Energize New Mexico (#1301346)
Annual Report – Year 4 (June 1, 2016–May 31, 2017)

Awardee Institution: University of New Mexico
Award Start Date: June 1, 2013
PI: William Michener; Co-PI: Anne Jakle
Report Submitted: February 24, 2017

I. Overview

The overarching **vision** of *Energize New Mexico* is to position New Mexico as a national leader in harnessing and promoting sustainable energy resources, cultivating a well-qualified STEM workforce, and developing a sustainable culture of innovation and entrepreneurship. The project **mission** is two-fold: (1) develop the research infrastructure that will enable New Mexico to address fundamental basic and applied research questions related to improving energy extraction efficiencies and promoting sustainable resource development; and (2) develop the human resources necessary to improve the state's research competitiveness in sustainable energy development, STEM education, and workforce and economic development capacity.

The project is organized into 13 components, each of which is associated with a strategic priority, specific objectives, and associated goals. Table 1 lists the **Year 4 goals and participating institutions** for each project component, based on the *Energize New Mexico* Strategic Plan.

Table 1. Year 4 Goals by Project Component

Component	Year 4 Goals	Participating Institutions
1. Bioalgal Energy Development	Continue and increase statewide collaboration and training on algal biofuel research. Conduct field studies using algal cultures to remove nutrients from primary wastewater. Expand research on transition metal catalyzed de-oxygenation of biocrude and the physiological and metabolomic analyses of encapsulated algae in more environmental conditions and across species. Start testing various harvesting schedules under fed-batch mode, refine operating procedures, and train new students in the operation of three hydrothermal liquefaction reactor systems. Make predictions and test hypotheses of which algae polycultures will be the most productive under different temperature regimes.	UNM, NMSU, ENMU, SFCC, WNMU, NM Consortium
2. Solar Energy Research	Obtain new results regarding spin-orbit effects on excited state dynamics and lifetimes, explore perovskite solar cells, and develop improved bulk heterojunction solar cells. Incorporate non-covalent guests such as phthalocyanines in photocatalytic systems and use ultrahigh vacuum thermal deposition techniques to fabricate photocatalytic devices. Assess photon counting and solar quantum yield measurements using silicon diode array instrumentation to further quantify photochemical efficiencies of polymeric systems. Integrate graphitic carbon material with MoS_2 to enhance adsorption and performance of composite photocatalysts for wastewater treatment. Prepare TiO_2 on carbon nanotubes as a photocatalyst; work toward next generation solar-driven CO_2 reduction.	UNM, NMT, NMSU
3. Osmotic Power Development	Assess the design requirements of membranes and membrane modules by testing different membrane distillation (MD) module configurations on temperature distribution using computational fluid dynamics. Develop new MD membranes with the focus on reducing the thermal conductivity of the membranes. Advance bench-scale osmotic power systems by designing and building a small-scale MD system for field-testing in a commercial greenhouse. Study the effects of membrane fouling and analyze the data generated during pressure retarded osmosis (PRO) testing.	NMT, NMHU, NMSU
4. Uranium Transport & Site Remediation	Characterize the nature, extent, and behavior of contaminants from legacy uranium (U) mining and milling in New Mexico. Use Nitrogen isotopes as an innovative and useful means of characterizing U mill tailings leachates.	UNM, NMT

	Address research objectives associated with mobility and immobilization of constituents from U mining and milling, characterize and map constituents from U mining and milling, and develop collaborative programs with regulatory agencies and national laboratories.	
5. Geothermal Energy Resources & Sustainability	Survey known geothermal systems and look for blind geothermal systems. Conduct magnetotelluric surveys in the Truth or Consequences and Rincon geothermal systems and interpret results. Utilize 3-D modeling to simulate variable density groundwater flow, solute, and heat transport and evaluate the sustainability of geothermal systems. Monitor springs to expand new geothermal "baseline" datasets for New Mexico.	UNM, NMT
6. Social & Natural Science Nexus	Refine models and begin integrating the dynamic statewide water budget model with energy models. Standardize information systems to improve ease of integration between project components. Continue to enhance collaborations with policymakers and reach out to state agencies to capture best available data and inform policymaking.	UNM, NMSU, Sandia NL
7. Diversity	Solicit another round of Diversity Innovation Working Groups. Further build the Natives in STEM program, making additions to the website, creating STEM professional profiles, and engaging in outreach to national audiences and pueblos and tribes in New Mexico about the project. Recruit diverse students to the STEM Advancement Program (STEMAP).	NM EPSCoR
8. Workforce Development	Recruit and engage new participants in core workforce development programs: STEMAP, Growing Up Thinking Computationally (GUTC), the Faculty Leadership Professional Development Institute (FLPDI), and Creative Startups. Improve programs using input from evaluation studies. GUTC will refocus its efforts to in-school curriculum support, rather than after school programs. Creative Startups will make significant improvements to curriculum, to the online portal for sites, and to its evaluation processes. The third round of graduate Externships will be implemented. FLPDI will be restructured to meet project goals.	UNM, NMSU, NMT, Creative Startups, NM EPSCoR
9. Cyberinfrastructure	Work with science component leads to integrate their research data products and associated metadata into the data portal. Refine the metadata entry interface in response to feedback from researchers who are using it and begin integration of data resource materials into the searchable interface within the portal. As data are added to the portal, they will be added to DataONE and UNM's institutional data repository.	UNM
10. External Engagement	Complete exhibit at the NM Museum of Natural History and Science on Bioalgal Energy and begin development of an exhibit at Explora Museum. Informal Science Education Network members will host meetings that engage researchers with the public in regions around the state and train museum professionals in informal science education. Continue to engage project participants and the NM community through the website, monthly newsletter, and social media.	NMMNHS, Explora, Nuclear Museum, NM EPSCoR
11. Assessment & Evaluation	Implement evaluation activities as planned, including administration of participant surveys after workshops and other activities and surveys to assess impact of STEMAP participation, Innovation Working Groups, Seed Awards, and museum exhibits. The EAC will meet and evaluate progress and the AAAS Panel will provide forward-looking guidance.	Minnick & Assoc.; Elsa Bailey Consulting, AAAS, EAC
12. Sustainability	Award additional Interdisciplinary Innovation Working Groups (I-IWGs) and new Infrastructure Seed Awards. Secure extramural funding. Implement a summer teacher workshop in Alamogordo and provide follow-up support to participants.	NM EPSCoR, SFCC, CNM, NMHU
13. Management	Continue to focus on supporting cross-component collaboration and communication, use of evaluation results for program improvement, and consistent monitoring and feedback on program metrics and fiscal management.	NM EPSCoR

