxes present to transportation infrastructure, and explores next-generation fiber-optic technology for pipeline monitoring and safety. The University of Utah's Chemical Engineering department leads the labwork and testing component, while Utah State University, through Dr. Scott Hill, connects existing industry networks and practical engineering/environmental concerns to the project. Brigham Young University, through Dr. John Hedengren, leads the advanced pipeline monitoring portion of the study.

Increased Collaboration

Even though the contracts with each University were finalized as recently as March 2014, the Energy Research Triangle's novel approach to funding research has already demonstrated great promise. Based on initial feedback from research teams, the collaborative requirement of the Energy Research Triangle has already led to new and strengthened partnerships across Universities. One example is the USU-led ozone study. Prior to this program, the co-investigators at USU had never met Dr. Jaron Hansen at BYU. In the process of seeking collaborators for this grant, they were able to identify Jaron as the ideal partner to fill a gap in their team's atmospheric chemistry group. This partnership with Dr. Hansen has also led to new collaborative proposals for funding from groups like the National Science Foundation. The Energy Research Triangle has been central to the formation of this productive relationship.

New Research Opportunities

In addition to increased collaborative research, the Energy Research Triangle grants have provided seed funding for additional research dollars. One example of this is with Dr. Roehner's waxy crude oil research. The Energy Research Triangle's funding allowed Dr. Roehner and his team to leverage the money this program provided to secure additional funding from industry. They have developed a cost-shared program to fund additional research into waxy crude oil transportation. This indicates that not only is the work being done relevant to Utah's employers and its economy, but it also was necessary to get the first dollars needed to get a study like this off the ground. Funding sources like the Energy Research Triangle provide valuable credibility to new research projects and teams.

Summary

The ERT program has fulfilled its objectives to date. Given the early stage of the program, we anticipate many additional benefits from the collaborations between researchers and institutions. Now that teams have begun working together, they have found new complementary projects to pursue. ERT is currently preparing another funding request to continue the momentum created by the first round. With

continued funding, the Energy Research Triangle has the potential to help reshape the landscape of energy research in the State of Utah.

Letters of Support for the Governor's Energy Leadership Scholars

Our scholars' faculty mentors have expressed support for the Energy Research Triangle's Tier 2 program. They recognize the value that these types of grants provide for their students and have written letters of support for the program

THE UNIVERSITY OF UTAH

Materials Science and Engineering

122 S. Central Campus Drive, Salt Lake City, Utah 84112 (801) 581-8632

June 9th, 2014

Al Walker and Ryan Streams,

Subject: *Governor's Energy Leadership Scholars program*

This letter is in support of the Governor's Energy Leadership Scholars program which provides truly unique research opportunities for undergraduates as well as graduate students.

Undergraduate research is undeniably one of the most important career training exercises that a student can experience during their education. Performing research is truly "where the rubber meets the road" and where students can apply the principles they have learned in their coursework. Students in my lab have commented that the concepts we discussed in my Materials Science and Engineering or Ceramic Engineering classes have made much more sense once they actually worked through research. Undergraduate labs accompanying courses are helpful, but critical thinking, problem solving, and design are explored when students undertake creative approaches to solving real research problems. With high and rising tuition costs, I have observed that undergraduates often take higher paying non-research part-time jobs. The University sponsored undergraduate research opportunities are wonderful, but are highly competitive and rather short-term. A program like the Governor's Energy Leadership Scholars program is unique in that students can come up with the research ideas themselves and then carry out practical application based research on issues that affect their community and state. It's very hard to overstate the value of a program such as this. Matthew is a student with a non-traditional background as an Armed Forces veteran who will graduate with an enormous advantage over his peers given the writing, research, reporting, and oral presentation skills he will develop during this project. Investing in the development of this human capital will ultimately result in the student developing into a leader in his field of research and work.

