Response to the Brookings Institutions' Request for Information on Utah's Energy R & D Assets

1. *What solid reports or inventories of Wasatch Front university, lab, or private-sector energy research or innovation assets, specializations, or capacities can you point us to? Please send links.*

    a. *University of Utah's (U of U)* Energy & Geoscience Institute (EGI) http://www.egi.utah.edu/

    EGI has established itself as a leader in fossil fuel, geothermal and carbon sequestration research, evidenced by 70 of the world's leading energy companies who are part of its corporate membership program and its execution of projects on all seven continents and in more than 70 countries. EGI's Carbon Sequestration Team has been awarded over $100 million, and its Geothermal Team ranks #1 among universities for Dept. of Energy (DOE) funding. EGI research report portfolio can be found at http://www.egi.utah.edu/content/ResearchPortfolio_1Q2010.pdf

    b. U of U's Institute for Clean and Secure Energy (ICSE) http://www.ices.utah.edu/

    ICSE is a leader in fossil fuel combustion, gasification and computer modeling research. ICSE has built impressive off-campus pilot-scale research facilities, and partners with industry to commercialize new technologies for responsibly utilizing conventional and unconventional fossil fuel and biomass resources. ICSE's carbon mitigation program includes oxyfuel combustion, chemical looping and gasification. ICSE research portfolio can be found at http://www.ices.utah.edu/research/index.jsp

    c. Utah State University (USU) Energy Dynamics Laboratory (EDL) http://energydynamicslab.com/

    EDL was recently formed to advance Utah State's ongoing energy research and demonstration projects in algae and other biomass feed stocks, unconventional fuels, water technologies and impact monitoring. Much of this research will be conducted at Utah State's extension centers located in the rural energy production centers of Utah, including a recently completed 70,000 sq/ft Bingham Entrepreneurship and Energy Research Center in Vernal, Utah.

USU also recently completed a state-of-the-art algae biofuels testing center in Logan, including raceways, strain selection facilities, and fuel-testing engine lab. For details, visit http://biofuels.usu.edu/htm/about/facilities/equipment.

i. http://www.utah.gov/ustar/documents/63.pdf. - This is a joint algae report prepared by Jeff Muhs and several collaborators.
ii. PREA white paper - attached
iii. EUSEP white paper – attached

2. *Could you list some of the leading examples of the area's existing clean energy research investment and assets? What are some of the signature efforts already being led by universities, industries, and/or labs?*

a. *U of U's* Energy & Geoscience Institute (EGI) http://www.egi.utah.edu/

As mentioned above, EGI has established itself as a leader in fossil fuel, geothermal and carbon sequestration research, evidenced by 70 of the world's leading energy companies who are part of its corporate membership program and its execution of projects on all seven continents and in more than 70 countries. EGI's Carbon Sequestration Team has been awarded over 100 million dollars, and its Geothermal Team ranks #1 among universities for DOE funding.

i. **EGI Geothermal Research Program**

EGI's Geothermal research team has more than 30 years experience in the geologic, geophysical, and geochemical assessment of geothermal and mineral resources throughout the world. This team, which ranks #1 among universities for DOE funding, has a number of specialties, including high-temperature chemical tracers for geothermal and groundwater systems. EGI houses a fully equipped laboratory for the development of geothermal and groundwater tracers. Most of the chemical tracers currently in use by the geothermal industry have been developed by EGI. EGI has specializes in the collection and interpretation of electrical, magnetic, and gravity data and the development of software for electrical geophysical methods, as well as the determination and interpretation of hydrothermal alteration and evaluation of the thermal evolution of geothermal reservoirs. For more information, see http://www.egi.utah.edu/director.php. Additional information is also available in attached document –EGI Geothermal Program Overview.