Key to institutions: UNM (University of New Mexico); NMSU (New Mexico State University); NMT (New Mexico Institute of Mining and Technology); ENMU (Eastern New Mexico University); WNMU (Western NM University); SFCC (Santa Fe Community College); NMHU (New Mexico Highlands University); Sandia NL (Sandia National Laboratories); NMMNHS (New Mexico Museum of Natural History & Science); CNM (Central NM Community College) EAC (External Advisory Committee); AAAS (American Association for the Advancement of Science)

Year 4: Key Accomplishments

Table 2. *Energize NM* Metrics at a Glance		
	Year 4 (6/16–2/17)	**Project Total**
Participants	275	380
Peer-reviewed Papers*	37	88
All Publications	66	154
Proposals Submitted	30; $38.8M	150; $221.2M
Proposals Awarded**	17; $9.4M	65; $44.1M
Presentations	126	430

* Includes only published papers that acknowledge EPSCoR (excludes submitted papers)
** Some awarded in Y4 were submitted in Y3

Intellectual Merit: *Energize New Mexico* research areas are divided into two main goals (1) improve energy extraction efficiencies, and (2) promote sustainable resource development. In general, publishing has accelerated in Year 4 as data obtained in the first three years of the project are written up and students advance in their degrees. In addition, collaboration among institutions and components has increased. It is noteworthy that as of the end of Year 4, NSF EPSCoR funds have been leveraged over 2:1: *Energize NM* participants have now secured over $44 million in external funding, ensuring sustainability and expanded reach of many project elements.

Goal 1: Improve Energy Extraction Efficiencies: The *Bioalgal Team* has made major strides in optimizing bioalgal productivity through treatment of primary wastewater effluent with algae, and in Year 4 the team demonstrated that they can achieve federal discharge standards in 3-4 days for traditional pollutants. In addition, outdoor growth experiments are improving cultivation practices by helping to identify the ideal species mixes and conditions to produce stable algal colonies with high yields. The team has also made advances in its studies of water use efficiency in plant cells and use of hydrothermal liquefaction to produce bio-crude oil. The *Solar Team* increased understanding of electronic structure contributions to fundamental excited state processes that contribute to absorption of light and control of excited state lifetimes. This provides alternative pathways to create long-lived charge transfer states that can convert to free charges for efficient photocurrent generation and, ultimately, could lead to more efficient solar cells. They also refined work on photocatalysts to enhance solar fuel conversion efficiency for CO_2 or CO_2 dissolved in water. The *Osmotic Power Team* is readying a pilot-scale geothermal membrane distillation system for deployment at a geothermal greenhouse in New Mexico and has advanced new membrane fabrication and characterization processes through Computational Fluid Dynamic modeling.

Goal 2: Promote Sustainable Resource Development: The *Uranium Transport & Site Remediation Team* continues its strong collaborations with NM tribes to gain additional insights into legacy uranium contamination and uranium mobility through soil, water, and biological systems. Reactive transport modeling has led to new understanding of uranium and vanadium reaction rates and solubility constants, and new studies of dust transport are determining how uranium concentration changes between distinct dust-size groups due to particle-size fractionation that occurs during transport. The *Geothermal Energy Resources Team* continued to search for known and blind geothermal systems in New Mexico through magnetotelluric (MT) surveys and characterization of CO_2 flux. The team has discovered extensions of the Valles Caldera (NM's "supervolcano") geothermal system in both northeastern and southwestern directions using geochemical tracers and CO_2 flux data. MT work has led to the discovery of a new hydrogeological application for MT research: showing that permeability variations may be sensed in some systems. The *Social & Natural Sciences Nexus Team* has advanced energy, water, and attitude and preference aspects of a systems dynamic model. They have now built energy systems dynamic models on hydrocarbon production, renewable energy development, and produced water management. The NM Dynamic State Water Budget continues to be refined to inform policymakers, including the NM Interstate Stream Commission and State Engineer. In addition, the first New Mexico

energy attitudes and preferences survey obtained important data on statewide attitudes toward future energy policy directions.

Broadening Participation: Our overall project diversity goal is to have 50% representation by women and underrepresented minorities (URMs) in all NM EPSCoR-supported programs. We achieved this goal in Year 4, with a total of 55% female or URM project participants. Of our Year 4 participants who voluntarily supplied demographic data (N=235), 47% are female and 36% are URM, including disabled. This compares with 121 participants in Year 1 (49% F, 29% URM), 202 participants in Year 2 (46% F; 33% URM), and 228 participants in Year 3 (46% F, 33% URM). In Year 4, diversity-specific programs such as Natives in STEM expanded their reach with new collaborations that led to hands-on community STEM events on the Navajo Nation and the release of a website that profiles Native STEM professionals.

Our Workforce Development programs continue to engage diverse populations of New Mexicans and foster engagement and retention at many points along the STEM pipeline. In Year 4, the STEM Advancement Program involved 13 students, 92% of which were female or URM, from Primarily Undergraduate Institutions (PUIs) in an 8-week summer research experience. Teams of two faculty members from 12 PUIs participate in the Faculty Leadership Professional Development Institute, learning about STEM student retention practices, such as micromessaging and mindset theory. Externships supported an additional seven graduate students in research experiences away from their host institutions, including a National Lab and state agency. We hosted our second Post Doc Leadership workshop, a 3-day intensive program for 19 post docs (53% F, 11% URM) from New Mexico, Idaho, and Nevada—including three from national laboratories—who gained skills in facilitation, proposal preparation, communicating research to the media, career building, research ethics, effective teaching in higher education, and mentoring in higher education.

Year 4 external engagement activities have already reached 8,200 members of the public in New Mexico, including teachers and students, but not including the up to 90,000 people who may have viewed our first museum exhibit. The "Get Going with Green Goop" exhibit on bioalgal energy is now installed at the New Mexico Museum of Natural History and Science, and planning is well underway for our next two museum exhibits. The NM Informal Science Education Network (ISE Net) is our primary vehicle for disseminating NM EPSCoR research to the public and engaging learners of all ages in STEM. In Year 4, ISE Net hosted two meetings with museum stakeholders from across the state, supported three mini-grants for NM EPSCoR researchers to work with ISE organizations to promote their research, and hosted a week-long Teacher Institute that instructed K-12 teachers on energy curricula. *Energize NM* faculty members are highly engaged throughout these outreach activities, including in museum exhibit development and presentations at public events.