Funding graduate research is likewise, if somewhat less valuable. Funding for scientific research is extremely competitive with most government grants having applicant success rates 10-20% or less. Each grant is typically 3 years in length meaning that a single grant will likely not even cover a full PhD student (typically 4-6 years). Therefore, unique research opportunities like these that bridge the gap between funding are a boon to stabilizing research groups. The greatest benefit, however, is the opportunity for the graduate student to practice writing a research proposal- particularly in a new research direction. Motivating Leila to work hard on her PhD has never been a challenge but I am so surprised at her passion and enthusiasm to accomplish this task now that she has come up with and taken ownership of.

Dr. Taylor Sparks
Assistant Professor of Materials Science and Engineering
University of Utah
Salt Lake City, Utah 84112

UtahStateUniversity

Yujie Sun, Ph.D.
Assistant Professor
Department of Chemistry & Biochemistry
0300 Old Main Hill, Maeser Lab 361
Logan, Utah 84322-0300
Phone: (435) 797-7608
Fax: (435) 797-3390
Email: yujie.sun@usu.edu

June 13, 2014

Mr. Alan J. Walker
Executive Director
Utah Energy Research Triangle

Dear Mr. Walker,

It's my great pleasure to write this letter to express my strong support for the program of Utah Energy Research Triangle.

Your program synergistically unites the research efforts of University of Utah, Utah State University, and Brigham Young University, the three major research-intensive institutes of Utah. The program does not only provide research funds to support energy-related projects, but also encourages scientific collaborations among faculties of those three universities. This strategy is of tremendous importance and effectiveness in enhancing the connection and productivity of funded projects.

Besides supporting collaborative research projects, the Energy Research Triangle program also places a remarkable emphasis on supporting students, including both undergraduate and graduate students. My own graduate student Nan Jiang was awarded the one-year fellowship of Energy Leadership Scholars. She treasured this award as an invaluable encouragement from the state government and it further strengthened her determination in pursuing science for her future career. I believe the positive impact of this fellowship on her academic career cannot be overestimated.

In summary, I fully support the program of Utah Energy Research Triangle. I sincerely wish the state government will continue this program and expand its funding capacity to support more research projects across the entire state. Given the nature of basic research, continuous funding over multiple years (instead of one year) is more appropriate to support university-based scientific projects.

Best regards,

Yujie Sun

Yujie Sun

DEPARTMENT OF PHYSICS AND ASTRONOMY

11 Jun 2014

To Whom It May Concern:

When I served on our graduate admissions committee, the top three items we always considered in applicants were grades, GRE exam scores, and what kind of research experience the student had had. Often a very positive letter of recommendation from a research advisor would sway the decision in favor of a candidate who (on paper) looked marginal—because paper doesn't tell the whole story of a student's ability or motivation. It is critical for undergraduate students to get involved in meaningful research.

However, given challenging course loads and the need to pay tuition and rent, it can be difficult for undergraduate students to find the time for research. If we want the state of Utah to continue developing leaders in the field of energy development, we must thus provide the financial resources so that these students can participate in substantial research. The Governor's Energy Leadership Scholars Program does just that, while also addressing the pressing energy development issues in the state of Utah.

My student Stephen Erickson has been the recipient of an Energy Leadership Scholars grant, which is paying for him to be an undergraduate researcher both part-time during the school year and nearly full-time during the summer. His research is on nanocrystals for use in high efficiency solar cells, which is of great interest given the large amount of annual sunlight seen in the state. He has already seen significant results, having been a co-author on one peer-reviewed publication already, and with another two or three publications to be submitted this summer. Having the opportunity to engage in this meaningful research will undoubtedly lauch Stephen into a top graduate program.

In summary, this program brings both immediate benefit to the state through the research being done, as well as long term benefits by developing leaders in energy research who will help the state and country become leaders in related fields throughout their careers.