ii. **EGI Carbon Engineering Research Program**
The main focus of this research group is to reduce greenhouse gas in the atmosphere by effectively sequestering carbon dioxide (CO_2) in underground

geological formations. U of U with help of USTAR professor is developing approaches to inject CO_2 into geologic formations in Utah and elsewhere (carbon sequestration). USTAR Professor's are also working on the geomechanics related to exploration, drilling, completion, stimulation and production techniques relevant to carbon sequestration. Recently, USTAR helped launch a new company joining the U of U's Carbon Sequestration team with Headwaters Incorporated, a large Utah-based energy company, to form Headwaters Clean Carbon Services (HCCS). HCCS was recently awarded $2 million by the Department of Energy to develop tools for assessing the risks associated with carbon sequestration. For more information:

http://co2.egi.utah.edu/index.htm
http://www.innovationutah.com/carbonengineering.html
http://www.covol.com/cleanCarbon.asp

iii. **Shale Gas Systems**

EGI in collaboration with TICORA (Weatherford Laboratories) and the Alberta Research Council is evaluating the geological, geochemical and experimental factors involved in a variety of shale gas systems. For more information:

http://www.egi.utah.edu/content/ResearchPortfolio_1Q2010.pdf

iv. **Tight Reservoir Fractures (Geological Characterization and Reservoir Performance)**

The goal of this project is to construct a comprehensive database on the sedimentologic and structural characteristics of tight (sandstone and shale) reservoir units of North America (Paleozoic, Mesozoic and Cenozoic) and to design numerical (computer) models on specific geologic and petrophysical parameters that control the performance of tight reservoirs. For more information:

http://www.egi.utah.edu/content/ResearchPortfolio_1Q2010.pdf

v. **Development of a Predictive Resource Model for Bacterial Gas Systems**

This research program addresses bacterial gas contribution in petroleum conventional reservoirs, coal beds and shale gas plays. Building the worldwide bacterial gas ARC-GIS databases and undertaking the 1st order multi-dimensional basin models to examine migration, mixing, and uplift scenarios; and developing the predictive resource model for bacterial gas system.
For more information:

http://www.egi.utah.edu/content/ResearchPortfolio_1Q2010.pdf

vi. **Hydrocarbon Exploration Models in Deep Water Rift and Passive Margin Settings**
EGI is developing exploration models that bridge regional and prospect level scales to improve understanding of the elements and processes contributing to basin and petroleum systems, the anticipated results highly relevant to future successful exploration. For more information:

http://www.egi.utah.edu/content/ResearchPortfolio_1Q2010.pdf

vii. **Biostratigraphy Integration and Interpretation Workspace**
In order to better constrain drilling risk, all disciplines are expected to improve the precision and accuracy of their results. To help meet these needs in biostratigraphy, TACS has focused on a fit for purpose strategy of developing rigorous, multivariate analytical methods (e.g., BioSlot and Fuzzy c-means (FCM)), tailored to the specific needs of industrial biostratigraphy, and these methods are already having positive impact in biostratigraphical analyses.
For more information:

http://www.egi.utah.edu/content/ResearchPortfolio_1Q2010.pdf

viii. **Deepwater Toe-Thrust Project**
Given the high costs of deepwater drilling, the results of this project will help constrain the sealing issues of thrust faults in deepwater environments. To achieve this goal, multi-disciplinary research integrating structural, petrographic, and petrophysical work is conducted to calibrate key factors controlling the sealing potential of toe-thrusts. EGI is also conducting a project to evaluate deepwater thrust faults from the perspective of fault architecture, fault rock fabric, sealing capacity, and fluid flow properties of the thrust faults.
For more information:

http://www.egi.utah.edu/content/ResearchPortfolio_1Q2010.pdf

b. U of U's Institute for Clean and Secure Energy (ICSE) http://www.ices.utah.edu/

As mentioned above, ICSE is a leader in fossil fuel combustion, gasification and computer modeling research. ICSE has built impressive off-campus pilot-scale research facilities, and partners with industry to commercialize new technologies for responsibly utilizing conventional and unconventional fossil fuel and biomass resources. ICSE's carbon mitigation program includes oxyfuel combustion, chemical looping and gasification.

i. **OxyFuel Combustion**

The Oxyfuel program focuses on clean coal utilization for power generation retrofit through oxycoal combustion and clean oil shale & oil sands utilization with efficient CO_2 capture. The ultimate objectives of this thrust areas are to produce (1) predictive capability with quantified uncertainty bounds for pilot-scale, single-burner, oxy-coal operation (forming the basis for application to full-scale, industrial burner operations), (2) the research and simulation tools needed to provide efficient CO_2 capture for process equipment for production, upgrading, and refining of oil shale and oil sands, and (3) predictive capability with quantified uncertainty bounds for a pilot-scale, oxy-gas process heater using flameless technologies. Given that that carbon capture and storage has yet to receive public acceptance, numerous environmental, legal and policy issues need to be addressed if these technologies are to be applied. Thus this thrust area also address the legal and policy issues associated with carbon management strategies in order to assess the appropriate role of these technologies in our evolving national energy portfolio. For more information:

http://www.icse.utah.edu/hierarchy/2010/

ii. **Underground Coal Thermal Treatment for Conversion to Synthetic Natural Gas**