Year 4: Problems, Opportunities, or Changes in Strategy

For a project of this size and scope, there were very few changes in Year 4 from what is outlined in the strategic plan. The PI for FLPDI, Phyllis Baca, retired from Santa Fe Community College, and NM EPSCoR office staff are now successfully managing the program (see "Workforce Development" section). Previous to her departure, the NM EPSCoR State Office had engaged in scoping activities to redesign the program, which was falling short of its objectives. In addition, the transfer of the Growing Up Thinking Computationally program from Santa Fe Institute to NMSU, which occurred in Year 3, took longer than expected, delaying the start of some of the work until the beginning of Year 4. Last, in response to Site Visit feedback, two research components (Osmotic Power and Social & Natural Sciences Nexus) have slightly modified their goals to better focus for the remainder of the award (see Section V: Special Conditions). We still have been unable to schedule NSF Day, but remain on a waitlist.

II. Research and Education Program

In this section, we describe the progress of the core research and education programs that compose *Energize New Mexico*. In parentheses after each component name, we provide the percentage of Year 4 activities in the Strategic Plan that we anticipate will be complete by the end of Year 4 and an overview of the number of participants engaged in the component at any point in Year 4. Combined, our six research components will complete 98% of Year 4 activities as listed in the Strategic Plan.

Bioalgal Energy (98%; 15 Faculty, 23 Grad, 12 Undergrad Students)

Table 3. Bioalgal Y4 Metrics	
Peer-reviewed Papers	11
All Publications	12
Proposals Submitted	6; $15.2M
Proposals Awarded	6; $5.4M
Presentations	18

Goal 1: Optimize Biological Productivity: In Year 4, *Galdieria sulphuraria* cultures (in 3x700L photobioreactors [PBRs]) at the Las Cruces Wastewater Treatment plant were fed primary-settle wastewater and performed well without any crashes. They achieved discharge standards for the traditional pollutants (biochemical oxygen demand [BOD], nitrogen, and phosphorous) in a single step, at a batch processing time of 3 to 4 days (Fig. 1; Selvaratnam et al. 2016, Henkanatte-Gedera et al. 2016). These results are potentially transformative in that current two-step technologies demand significant energy input and dissipate the valuable carbon and nutrients in the wastewater, while this process concentrates carbon and nutrients in the wastewater into biomass for downstream recovery by hydrothermal liquefaction (HTL). Future research will focus on reducing the batch processing time to 2.5 to 3 days, switching to semi-continuous mode, and recovering nitrogen and phosphorous from the byproducts of HTL (research leads: Holguin, Khandan, NMSU).

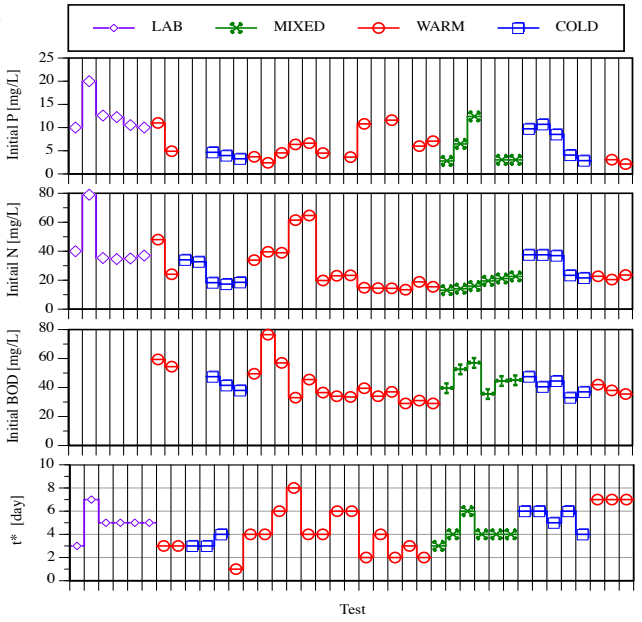


Figure 1. Summary of results from over 40 lab and pilot tests, with cold season, warm season, and mixed cultures. t* is the process time to meet discharge standards for all three traditional pollutants (i.e. BOD, N, and P).

In addition, Hanson (UNM) and students have successfully encapsulated solid-state bioreactors and are optimizing methods for tracking growth and function of algae encapsulated in silica over long timeframes. They have found some differences between species in the ability of cells to divide when encapsulated and are characterizing them microscopically. UNM will use a newly purchased membrane inlet mass spectrometry (MIMS) system to test gas diffusion through encapsulation gels and simultaneously monitor oxygen and carbon dioxide exchange. Results will be presented at the International Algal Biomass Biofuels and Bioproducts Conference in June.

UNM faculty (Bixby, Hanson, Crossey [Geothermal group]), and NMSU faculty (Boeing), in collaboration with Los Alamos National Laboratory (LANL), have developed projects aimed at culturing and quantifying the composition and function of algal communities in extreme environments (caves, hot springs, and high CO_2 ponds). Samples were collected from high CO_2 ponds in fall 2016 for culturing in lab conditions, and work was initiated on characterizing function of the photosynthetic carbon fixing enzyme, Rubisco. Preliminary results have identified the dominant diatom community members in the high CO_2 ponds and the group is continuing to work to replicate high CO_2 environments needed to culture taxa from those ponds in the laboratory.

Goal 2: Improve Cultivation Practices: In addition to work at the Las Cruces Wastewater Treatment Plant, NMSU (Holguin, Khandan) continued with outdoor growth experiments with various cultures of algae, varying the growth system (open raceways, open basins, and closed PBRs stirred by an enclosed

paddlewheel) and the algal species (*Galdieria sulphuraria*, *Chlorella sorokiniana*, and *Scenedesmus* sp.) to measure the seasonal effects on algal growth rate and physiological performance. For all of these species and growth conditions the biomass production rates are assayed and lipid content is estimated via energy content analysis. Additionally, the physiological performance of the algal cultures is assayed by high-resolution analysis of photosynthesis rates through the measurement of dissolved oxygen production rates.

A major impediment to growing outdoor algal cultures for a continuous, sustained period has been their rapid decline due to the presence of biological competitors or predators. To address this issue the team is determining if polycultures and local algal species are naturally resistant to the locally present pathogens and competitors. NMSU continues to maintain long-term cultures in a series of 500-L outdoor basins filled with a variety of different algal cultures, including cultures that have crashed in the open raceways. The goal is to capture not just a locally adapted strain but to generate an ecosystem capable of encouraging optimal growth. They established two basins filled with crashed cultures from the open raceways and were surprised to see that algal cultures quickly reestablished themselves and appear to be highly productive. They use a combination of physical and genetic analysis to determine what algal species are present in these long-term cultivation ponds and how they and pathogens change over time.