Sincerely,

J. S. Colton

Dr. John S. Colton, Associate Professor
Department of Physics and Astronomy
Brigham Young University

BRIGHAM YOUNG UNIVERSITY • N. 283 ESC • PROVO, UTAH 84602-4004
(801) 422-4401 • FAX (801) 422-0553

APPENDIX S

ANNUAL REPORT TO NATURAL RESOURCES, AGRICULTURE AND ENERGY

Governor's Energy Advisor & Office of Energy Development (OED)

Annual Report to the NRA&E Committee
October 15, 2014

Cody Stewart – *Energy Advisor to Governor Herbert*
Dr. Laura Nelson – *Director, OED*

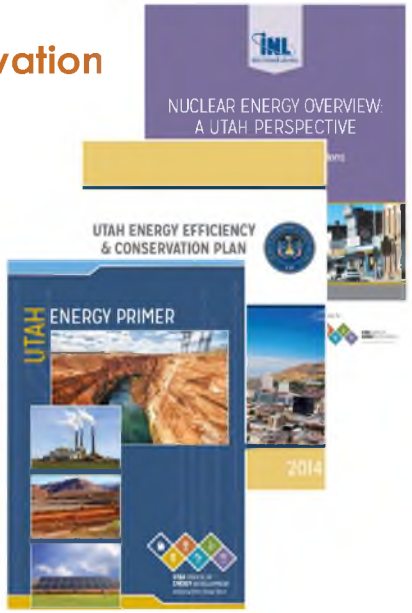
Overview

- **Energy Primer & Other Documents**
  - *UT Energy & Minerals Production, Associated Benefits*
- **OED Initiatives/Accomplishments - 2014**
- **Policy Recommendations**
- OED Budget/COBI
- OED Initiatives/Goals – 2015

- Addenda

Resource Primer, Conservation Plan, Nuclear Study

Educating the public, and providing leaders with the tools they need to develop effective energy policies for the 21st Century.



State Energy & Minerals Production

- Oil – ***$2.3 Billion***
- Natural Gas – ***$1.23 Billion***
- Coal – ***$626 Million***
- Natural Gas Liquids – ***$406 Million***
- Uranium – ***$31 Million***
- Renewable Energy – ***$166 Million***
- Other Minerals – ***~$4.5 Billion***

- Energy Efficiency – ***1.6% of PacifiCorp's UT portfolio in 2013, 7.3% by 2022***

*"Direct production value of energy is **$5 billion** and other minerals over **$4.5 billion**, which together means **$30 billion** according to standard economic multipliers."*

Benefits of Energy Production

- Low energy costs: Capital investment, job growth
- Rural development
  - *Tax base growth (30-80% of rural property tax base)*
  - *High-paying jobs (190% of state mean wage)*
- Energy self-sufficiency and export potential
  - *Electric generating capacity fueled w/UT resources (91% hydrocarbon, coal/gas, and 9% renewable)*
  - *Produce 56% of oil we consume*
  - *Exporting 31% of all energy (gas exports driving trend)*

OED Initiatives – *2014 Snapshot*

- **Industry Engagement**
  - *Infrastructure Authority, Development Incentive, Production Tax Credit, Site Visits, Recruitment*
- **Outreach, Education & Research**
  - *Summit, Conservation Plan, Nuclear Study, Alternative Transportation Education, Partnering on Rural Development, Energy Research Triangle*
- **Policy Initiatives**
  - *Leading on comments on EPA CAA and CWA proposed rules, Updating State's Energy Policies, Keeping Law In-Step w/Sector Advances*
- **Policy Implementation**
  - *Alternative Energy Incentives, State Energy Policy, Revolving Loan Fund, Incentives, Bonding, Emergency Preparedness*

OED: Advancing Critical Energy Projects

- Infrastructure initiatives outline paths to public-private partnership
  - *Multiple transmission developments and energy storage to support a diverse energy portfolio*
  - *Pipeline and transportation initiatives to support production growth and market access*
- Incentives to facilitate Utah's first commercial shale and sands projects