The In-Situ Underground Coal Thermal Treatment thrust area focuses on secure fuel production by in-situ substitute natural gas (SNG) production from deep coal seams and secure liquid fuel production from in-situ thermal processing of oil shale and oil sands. The ultimate objective of this thrust area is to apply science, engineering, technology and economics research tools developed within the Institute to a wide variety of in-situ processes and to explore the environmental, legal and policy framework for implementation of such technologies on public and private lands. For more information:

http://www.icse.utah.edu/hierarchy/2010/

iii. **Chemical Looping Combustion**

Chemical Looping Combustion is currently being investigated as a novel technique for coal combustion with carbon capture. Our work involves exploring options to extend the promising results of laboratory scale studies on chemical looping combustion of coal into economically viable combustion processes. The research project aims to identify the engineering parameters and scale-up bottlenecks which need to be addressed for commercial implementation.
For more information:

http://www.icse.utah.edu/hierarchy/2010/

iv. **Coal and Biomass Gasification**

The ultimate objective of this thrust area is to provide a simulation tool for industrial entrained flow integrated gasification combined cycle (IGCC) gasifier with quantified uncertainty. The project's target is to develop a prototype simulation tool, perform preliminary uncertainty quantification on a pilot-scale gasifier, and to begin to predict coal conversion, soot formation, synthesis gas composition and char-slag transformations. For more information:

http://www.icse.utah.edu/hierarchy/2010/

c. *U of U Solar Energy Research Center (USERC)*

USERC will develop and integrate technologies to efficiently harness the solar energy spectrum. This will be accomplished by establishing a multi-disciplinary, centralized environment conducive for forward-looking, cutting-edge research and education activities. Research activities include light management schemes and synthesis of advanced thin film materials for photovoltaic devices. USERC will further take advantage of close collaborations with industry partners and explore opportunities for technology transfer. Focus Areas, will include developing new low-cost thin film PV materials; use of advanced optical methods to enhance the collection/utilization of solar energy for thin-film PVs, the investigation of hybrid solar PV/thermal systems. For more information:

http://photonics.ece.utah.edu/>

d. *U of U Sustainable Research Center (SRC)*

SRC is researching better methods for using geothermal energy for power production and underground thermal energy storage. Unlike Ground Source Heat pumps that use constant earth soil temperatures for energy exchange, the invention of Smart Thermosiphon Arrays (STAs) allows the creation of underground heat banks and cold banks in native soils to TiVo seasonal energy for fossil fuel free heating and air conditioning. Cold winter air is used to freeze a large volume of subsurface soil and groundwater (cold bank) to meet summer air conditioning energy needs. Likewise, innovative hybrid solar water heaters (see hybrid solar PV/thermal systems identified in the USERC description below) are used to collect the heat of the summer to be stored in underground soils (heat bank) for use in the winter for heating. This innovative technology uses cost-effective and environmentally benign materials and drilling techniques to efficiently transfer and store energy in the subsurface.

Three homes in the Daybreak Sustainable Community are to be designed and built with the goal of producing cost effective practices to construct net zero energy dwellings that

are both architecturally appealing and sustainable in function. http://zeroenergycbc.org These homes are to be sold once data on energy use are generated.

e. *USU (USU) Energy Dynamics Laboratory* http://energydynamicslab.com/

Algae biofuels

Most assume biofeedstocks need good soil and rain to grow - an assumption that leads to competition between food and fuel crops in America's heartland. But biomass comes from sunlight - which shines more in the southwest. Conventional wisdom says the southwest will never produce biofuels because it has poor soil and receives little rain. USU is using alternative thinking to design new ways to grow algae without needing fertile soil or rain. The approach uses sunlight to its fullest potential, conserves water, produces oil 50 times faster than regular crops, and can co-produce electricity. For more information:

http://biofuels.usu.edu/htm/about/research/algae-biofuels

i. **Automated Electric Transportation**

"In-the-box" pathways to use electricity in vehicle transportation perpetuate a paradigm suggesting vehicles themselves must be energy carriers. They fail to leverage electricity's ability to automate energy delivery and eliminate on-board storage. Vehicle transportation will be transformed when electricity becomes the dominate energy carrier - not vehicles. Disruptive technologies are needed to automate the delivery of energy to vehicles in real-time and minimize the need for on -board energy storage. USU is working with others to create this paradigm shift.