Other cultivation improvements were discovered through experiments with small (bench-scale) PBRs testing operational factors affecting algal settleability in mixed culture algal systems (PhD student Roesgen, UNM). The team determined that settleability of algal biomass could be greatly improved by inclusion of settling phase during cultivation of a mixed culture, including enrichment for filamentous, floc-forming algae.

In the area of water use efficiency, the team has developed and published new rapid methods for measuring carbon and water exchange of leaves using the EPSCoR-purchased LICOR 6800 systems (Stinziano et al., in press). In addition, Hanson developed gas exchange chambers for making advanced measurements of epidermal water loss that has implications for understanding photosynthesis in future dry and hot environments, which led to new NSF funding (IOS-1658951) and an invitation to present at the premier international meeting on carbon fixation (Gordon Research Conference). Two new manuscripts are in preparation on this work.

Goal 3: Enhance Energy Return on Investment & Wastewater Utilization: NMSU (Holguin, Khandan and students) performed an experimental study comparing the yields and bio-crude oil characteristics from the HTL of a high-lipid algae (*Nannochloropsis salina*) and a low-lipid algae (*Galdieria sulphuraria*) under different reaction conditions. Results showed that more severe reaction conditions are needed to convert low-lipid, high protein algae but that increased yields may occur at the expense of more difficult-to-upgrade bio-crude oils. Two manuscripts have been prepared, with submission to occur as soon as the remaining characterization data is available. An experimental study using the 2L batch reactor was also used to compare the yields and bio-crude oil characteristics from HTL of *Galdieria sulphuraria* grown on media and grown on wastewater, including the differences between the hot-weather and cool-weather strains. Results show that the high ash content of the wastewater-grown algae is detrimental to HTL processing in terms of yield and potential for clogging. Follow-on studies will explore algae pretreatment methods to remove ash. A manuscript is being prepared for submission Summer 2017. For the remainder of Year 4, NMSU will continue to evaluate several solids loading rates for algal biomass to be introduced to a continuous HTL operation. Preliminary results show that a reduced loading rate below 20% mass concentration (w/v) but above 5% w/v will be sufficient for optimal conversation at pilot scale.

Goal 4: Cross-cutting Infrastructure: The NMSU Chemical Analysis and Instrumentation Lab (CAIL) has characterized multiple HTL bio-oil samples from various NM EPSCoR cultivation and conversion group members, and the Year 4 CAIL bioalgal activities have resulted in four publications that directly relate to the subject area (Muppaneni et al. 2017, Jarvis et al. 2016, Reddy et al. 2016, Bartley et al. 2016) and eight publications overall. The PI of CAIL (Schaub) was able to extend EPSCoR funds to purchase a triple quad mass spectrometer for the analysis of primary metabolism, lipids, and contaminates of

emerging concern in wastewater streams, after receiving an NSF Major Research Instrumentation award (#1626468).

Solar Energy (100%; 6 Faculty, 12 Grad, 6 Undergrad Students)

Table 4. Solar Y4 Metrics	
Peer-reviewed Papers	8
All Publications	9
Proposals Submitted	4; $5.5M
Proposals Awarded	1; $435k
Presentations	18

Goal 1: Purchase and Install Equipment: Due in part to equipment purchases through NM EPSCoR, NM is now known as a national center for innovative electronic and photonic materials research. In Year 4, Kirk (UNM) purchased a new research-grade fluorimeter, which will be used for the study of emissive electronic materials and molecules and allow high resolution photoluminescence data to be collected at room temperature (300 Kelvin) down to 4K. No such research grade instrumentation exists at UNM and it will support the research programs of the entire Solar Team across institutions. Ultrafast and Ti:Sa lasers have contributed to an expansion of UNM's Center for High Technology Materials. In addition, the Horiba Fluorescent Lifetime instrument is now widely used by new faculty at NMT.

Goal 2: Use Nanoparticle ZnS to Catalyze Reduction of CO2: Much of the ZnS work was completed in Year 3, with a publication that detailed development of a new earth-abundant non-toxic photocatalyst (Leonard et al. 2015). In Year 4, Solar Team co-lead Heagy and junior faculty Chowdhury (NMT) developed a new photosensitizer for improved optical absorption of the solar spectrum via plasmonic surface chemistry using Au and Ag nanoparticles (manuscript in preparation). Silver coated copper oxide (Ag@Cu2O) shows some of the highest reported bicarbonate conversion to formate, which is higher than Cu2O by itself and higher than Ag nanoparticles mixed with Cu2O. This finding represents another pathway to enhance solar fuel conversion efficiency for CO2 or CO2 dissolved in water. For the remainder of the project, this research thrust will expand into methane/methanol conversion.

Goal 3: Obtain New Results Regarding Spin-orbit Effects on Excited State Dynamics and Lifetimes, Explore Perovskite Solar Cells, and Develop Improved Bulk Heterojunction Solar Cells: Much of the UNM team's effort (Kirk, Grey, and students) has been expended toward understanding electronic structure contributions to fundamental excited state processes that contribute to absorption of light and control of excited state lifetimes. Increased excited states for electrons and long-lived triplets are excellent for solar energy and ultimately will contribute to its increased efficiency. The solar team at UNM studied new doublet and quartet exchange coupled excited states to determine how a third spin (e.g., polaron) perturbs photogenerated singlets and triplets to allow the chromophore to facilitate a spin-allowed localized singlet-to-triplet intersystem crossing. This excited state magnetic exchange interaction imparts magnetooptical activity on the systems and modulates excited state lifetimes in a controlled manner. Kirk (UNM) has also led work developing new molecular systems that explicitly test the origin of vibronic spin-orbit coupling and its potential role in polythiophenes and polyselenophenes (Steenbock et al. 2016). Vibronic spin-orbit coupling provides a mechanism for intersystem crossing to long-lived triplet excited states. These long-lived states can be used to enhance the probability of charge separation. These findings are meaningful because they provide alternative pathways to create long-lived charge transfer states that can convert to free charges for efficient photocurrent generation. Ultimately, this could contribute to higher efficiency low-cost solar cells. Such dramatic spin and spin-orbit effects on excited state processes were not originally anticipated, and for the remainder of *Energize New Mexico* the Solar Team will continue to explore this remarkably fruitful area of research.