OED Partners to Invest in Rural Communities

- In recent years OED has partnered with rural communities on diverse projects ranging from efficient street lighting to school HVAC systems.
- OED's **$9.2 Million investment in a sampling of 36 representative projects will yield $20.5 Million in energy savings** to impacted communities.
- **Energy savings in first 10 years will pay back total investment,**
- System Lifetime **ROI of 124%.**
- Rural partners: *Beaver, Blanding, Ephraim, Enterprise, Fillmore, Hatch, Holden, Kanosh, Kaysville, Monroe, Morgan, Oak City, Parowan, Price, Richfield, Roy, Santa Clara, Smithfield, Spring City, Springdale, etc.*

Advancing Energy Education & Research

- Utah Energy Research Triangle
  - $445K awarded to 25 researchers participating in one-of-a-kind collaborative program.
  - Topics Funded in '14:
    - ***Uinta Basin Air Quality – Ozone***
    - ***CO2 to Methanol***
    - ***Electric Vehicle Batteries***
    - ***Molten Salt Energy Storage***
    - ***Advanced Hydrogen Fuel Cells***
    - ***High Efficiency Solar Cells***

Policy Recommendations

- Updating State Energy Policy *(63M-201, 301, 401)*
  - *Minerals; energy storage; representing Governor in utility regulatory sphere*
- Energy Research Triangle: *Ongoing funding*
- Alternative transportation incentive updates: *Streamlined, results-oriented*
- Updating Utah Energy Infrastructure Authority
  - *Inclusion of C-PACE, reconfiguration of Board*
- Industry/Partner Goals: *Coordination with industry on transportation options*

Compendium of Budget Information (COBI)

- OED Budget
  - *$1.3M General Fund (ongoing), $0.3M Federal (formula grant), $1.5M PVE (one-time, non-lapse)*
- COBI Metrics: 2012–2014
  - *Investment Leveraged*
  - *Incentives Authorized*
  - *Attendees Hosted/Educated*
- 2015 Recommended COBI Metrics
  - *Investment Leveraged (Captures value added by incentives)*
  - *Attendees Hosted/Educated*
  - *Total Energy Produced*

OED 2015 Goals & Initiatives

- **Continue to enhance conventional, alternative and commercial energy projects**
  - Leveraging UEIA: *Pipelines, transmission, substations, C-PACE*
  - Leveraging existing incentives to drive investment: *AEDI, RESTC*
  - Advancing new/developing OED programs: *Industrial & Agricultural EE, Transportation*
- **Continued leadership/collaboration on federal issues impacting energy:** *111(d), Waters of the U.S., etc.*
- **Energy Education**
  - Economic Assessment: *Comprehensive study on impact of energy and minerals development*
  - *Energy and minerals education K-12*
- **Stakeholder Outreach**
  - Governor's Energy Development Summit
  - Uinta Basin Applied Technology College Partnership

Questions?

Cody Stewart – *Energy Advisor to Governor Herbert*
(801) 538-1039 | codystewart@utah.gov

Dr. Laura Nelson – *Director, OED*
(801) 538-8726 | lnelson@utah.gov

4th Annual Governor's Energy Development Summit
» » »
May 21, 2015 at the Salt Palace Convention Center

Utah's OED-Led Response to EPA's 111(d)
Coordinated Effort

Stakeholder input on technical issues

- Investor-owned, municipal, and rural co-op utilities: *PacifiCorp; Utah Associated Municipal Power Systems (UAMPS); Utah Municipal Power Agency (UMPA); Intermountain Power Authority (IPA); Deseret Power*
- State agencies: *Department of Environmental Quality (DEQ); Division of Public Utilities (DPU); Public Service Commission (PSC)*

Modeling

- OED-directed in-state modeling (Energy Strategies)
- Regional modeling by Western Interstate Energy Board (WECC)