http://biofuels.usu.edu/htm/about/research/aet

ii. **Adaptive Solar**

Solar energy systems will be more effective when they are adaptive, multifunctional, and capable of responding to multiple end-use needs. Sunlight has many uses in buildings (as interior light, radiant heat, hot water, and electricity) and the value of these uses change over time based on occupants needs. **USU** is developing adaptive solar energy systems capable of addressing multiple needs while tripling the overall solar efficiency when compared to single-purpose solar electric technologies.

http://biofuels.usu.edu/htm/about/research/adaptive-solar>

iii. **Intuitive Buildings**

Considerable energy is wasted in building illuminating, heating, cooling, ventilating, and providing other energy-related services that are unnecessary given the preferences and needs of occupants, their location, and the tasks they're performing. USU is developing anticipator and intuitive energy end-use systems that will cut energy use in buildings by more than half when compared to today's best practices.
http://biofuels.usu.edu/htm/about/research/intuitive-buildings
http://biofuels.usu.edu/htm/about/research/intuitive-buildings

iv. **Advanced Fusion Regimes**

There is enough inexpensive heavy hydrogen in the oceans to meet all of Earth's energy needs for a billion years using fusion, the same process that heats the sun. Many fusion devices employ magnetic fields to confine fuel while it is heated to high temperatures - a hundred million degrees - and they release virtually no greenhouse gases. Most researchers envision a fusion energy future based on very large, expensive reactors. USU is exploring a different theory based on a phenomenon observed in the atmosphere of Venus. If successful, the work will lead to clean, neighborhood-sized fusion power plants.

http://biofuels.usu.edu/htm/about/research/fusion

v. **Lidar Wind Energy Profiling**

The Center for Active Sensing and Imaging (CASI) at USU is a national leader in modern lidar technology and believes recent technological advancements offer excellent prospects for dramatically improving the speed and accuracy of large area wind profiling when compared to conventional techniques.

http://biofuels.usu.edu/htm/about/research/wind

f. Brigham Young University's Advanced Combustion Engineering Research Center
http://www-acerc.byu.edu/

The mission of The Combustion Laboratory at BYU is to provide exceptional educational and research experiences for students in the area of the fate of fuel impurities during combustion. USTAR's Technology Commercialization Grant (TCG) program has provided support to new spin offs from BYU and is actively collaborating with different universities in Utah like BYU, USU and U OF U to commercialize new initiatives.

3. Can you provide a brief description of Utah's major energy research laboratories and related energy research equipment?

    a. University

        i. *U of U Energy & Geoscience Institute* (EGI)

        EGI is home to the largest industry cost-shared upstream petroleum research program at any University in the world, with more than 70 petroleum companies supporting EGI research.

            I. **EGI Geochemistry Lab**

            EGI's geochemistry lab provides highly specialized research analytical services in asphaltene separation, column chromatography (polarity separation), soxhlet extraction (source rock), high-resolution gas chromatography, gas chromatography-mass spectrometry, isotopic analysis of crude oils and source rock extract, as well as closed tube pyrolysis-gas chromatography.

            II. **EGI 3D Visualization Lab**

            EGI's Visualization Center was designed as a 'water cooler' type project room capable of seating up to 15 people. A large 12' X 6' screen allows small working groups to view and evaluate their data in stunning clarity. The "Viz Center" is situated in the center of the research floor with two half walls to encourage discussion from those 'passing through'. The system is rear projected with four projectors capable of passive stereo viewing. Two high-end HP XW9300 computers with 8 GB of RAM and top level graphics cards.