NSF CAREER (#1453083) awardee and junior faculty member Qin (UNM) has also developed synthetic strategies for mid-bandgap organic tetrapods for application in organic solar cells in order to develop new structure−property−function relationships (Yang et al. 2016). These findings may lead to improved charge mobility, which could ultimately increase device performance leading to lower-cost, specialized organic solar cells.

At NMSU, Luo and students studied catalysts for photodegradation of toxic pollutants. They explored TiO_2 and TiO_2-graphene composite photocatalysts for photocatalytic degradation and developed

exfoliated/thin layered g-C_3N_4 as an efficient photocatalyst. Findings indicate that thin layer g-C_3N_4 demonstrates enhanced photocatalytic performance in contrast to its bulk structure. Luo and junior faculty member Chowdhury (NMT) also studied defect-free MoS_2 and defect-rich MoS_2 for fluorescence quenching work, and a manuscript on findings is being prepared and will be submitted by the end of the grant year.

Osmotic Power Development (100%; 5 Faculty, 4 Grad, 8 Undergrad Students)

Table 5. Osmotic Y4 Metrics	
Peer-reviewed Papers	0
All Publications	2
Proposals Submitted	1
Proposals Awarded	1; $17k
Presentations	6

Goal 1: Design, Construct, and Modify Bench-scale Osmotic Power Systems: Three bench-scale hollow-fiber membrane distillation (MD) systems are in operation at NMT for evaluating water flux, thermal conductivity, and salt rejection of fabricated small-scale hollow-fiber modules. The team is collaborating with Masson Greenhouse, a large geothermal greenhouse, to work toward meeting its demand for irrigation at a lower cost while conserving existing freshwater resources through treatment of geothermal fluids. Geothermal greenhouses are a promising avenue of economic development, as they are well established in New Mexico; in 2006, 46 acres of greenhouses were heated by geothermal energy generating annual gross receipts of $27 million with annual energy savings over $2.5 million compared to natural gas. These greenhouses, however, are limited by water scarcity. In November, the team met with the operations manager and a geothermal resources consultant to discuss a field deployment plan for a pilot-scale geothermal membrane distillation (GMD) system for the greenhouse. It was later determined that the treatment capacity of the system should be increased in order to have a more meaningful GMD field evaluation. The field system is currently undergoing modifications for projected deployment to Masson during the summer of 2017.

Goal 2: Develop New Membranes and Modules to Maximize Power Generation: In Year 4, Huang and students (NMT) continued to develop new membrane fabrication and characterization processes. The team is currently studying hollow-fiber membranes spun from 12 and 15 weight % of polyvinylidene fluoride (PVDF). Computational Fluid Dynamic (CFD) modeling was performed using COMSOL to examine the effect of module packing density on water flux and temperature polarization. An apparatus for cloud-point measurements has been designed. The cloud-point data can be used to modulate the membrane pore structures through the compositions of the coagulation and bore fluids.

Significant water flux with excellent salt rejection (>99.99%) was observed with the asymmetric PVDF hollow-fiber membranes fabricated in the lab. For example, the water flux is about 166 liters per m^2 of membrane area per hour at a log mean temperature difference (LMTD) of 70°C for membrane modules housing hollow fiber membranes made with 12 (w)% of PVDF and 12 (w)% of ethylene glycol (Fig. 2). The feed for the testing is the simulated geothermal fluid with a total dissolved solids (TDS) concentration of 3800 mg/L.

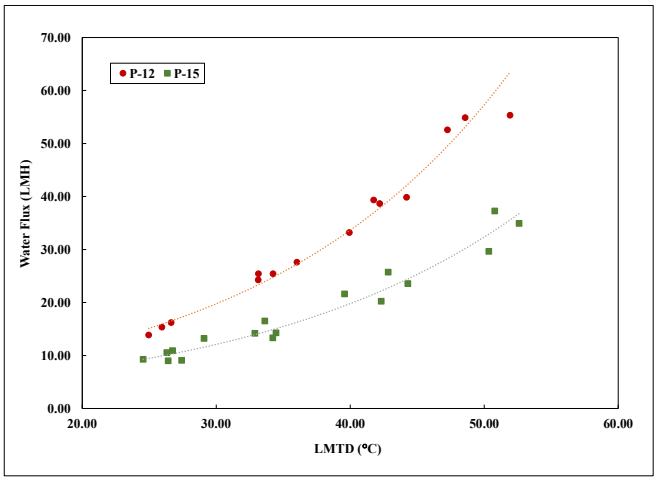


Figure 2. Water flux versus LMTD for PVDF membranes.

The team has also found that packing density negatively impacts the water flux. Therefore, using water flux and temperature polarization results from 2D and/or single-fiber CFD simulations to design a full-scale MD system as typically done in the literature is problematic. The team (Huang, Masters student Sanchez) has developed models for 3-D multiple-fiber CFD simulations and correlated the model output with experimental data.

Throughout this project, significant physical infrastructure and expertise in membrane fabrication and characterization have been developed in the Osmotic Team. With water quality deteriorating and freshwater resources dwindling in New Mexico, membrane desalinization will become increasingly popular, and having the ability to conduct R&D in this area will provide a competitive edge.

Goal 3: Investigate the Occurrence, Prevention, and Mitigation of Membrane Fouling: Chemical speciation modeling was performed to determine the potential membrane foulants from the geothermal fluid. Short-term fouling experiments were conducted using the simulated geothermal fluid for a period of 5-7 days. The team has preliminary data showing that vibration could be an effective way to prevent membrane fouling from potential precipitates in the geothermal fluid, particularly sepiolite at Masson Greenhouse. In the remainder of the grant year, additional experiments will be conducted to evaluate the effectiveness of different fouling mitigation methods.

Uranium Transport and Site Remediation (100%; 9 Faculty, 1 Post Doc; 9 Grad, 4 Undergrad Students)

Table 6. Uranium Y4 Metrics	
Peer-reviewed Papers	7
All Publications	10
Proposals Submitted	5; $4.2M
Proposals Awarded	2; $756k
Presentations	5

Goal 1: Characterize the Nature, Extent, and Behavior of Contaminants from Legacy Uranium Mining and Milling in New Mexico: Cerrato and PhD student Avasarala (UNM) conducted reactive transport modeling to estimate reaction rate and solubility constants for the dissolution of uranium (U)-vanadium (V) minerals in mine wastes from the Blue Gap Tachee Claim 28 site on the Navajo Nation. These results coupled with electron microscopy data suggest that the release of U and V is affected by water pH and the crystalline structure of U-V-bearing minerals in mine wastes from this site. A manuscript resulting from this study has been submitted to *Environmental Science & Technology* (Avsarala et al., in review).