Consultation with other states

- Center for the New Energy Economy (thirteen western states)

Utah's OED-Led Response to EPA's 111(d): *Snapshot of Technical Comments*

- UT's coal plants are already better than many others. State targets should be based on unit-specific performance.
- Proposed heat rate improvements (6 percent) are not feasible.
- Reducing coal dispatch will degrade coal plant efficiency.
- Turbine improvements and new construction require significant lead time.
- Interim compliance period (2021 – 2029) does not allow enough time.
- Lake Side 2 was still under construction in 2012.
- State plan must allow flexible responses to market or technological developments.
- The renewable building block was set on the basis of neighboring state RPS' – not on the basis of actual Utah potential or policy choices.

Key OED Team Members

- **Dr. Laura Nelson, Director**
  - *801.538.8726, lnelson@utah.gov*
- **Jeffrey Barrett, Assistant Director**
  - *801.739.5191, jhbarrett@utah.gov*
  - *Policy, Communications, Renewable Energy, Incentives , Infrastructure*
- **Stuart Clason, Conventional Energy**
  - *801.300.0496, sclason@utah.gov*
  - *Oil, Gas, Coal, Mining, Corporate Recruitment*
- **Alair Emory, Unconventional Energy**
  - *801.538.8661, alairemory@utah.gov*
  - *Oil Shale, Oil Sands, Mining, Uranium/Nuclear*
- **Jennifer Gardner, Planning & Programs**
  - *801.538.8724, jgardner@utah.gov*
  - *Energy Efficiency, Distributed Renewables, Federal Programs*
- **Rob Simmons, Energy Policy & Law**
  - *801.538.8658, rsimmons@utah.gov*
  - *Public Lands, Species & Environmental, Energy Law*

REFERENCES

Ericson, Stephen, Trevor Smith, Cameron Olsen, Joh Colton, and Richard Watt. *Materials Study for 3rd Generation Solar Cells Using Protein Enclosed Nanocrystals*. Working paper. Provo: Brigham Young University, 2014. Print.

Ghadbeigi, Leila, and Taylor D. Sparks. *Evaluation of Cold Temperature Performance of PCM Based Thermal Managment System in Hybrid Electric Vehicles*. Working paper. Salt Lake City: U of Utah, 2014. Print.

Gwillam, Tyler S. *Economic Feasibility of Oil Sand Use in Asphalt Pavement*. Rep. Salt Lake City: Utah Science Technology and Research, 2010. Print.

Herbert, Gary R. "First Inaugural Speech." Governor's Inauguration. State Capitol Rotunda, Salt Lake City. 11 Aug. 2009. Speech.

Herbert, Gary R. "First State of the State Address." Governor Herbert's State of the State Address to the Utah Legislature. State Capitol Rotunda, Salt Lake City. 26 Jan, 2010. Speech.

Herbert, Gary R. "10-Year Strategic Energy Plan." *ENERGY INITIATIVES & IMPERATIVES Utah's 10-Year Strategic Energy Plan*. GOVERNOR GARY R. HERBERT, 2 Mar. 2011. Web. 1 Nov. 2014. www.utah.gov/governor/docs/10year-strategic-energy.pdf.

Jiang, Nan, Lia Bogoev, and Yujie Sun. *Electrodepositied Nickel-Sulfide Films as Competent Hydrogen Evolution Catalyysts in Neutral Water*. Working paper. Logan: Utah State U, 2014. Print.

Judge, Matthew, and Taylor D. Sparkes. High Performance Nanostructured Mg2Si Thermoelectric Materials. Working paper. Salt Lake City: University of Utah, 2014. Print.

Muhs, Jeff. "Utah Energy Research Triangle Overview." Presentation to Governor's Energy Task Force. State Capitol, Salt Lake City. 22 Aug. 2012. Presentation.