            The Visualization Center is supported with a full suite of Landmark interpretation software, including GeoProbe, through an academic research grant from Halliburton. Additionally there are GIS tools that feature the ability to manipulate and view map data in stereo.

        ii. *U of U Institute for Clean & Secure Energy* (ICSE)

            I. **ICSE Industrial Combustion and Gasification Research Facility (ICGRF)** is located off campus and comprises three buildings plus an office building. The ICGRF houses numerous combustion and gasification test facilities, including a 5 million BTU/hr pulverized coal/multi-fuel furnace, pressurized fluidized-bed gasifier, 1 million

BTU/hr Grate-fired combustor (stoker), 250,000 BTU/hr oxyfuel combustor, 1 million BTU/hr Circulating fluidized bed, Diesel engine test facility, Large-scale fire facility, 3 million BTU/hr process heater control room, thermal and catalytic cracker

http://www.ices.utah.edu/research/ICGR_facility.jsp

II. **ICSE Computer Simulation Modeling Facilities**

As team members of the Center for the Simulation of Accidental Fires and Explosions (C-SAFE), we have access to two parallel machines housed in the SCI Institute at the U of U. Inferno, a 256 processor Linux cluster with 2.4 Ghz Pentium 4 processors, is used to run small to medium scale simulations. Muse, a 64 processor SGI Origin 3000 with 600 Mhz R14k processors, is used for visualization of the simulation results

C-SAFE is part of the Department of Energy's Advanced Scientific Computing (ASC) initiative, which gives team members access to massively parallel machines located at various national laboratories. Currently we are utilizing machines at Lawrence Livermore National Laboratory (LLNL) and Los Alamos National Laboratory (LANL).

http://www.ices.utah.edu/research/capabilities_simulation.jsp

iii. *U of U's Scientific Computing and Imaging Institute (SCI)*

The SCI Institute is an international research leader in the areas of scientific computing, visualization, and image analysis. SCI collaborates with the Institute for Clean and Secure Energy, and other energy researchers, including the U OF U Nuclear Engineering Program, to advance new computer modeling and visualization tools for developing new energy technologies.

http://www.sci.utah.edu/

iv. *USU (USU) Energy Dynamics Laboratory*
http://energydynamicslab.com/

I. **USU Sunlight Utilization & Optimization Laboratory** is equipped with multiple fiber-optic-based sunlight collection systems capable of distributing 200,000 lumens of visible sunlight (photosynthetically-active radiation) to 5 lab-scale photobioreactor workstations. The sunlight distribution system (with resulting

chromaticity values and color temperatures that are nearly indistinguishable from that of direct, non-diffuse sunlight) provides a unique and versatile setting for sunlight utilization experiments. Each workstation is dedicated to differing photobioreactor design approaches for both bio-film and suspended solution reactor types. Associated research tools, monitoring equipment, and measurement systems are provided to track various physical and biological parameters in the reactors in real-time.

In addition to these experimental tools, the lab is equipped with a PC-based sunlight utilization modeling system with optical ray-tracing capabilities. By combining this analytic tool with project-specific algae templates and reactor physical layouts, the system is capable of predicting sunlight utilization in numerous open / hybrid / closed reactors - providing spatial maps of sunlight utilization. In addition to these tools, USU has developed a techno-economic model from which to understand and assess various algal-based system architectures and business models from an economic viability perspective.

The lab is also doubling as a platform for developing multifunctional solar energy systems capable of meeting multiple building end-use needs (interior lighting, electricity generation, radiant heating of occupants, and point-of-use water heating.

II. **USU Algae Characterization Laboratory** is equipped with equipment to study the growth rate of specific strains relative to optimal gases, light penetration in liquid culture and light intensity. The facility contains for cell harvest, spectrometers, and cold storage (refrigeration, freezer and -80oC deep freezer). Additional labs are equipped with light trays for solid media growth, controlled environment (refrigerated) lighted incubation chambers, as well as intensive light growth shaker tables. Multiple mid-scale growth (5 liter) setups with controlled gas delivery are utilized for initial growth characterization to determine total cell and oil yields. The analytical facilities include a dedicated gas chromatograph with both flame ionization and mass spectrometry capabilities for identification and quantification of various oils. This instrument is capable of resolving all components of the oil fraction (phytols, fatty acids, hydrocarbons and triacylglycerides). This laboratory also contains two hoods with dedicated extraction apparatuses for solvent and mechanical extraction methods and a laboratory grade

microwave for rapid conversion of lab scale oils to biodiesel. In addition, a gas chromatograph with associated thermal conductivity probe is available for characterization of headspace gases (including oxygen, nitrogen and carbon dioxide). These facilities are fully-functional and ready for use with minimal time required for experiment setup and methods development. Oil analysis and quantization is ongoing for a number of candidate strains.