Initial XRD studies of uranium-vanadium minerals from the Grants region (Masters Student Caldwell, NMT) show that mineral assemblages contain a complex series of minerals with variable metal cations, consistent oxidation states, and locally variable hydration. Minerals that contain reduced uranium show substantial destruction by oxidizing fluids that moved down through the host rocks, likely during regional crustal uplift that occurred late in geologic time (Laramide orogeny). For the remainder of Year 4, the team will continue to analyze the mineralogy and paragenesis of U-(V) minerals and associated diagenetic phases via ore petrography and XRD analyses.

Isotopic and chemical analyses were conducted in the Grant's Mining District to identify the source and extent of uranium contamination in groundwater (Thomson, Masters Student Schatz, UNM). This work provides an innovative approach for uranium contamination tracking that can be used in other sites affected by mining impact. The work was completed in collaboration with the New Mexico Environment Department.

The initial results from the investigation of the reactivity of uranium in organic-rich sediments from Laguna, New Mexico, served as a foundation for the 2017 NSF CAREER award (#1652619) of component co-lead and *Energize NM* junior faculty hire, José Cerrato.

Goal 2: Address Research Objectives Associated with Mobility and Immobilization of Constituents from U Mining and Milling, Characterize and Map Constituents from U Mining and Milling: Important relationships between surface roughness, dust flux, and soil and dust geochemistry have been identified through dust and soil collection at Laguna Pueblo. Although many of the relationships were expected based on past research, the team (Cadol, Masters student Brown, NMT) has added important new information regarding uranium geochemistry in dust. Results show that the metal concentrations are different in the dust compared to the soil. This suggests that if the dust is locally sourced then it is undergoing changes during transport. By the end of this grant year, they expect to determine how uranium concentration changes between distinct dust-size groups due to particle-size fractionation that occurs during transport.

Initial development of a sequential extraction method for uranium mineral concentrates is underway (Walder, Masters student Pearce, NMT). Although sequential extraction has been used to extract metals from many other minerals, this is one of the first experiments to develop a method for uranium. We expect this method to be completed by the end of Year 4.

The accumulation of uranium in roots of salt cedar plants from Laguna, New Mexico, has been investigated using in-vitro experiments (El-Hayek, UNM). Microscopy and spectroscopy analyses are currently being conducted to identify the mechanisms of uranium accumulation in the cells of the roots. The development of more complex experiments in this area of research is expected in 2017 and 2018.

In addition, development of a uranium-filter prototype has begun (Frolova, Rogelj, Masters student Saville). The team has found that HCl rinses not only permit recycling of the material, but they improve adsorption. That observation has allowed further modifications that improve the selective uranium adsorption properties. The uranium-filter patent application, which was submitted last May, is now in the provisional-patent stage development, which should be submitted by the end of this reporting period.

Goal 3: Develop Collaborative Programs with Regulatory Agencies, National Laboratories, Tribes, and Industry: In April 2016 (after submission of the Y3 annual report), the Uranium Team held an outreach day at Laguna Pueblo, in conjunction with the Pueblo's Environment Department to share research findings and further develop relationships with the Pueblo's members. The New Mexico Geological Society spring 2017 meeting is chaired by Uranium Team researchers (Frey, McLemore) and the theme of the meeting will be "Uranium in New Mexico: the Resource and the Legacy" and includes an industry keynote speaker. For the first time, the meeting will feature an evening mixer where students can seek career advice from industry representatives. In late Year 3 (after the annual report was submitted), the team also organized a field trip for 16 students from four NM universities to visit an in-situ U mine in Wyoming; members of industry also attended the field trip. A new collaboration with the Isleta Pueblo was established this year, adding to strong collaborations with Laguna Pueblo and the Navajo Nation, and research is now taking place within the three tribal boundaries. Cerrato (UNM) is a Science Communication Fellow with the Explora Science Museum, and has created activities for the general public on water quality impacts of mining legacy. In addition, he is collaborating with Central New Mexico Community College (CNM) and Explora on uranium science communication (see Sustainability section). The Uranium Team also has ongoing research and outreach collaborations with the NM Environment Department, NM Bureau of Geology & Mineral Resources, and the NM Museum of Nuclear History & Science (see External Engagement section).

In Year 4, UNM Uranium Team co-lead Bruce Thomson retired and passed leadership to NM EPSCoR junior faculty hire, José Cerrato.

Geothermal Energy (100%; 7 Faculty, 9 Grad, 7 Undergrad Students)

Goal 1: Survey Known Geothermal Systems and Look for Blind Geothermal Systems: The Geothermal Team continued to conduct magnetotelluric (MT) surveys in the Truth or Consequences (T or C) and Rincon geothermal systems and interpret results. There was a shift in Year 4 to 3D MT surveys, as this is required for the geologic complexity of the Rio Grande Rift. In Year 4, Person and his NMT team (Kelley, grad students Peppin and Folsom) surveyed approximately 23 MT stations across Cuchillo Negro and portions of the Mud Springs near T or C to expand surveys to 3D. In addition, for the Sevilleta MT survey they collected soundings at new sites and uncovered legacy MT surveys near the Socorro geothermal system.

Table 7. Geothermal Y4 Metrics

Peer-reviewed Papers	7
All Publications	20
Proposals Submitted	5; $5.7M
Proposals Awarded	4; $2.6M
Presentations	41

This work has led to the discovery of a new hydrogeological application for MT research: using MT results as a new calibration measure for hydrothermal models to calibrate model permeabilities at depth. This idea will be published in the manuscript "Can Magnetotelluric Surveys detect Permeability Variations within Deep (> 5 km) Hydrothermal Flow Systems?" which has been prepared for submission

to *Geophysical Research Letters*. MT findings show that permeability variations may be sensed in some systems. While shallow saline formation fluids and complex fault geometry could confound such a conclusion (meaning the approach may not work everywhere), the paper uses forward models to predict salinity, temperature, and resistivity patterns for different permeability structures. It then computes synthetic MT soundings (resistivity verses period) within recharge and discharge areas to determine if there are characteristic differences between these patterns (Fig. 3). A proposal to the NSF Hydrologic Sciences program based on this research is planned in the spring quarter.