Streams, Ryan. Proposed Agenda. Proposed Agenda for RFP Consideration. State Capitol, Salt Lake City, 14 January, 2014. Agenda.

Stewart, Cody, and Laura Nelson. *Governor's Energy Advisor & Office of Energy Development (OED) Annual Report to the NRA&E Committee*. Rep. Salt Lake City: Governor's Office of Energy Development, 2014. Print.

Utah Cluster Acceleration Partnership (UCAP). *ACCELERATING UTAH'S ENERGY INDUSTRY.* Utah Cluster Acceleration Partnership. Fall 2010. Web 1 Nov. 2014. www.growutahventures.com/wp-content/uploads/Energy-Final_Report.pdf.

Utah Cluster Acceleration Partnership (UCAP). *ACCELERATING UTAH'S ENERGY INDUSTRY.* Utah Cluster Acceleration Partnership. January 2013. Web 1 Nov. 2014. www.slcc.edu/energycluster/docs/ECAP.pdf.

Utah Cluster Acceleration Partnership. Grant Agreement. Salt Lake City: Utah Department of Workforce Services, 17 December 2013. Print. Ser. 141664.

Utah Department of Transportation. (UDOT). *Uintah Basin Energy and Transportation Study*. Utah Department of Transportation, 22 July 2013. Web 1 Nov. 2014. www.utssd.utah.gov/documents/ubetsreport.pdf.

Walker, Alan J., and Ryan Streams. "Energy Research Triangle – Project Recommendations." Presentation to Governor Herbert and the Energy Task Force. State Capitol, Salt Lake City. 17 January, 2014.

Walker, Alan J. "Notice of Grant Award." Letter to Dr. Daniel Ess. 18 Feb. 2014. MS. Utah Energy Research Triangle, Salt Lake City, Utah.

Walker, Alan J. "Notice of Grant Award." Letter to Ms. Leila Ghadbeigi. 18 Feb. 2014. MS. Utah Energy Research Triangle, Salt Lake City, Utah.

Walker, Alan J., and Ryan Streams. Energy Research Triangle – Breakfast Presentation Script. Governor's Energy Development Summit. Salt Palace Convention Center, Salt Lake City. 10 June, 2014.

Walker, Alan J., and Ryan Streams. "Powering the Energy Research Triangle." Presentation to Dr. Tom Parks. University of Utah, Salt Lake City. 26 Jan. 2013.

Walker, Alan J., and Ryan Streams. "Powering the Energy Research Triangle." Presentation to Exoro. Alta Club, Salt Lake City. 22 Jan. 2013.

Walker, Alan J., and Ryan Streams. "Powering the Energy Research Triangle." Presentation to Governor Gary Herbert. Utah State Capitol. Salt Lake City. 12 Feb. 2013.

Walker, Alan J., and Ryan Streams. "Powering the Energy Research Triangle." USTAR Governing Authority Funding Request. Utah World Trade Center, Salt Lake City. 26 Jan. 2013.

Walker, Alan J., and Ryan Streams. "Utah Energy Research Triangle." Governor's Energy Development Summit. Salt Palace Convention Center, Salt Lake City. 10 June, 2014.

Walker, Alan J., and Ryan Streams. *Utah Energy Research Triangle Final Report to the Utah Cluster Acceleration Partnership*. Rep. Salt Lake City: Utah Energy Research Triangle, 2014. Print.

Walker, Alan J. "Request for Proposal." Letter to Dr. Behunin, Dr. Harker, and Dr. Parks. 18 Dec. 2013. Utah Energy Research Triangle, Salt Lake City, Utah.

Walker, Alan J. "Strategic Initiative Funding Request." Energy Research Triangle Proposal to the USTAR Governing Authority. Utah World Trade Center, Salt Lake City. 5 Dec. 2013.

Walker, Alan J. Utah Cluster Acceleration Grant Proposal. 26 Aug. 2013. Application. University of Utah, Salt Lake City.