USU Energy Lab currently owns and operates a 5000-gallon raceway pond that is covered by a greenhouse. The covered pond is located such that it receives unobstructed solar radiation throughout the year. The greenhouse is equipped with temperature control options to maintain favorable growth temperatures through cold weather periods in the Spring and Fall. The pond became operational in July 2008 with the inoculation of *Neochloris oleoabundans*. Initial results indicate that the strain has sustained growth over a period of two weeks under non-sterile conditions while growing on a minimal growth solution comprising of mineral salts supplemented with phosphorus and inorganic nitrogen. The biomass yield obtained in this first run is ~0.3g/L. Tests are currently underway to evaluate growth rates and lipid content. Future tests planned include continuous operation and growth of other microalgae including *Dunaliella sp*. and *Chaetoceros sp*.

Additional USU labs are being instrumented for research on anticipatory building end-use energy systems and hybrid electric transportation.

III. **USU Bingham Entrepreneurship and Energy Research Center (BEERC)** will be dedicated in September 2010 and will provide office space and laboratory facilities for biology, geology, chemistry, natural resources, engineering, physics, and math. These facilities are for use by academia, research, and industry to provide opportunities to collaborate on regional issues to push commercialization and economic development. The BEERC is ideally suited to make timely progress to resolve regional problems such as environmental mitigation, produced water management, black wax transportation, oil sand exploitation, oil shale development, and many other challenges to environmentally sound regional energy development.

Located in one of the rural energy production centers of Utah, the BEERC is a 70,000 sq/ft facility that will encourage research collaboration among Utah's research Universities, industry and Idaho National Laboratory.

b. Industry

i. **The TerraTek Geomechanics Laboratory** is the recognized world leader in geomechanics laboratory testing and analysis—providing multidisciplinary expertise in geosciences and engineering. There expertise lies in Unconventional gas recovery, Drilling and completions performance, Core-log integration, Rock mechanics.

http://www.slb.com/services/reservoir_characterization/geomechanics/geomechanics_coe/terratek.aspx

ii. **Ceramatec -** Ceramatec's focus is primarily in energy & environment (cleantech) areas, including industrial applications of ionic conducting ceramics and electrochemistry and fuel reformation and synthesis.

http://www.ceramatec.com/

4. *Are any strengths in other existing industries (say in aerospace, water management, etc) relevant to building the Mountain West's potential in the clean energy sector? If so, what are they and how are they relevant?*

a. The Utah Water Research Laboratory (UWRL) is a stand-alone facility located at USU on the Logan River, Logan, Utah. The UWRL operates within an academic environment and collaborates with government and private sectors to address technical and societal aspects of water-related issues, including quality, quantity, distribution, and conjunctive use. This is accomplished through providing more than 100,000 sq/ft of state-of-the-art laboratory, computer, and office space. UWRL works with USU's Energy Dynamics Laboratory and industry to deploy water technologies for use in the energy industry. For example, Purestream Technology uses technology developed at USU to purify water contaminated producing oil and gas.

http://uwrl.usu.edu/
http://www.purestreamtechnology.com/

b. Utah has a rich history in aerospace. Many of the nation's leading aerospace companies are headquartered or have branches in Utah. USU's Space Dynamics Laboratory (SDL) is a leading research center for new space and military technologies. SDL continues to lead the way in the development of sensors and

supporting technologies. Some examples of SDL's innovations include the first successful space-borne, solid-hydrogen cooled IR sensors; real-time reconnaissance data visualization hardware and software for operational military applications, and the DoD University Affiliated Research Center (UARC) for sensors and supporting technologies. SDL is working closely with USU's Energy Dynamics Laboratory to combine their strengths in the development of new energy technologies. USU and other Utah Universities also work closely with Hill Air Force Base to develop new aerospace and related energy technologies. For example, Hill Air Force Base has partnered with USU's Energy Dynamics Laboratory to develop algae-based fuels for the US Air Force's fleet of planes. Utah is also known for its industry and research leadership in developing new composite materials for aerospace and energy applications.

http://www.sdl.usu.edu/index-noflash.html
http://www.hill.af.mil/
http://www.usu.edu/ust/index.cfm?article=37507
www.utahsampe.org

5. *How many regional energy innovation and research centers could one reasonably imagine operating successfully in the Mountain West?*

   Utah has a highly educated workforce, including a high number of trained engineers, scientists and technicians. The U of U awards about 500 undergraduate and 250 graduate engineering degrees every year. Brigham Young University and USU award an additional 750 undergraduate and 100 graduate engineering degrees each year. With the extensive energy research faculty, students and facilities at these three campuses, existing industry collaborations, and investment being provided by the Utah Science Technology and Research Initiative (USTAR), it is conceivable that 5-7 significant regional energy innovation and research centers based in Utah could be operated successfully in the Mountain West.