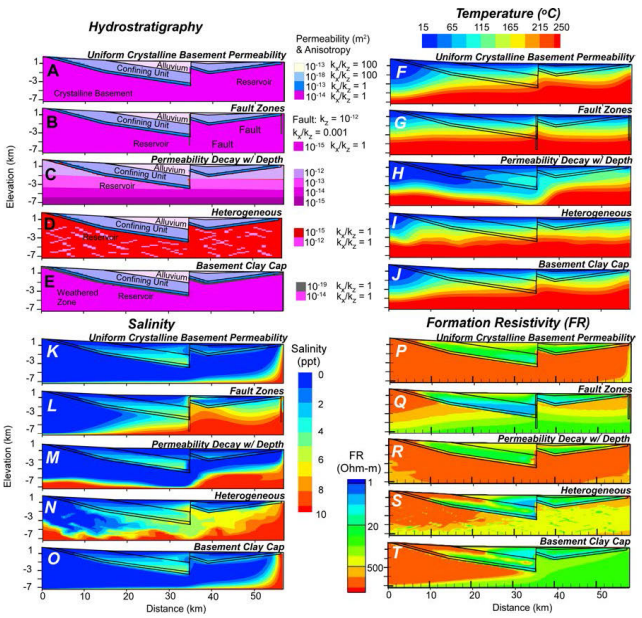


Figure 5. *Crystalline basement permeability scenarios including: (A) homogeneous (k = 10^{-14} m²), homogeneous (10^{-15} m²) with two conductive vertical faults (k_z = 10^{-12} m²), (C) permeability decays with depth from 10^{-12} to 10^{-15} m²; (D) heterogeneous (10^{-12}, 10^{-15} m²); (E) homogeneous (10^{-14} m2) with upper low-permeability weathered zone (10^{-19} m²). Porosity was varied between 0.05 to 0.02 and correlates with permeability. Simulated temperature patterns (F-J) after 10^{6} years using permeability conditions described by (A-E). Simulated salinity patterns (K-O) after 10^{6} years using permeability conditions described by (A-E). Computed formation resistivities (P-T) using the modified Glover et al. (2000) equation (2) assuming a connectivity value of 2.*

Figure 3. Image from draft of MT Paper illustrating results.

<u>Goal 2: Monitor Springs to Expand New Geothermal "Baseline" Datasets for New Mexico.</u> The UNM team (Crossey and students) has characterized the compositions of waters and gases in NM using published and new data and they are continuing to monitor springs and groundwater in the Jemez Mountains near the Valles Caldera. In June, the team completed initial CO2 flux surveys above the west side of the Socorro Magma body. They also initiated monitoring of springs in the Sandia Mountains in collaboration with the U.S. Forest Service. Three Masters projects were completed in Y4 that identified significant new elements to the evolution of the Rio Grande fluvial system over the past 5 million years (Repasch), identified connections between the Valles Caldera geothermal system and northern expressions of geothermal resources using multiple tracers including gas chemistry (Blomgren), and demonstrated high CO2 flux distal to the Valles Caldera geothermal system consistent with hydrochemical results (Smith). During the remainder of Year 4, the team will complete seasonal sampling of the Rio Ojo river system to evaluate geothermal inputs.

<u>Goal 3: Develop Collaborative Programs across Academic Institutions, Regulatory Agencies, Industry, and National Labs</u>: In 2016, UNM hosted two NM Alliance for Minority Partnership (AMP, #1305011) summer SCCORE students. Crossey oversaw the program and the students (both Hispanic STEM undergraduates) transferred to UNM in Fall 2016. One worked with Hanson's Bioalgal group and the other worked with the geothermal team. Both presented their results at the fall New Mexico Academy of Sciences (NMAS) Research Symposium. Crossey also worked with the Explora Museum as a Science Communication Fellow to develop geothermal-based outreach materials that will be presented in fall 2017. Many team members presented results at six conferences, including American Geophysical Union, the Society for Exploration Geophysics, and Geological Society of America.

The team continues industry collaborations with Ormat and shares MT and other data with the geothermal developer. Crossey, Karlstrom, and Kelley worked with TerranearPMC on a deep borehole pilot proposal for a pilot for deep disposal of nuclear waste in SE NM, which was selected for further research. Crossey began collaboration with USGS representatives on geothermal resources in Mesilla Basin. Pepin (NMT PhD student) is engaged as a USGS Pathways intern on this project as well. In addition, the geothermal group loaned equipment to and participated in the SAGE geophysical camp at LANL.

The Geothermal Team has trained New Mexico undergraduates and graduate students on projects in NM that prepare them for the workforce with skills in hydrology, geology, geophysical and geochemical sciences. Several recent graduates have been hired in local NM companies or are interning with state and federal agencies.

Social & Natural Sciences Nexus (90%; 4 Faculty, 2 Post Docs; 13 Grad Students)

Goal 1: Build System Dynamics (SD) Infrastructure to Integrate Social and Natural Sciences by Developing Three Dynamic Budgets (Energy, Socio-Economic, and Water) that Provide the Relationships Between Inputs and Outputs of a Resource Over Time: The Social & Natural Science Nexus (SNSN) team has advanced work on socio-economic budgets incorporating energy models (Chermak and students, UNM), a newly developed data gathering mechanism for human perceptions (Chermak, Thatcher, UNM), and a statewide water budget (Fernald, NMSU). Ultimately these systems will be merged into wider systems dynamic models (Fig. 4).

Table 8. SNSN Y4 Metrics	
Peer-reviewed Papers	1
All Publications	10
Proposals Submitted	3; $7.5M
Proposals Awarded	0
Presentations	22