6. *Speaking of Utah, could you suggest some likely locations, partnerships (between universities, industries, and labs) and areas of focus (e.g., energy efficiency, smart grid, solar power, etc)?*

   a. ***Expansion of Carbon Capture and Sequestration Collaborative Partnership –*** Utah is already a leader in carbon capture and sequestration research. The U OF U's Institute for Clean and Secure Energy is pursuing a number of different approaches to carbon capture, including oxyfuel combustion, gasification and chemical looping.

      http://www.ices.utah.edu/research/science_and_technology.jsp

      The U of U's Carbon Sequestration team, led by Dr. B.J. McPherson, who also leads the DOE Southwest Partnership on CO_2 Sequestration, is researching the viability of

commercial-scale CO_2 sequestration. In advancing this effort, the Uof U is teaming up with numerous industry partners, including the forming Headwater Clean Carbon Services with Headwaters Incorporated.

http://co2.egi.utah.edu/index.htm
http://www.southwestcarbonpartnership.org/
http://www.covol.com/cleanCarbon.asp

While these Utah research teams are already working with industry leaders and national labs, a more robust collaboration focused on capturing CO_2 from regional power plants and storing it permanently in Utah's ideally suited deep saline aquifers would help the country meet the difficult challenge of providing affordable and reliable energy in a carbon constrained world.

b. ***Create a Western Geothermal Research and Commercialization Hub at the U of U***

The U of U's Energy & Geoscience Institute's (EGI) Geothermal Team has more than 30 years experience in the geologic, geophysical, and geochemical assessment of geothermal and mineral resources throughout the world. This team, which ranks #1 among universities for DOE funding, is already collaborating with a number of industry and research partners in advancing and commercializing geothermal technologies.

Working together with USU's growing geothermal program, EGI could expand its collaborative partnerships to become the central hub for connecting industry, national labs and universities interested in harnessing the West's extensive geothermal resources.

http://www.egi.utah.edu/director.php and additional information available in attached document.

7. *What are the best examples to illustrate a regional culture of collaboration? How have universities, industries, and/or labs worked together in the past and towards what ends?*

a. **Utah Science Technology and Research Initiative (USTAR) -** The State of Utah is actively supporting the development of Utah's energy innovation assets with USTAR, a long-term commitment to energy technology development through significant state funding of world-renowned research teams, research infrastructure, and connecting Utah's Utah's R & D assets, including the research universities with industry. USTAR in collaboration with the U of U and USU has recruited top researchers to work in the Energy field in the following categories:

I. **Fossil Energy - Carbon Engineering**
The main focus of this research group is to reduce greenhouse gas in the atmosphere by effectively sequestering CO_2 in underground geological formations. U of U with help of USTAR professor is developing approaches to inject CO_2 into geologic formations in Utah and elsewhere (carbon sequestration). USTAR Professor's are also working on geomechanics related to exploration, drilling, completion, stimulation and production. Recently, USTAR helped launch a new company joining the U of U's Carbon Sequestration team with Headwaters Incorporated, a large Utah-based energy company, to form Headwaters Clean Carbon Services (HCCS). HCCS was recently awarded 2 million dollars by the Department of Energy to develop tools for assessing the risks associated with carbon sequestration.

http://co2.egi.utah.edu/index.htm
http://www.innovationutah.com/carbonengineering.html
http://www.covol.com/cleanCarbon.asp

II. **Biofuels**
This group is working on maximizing the biomass production of oil-rich algae for use as alternative fuels.

http://www.innovationutah.com/biofuels.html

III. **Intuitive Buildings**
The Institute for Intuitive Buildings team, hosted by the EDL, is working on electric lighting they are trying to cut lighting electrical use in half in buildings through anticipatory and task-adaptive lighting systems.

http://www.innovationutah.com/I2B.html

IV. **Alternative Energy**
Research team involved with alternative energy is researching on profitable way to develop and market catalysis and solar energy technologies.

http://www.innovationutah.com/alternativeenergy.html

b. **Partnership for Roadway Electrification and Automation (PREA)** - The future of electric vehicles - Partnership of National Renewable Energy Laboratory (NREL); Oak Ridge National Laboratory (ORNL); Texas A&M University; USU; University of California Berkeley; The University of Auckland, New Zealand; Toyota; and General Motors. See attached white paper for more information.

c. **Eastern Utah Secure Energy Partnership (EUSEP)** – USU, Idaho National Laboratory (INL), U of U and a number of industry partners will collaborate on demonstration-scale testing of new unconventional fuels technologies. EUSEP document attached.

d. **Governor's Taskforce on Utah Renewable Energy** Zones (UREZ) - is creating a report that will identify areas with the greatest potential for renewable energy production and encourage innovative approaches for harnessing those resources, including mechanisms that would facilitate the development of needed transmission.

http://geology.utah.gov/sep/renewable_energy/urez

e. **Utah Clean Cities Coalition –** State, university and industry consortium to encourage transportation sector petroleum reduction technologies in the region, including increasing the use of compressed natural gas and biofuels. Partners include CH4 Energy, Flying J, CP Fuels, Go Natural CNG, Jordan School District, Ogden City, Questar Gas Company, Robinson Waste, Semi-Service Inc, St. George Express, Salt Lake City, State of Utah, Sysco, U of U, Utah Transit Authority, USU, Wasatch CNG and Washakie Renewable.

http://www.utahcleancities.org

f. **Southwest Utah Renewable Energy Center** (SUTREC) - The Southwest Utah Renewable Energy Center (SUTREC) showcases and promotes renewable energy in the resource-rich area of Beaver County and Southwest Utah. This area has been identified as a Western Renewable Energy Hub. SUTREC Partners cooperate to advance renewable energy education, training, research, technology and production leading to high-skill, high-wage employment, career and entrepreneurial opportunities.

http://www.sutrec.org

g. **U of U Office of Sustainability** - The Office of Sustainability works towards a more sustainable future by establishing the U of U as a leader and innovator in the field of sustainability. They lead and coordinate sustainability initiatives and demonstrate sustainable behavior in operations and policy that supports a healthy community and learning environment. Promote environmentally responsible practices and foster a culture and ethic of sustainability by creating a successful program models that can be replicated elsewhere.

www.sustainability.utah.edu

h. **Energy Efficient Building Research Programs** – Southern Utah University, USU and the U of U are researching new techniques and technologies for improving energy efficiency in new and existing buildings.

http://zeroenergycbc.org
http://www.theutahhouse.org

i. **Utah Building Energy Efficiency Strategies (UBEES) -** Utah Governor's Energy Advisor Office**,** Utah State Energy Program**,** Department of Facilities and Construction Management and Utah Clean Energy are teaming up to drive innovative approaches for increasing energy efficiency in new and existing building design, construction and retrofit.

http://www.energy.utah.gov/Energy_Efficiency/UBEES.htm

j. **Solar Salt Lake Project** – Government, University and Industry effort to Drive innovative approaches to expanding solar energy in Salt Lake City and surrounding region. Partners include Salt Lake City Corporation, Salt Lake County, Ballard Spahr, LLC, Interstate Renewable Energy Council, Utah Governor's Office of Economic Development, Utah State Energy Program, Kennecott Land and Utah Clean Energy.

http://utahcleanenergy.org/our_work/solar_salt_lake_project

k. **State of Utah Energy Program Initiatives** – The state energy program has several initiatives to encourage renewable energy development, including the Utah Wind Power Campaign.

http://utahcleanenergy.org/our_work/utah_wind_power_campaign
Anemometer Loan Program -
http://geology.utah.gov/sep/wind/anemometerdata/index.htm
Geothermal Resource Assessment Program -
http://geology.utah.gov/emp/geothermal/index.htm>; and the Solar Resource Assessment Program <see more> <http://geology.utah.gov/emp/solar/index.htm

8. Additional Resources:

a. Utah Clean Tech – Alternative energy and green technology news

http://www.utcleantech.org/

b. Utah Clean Energy – Nonprofit dedicated to building the new energy economy

http://utahcleanenergy.org/

c. USU Center for the Market Diffusion of Renewable Energy and Clean Technology

http://huntsman.usu.edu/cleantech/

d. Working with the states research universities, Salt Lake City Community College and the Utah College of Applied Technology have training programs in place to produce trained energy technicians who will support the engineers and scientists working to build Utah's clean energy technologies.

http://www.slcc.edu/continuinged/greenacademy2.asp

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