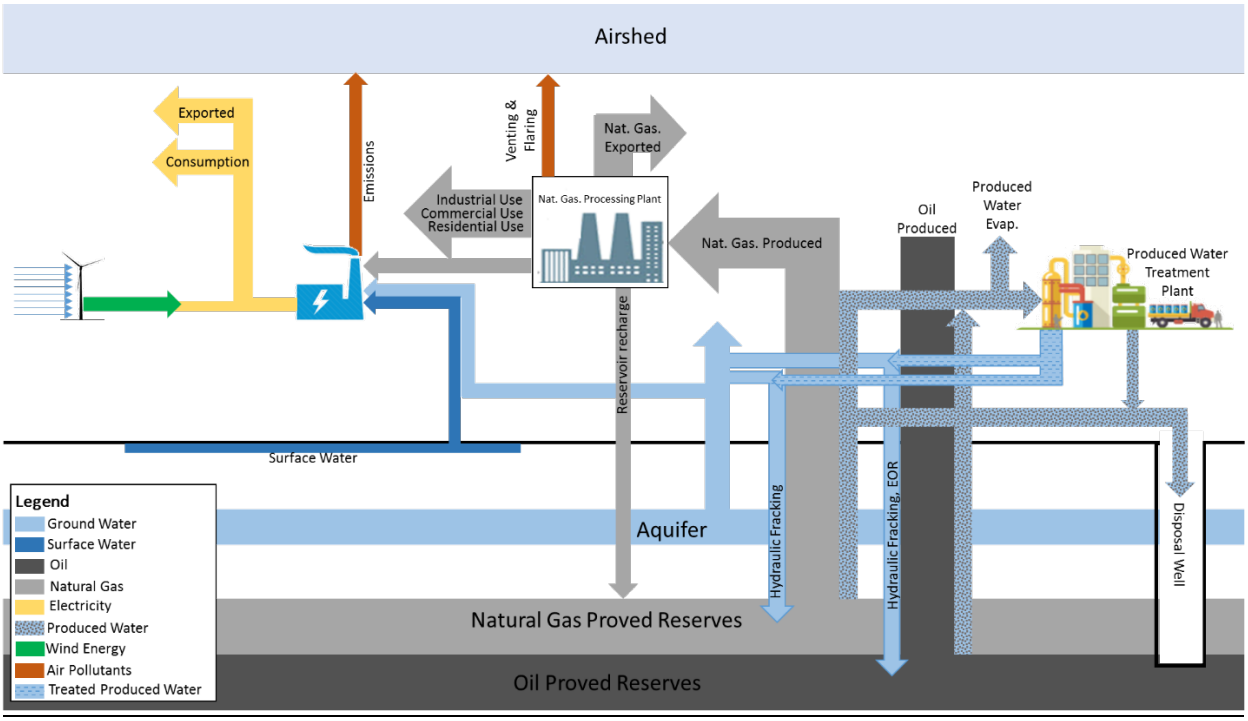


Figure 4. NM SD Modeling Frame

Progress has been made on many component parts of the energy model. Modeling the production of hydrocarbons and water is a challenging task, and a main focus has been on simplifying a complex econometric model that allows us to consider the individual impacts of various factors on production into a process that is more appropriate for an SD model. The team has now aggregated hydrocarbon production to the level of a Township-Range at one-month steps and has developed a set of type curves for production. The San Juan Basin model has been developed and is being calibrated. As a part of this work, historical data on production and completions for New Mexico were updated and merged.

Modeling water associated with hydrocarbon production for incorporation into the SD model resulted in a new strand of research. Traditionally, completion of wells utilizes freshwater and produced water (a byproduct of hydrocarbon production) is disposed of. In semi-arid regions like New Mexico, the use of produced water for completions, and the potential of reuse for other water demands has complicated this. The team has modeled the management choices for disposal or reuse by quantifying the

spatial variation in energy demands of alternative management strategies for produced water. Results indicate that conventional disposal is, in many cases, less energy intensive than treatment and reuse, but freshwater acquisition can exceed energy requirements for produced water disposal in some regions of the state. Furthermore, mean energy requirements are highest for both fresh and produced water transportation and the greatest variability in energy requirements results from treatment estimates. Comparison of these results suggests that both treatment and increasing reuse of produced water in oil and gas operations, particularly for hydraulic fracturing, may become more prevalent in the future.

The team has also developed a renewable SD energy module that allows us to estimate job impact for renewable energy facility construction and utilization. The module is based on capacity and can be used for planned and potential facilities and allows for water and emissions savings estimates, compared to fossil fuel facilities. Energy models will be refined in the remainder of Year 4 to complete San Juan and Permian Basin components (the major oil producing regions of the state), complete the energy futures scenarios, complete the model for electricity generation for the entire state, and develop modeling for emissions to pollution levels.

The NM Dynamic State Water Budget (NMDSWB) SD model developed in Year 3 continues to account for the origin and fate of New Mexico's water resources through time. The NMDSWB features four levels of mass balance accounting units: counties, water planning regions, river basins, and statewide. Mass balance terms can be calculated for any sequence of months from January 1975 through December 2010. In addition to a best estimate, the NMDSWB interface includes a 95% confidence interval, to help visually represent uncertainty in the calculations and data.

The team is exploring uses for the NMDSWB model, including investigating how shocks to a water-energy system might occur and how relationships in this complex system might change. This approach can also be used to discover unknown linkages and effects between interested variables in a system. For example, if there were to be a large drought, this approach would be able to identify how a drought might affect water rights allocations. Many linkages throughout this system link water rights to climate variability, including crop yields, water availability, and water pricing. This model would allow the delineation of which combination of factors affect water rights allocation, or discover a link that was previously unknown in the system. The NMDSWB has already been developed to include a direct water energy link for the cost of pumping groundwater for irrigation, one of the main uses of water and one of the primary energy costs of irrigation.

Attitudes and preference surveys were administered across New Mexico in Year 4 to improve understanding of the heterogeneity of New Mexicans' attitudes and preferences towards energy, which is vital to future energy policy and has not been well researched. Design and administration of the attitudes survey took several rounds of modifications and changes due not only to the complex nature of energy and energy use in the state, but also due to it being a controversial topic for many. Ultimately, 1,900 New Mexicans located across the state were invited to participate. Some results include:

- 71% of respondents agreed that climate change was occurring and humans contributed
- 73% of respondents indicated renewable energy should either be kept at the current level or increased
- 43% of respondents favored importing nuclear energy from Arizona
- 34% of respondents were at least somewhat opposed to reducing coal-fired generation
- 51% of respondents thought natural gas was the long-term solution for energy in NM.

An additional focus group and survey on renewable energy will take place in Year 4.

Merging of the SD models will be led by a new post-doc hire, Saeed Langarudi, who started in late 2016. An additional post doc at NMSU is working on aspects of the state water budget and water policy. Sustainability of this work is being pursued through a number of major grant proposals, including ones to further integrate water and energy SD components, assess the viability of an energy innovation ecosystem across the Four Corners states, and a possible Sandia National Laboratory-led test bed focusing on developing dynamic water portfolios, considering all water and energy uses. Because the success of the program will be measured not only through the work, but also through the sustained use of the modeling

efforts, additional research questions will be posed and additional funding will be sought to continue the refinement of the SD frame.

Goal 2: Enhance Collaboration with Policymakers and Stakeholders from the Community at Large and Reach Out to State Agencies: The NMDSWB has been the focal point of interactions with multiple organizations to leverage funding for the modeling effort. Leverage has been provided primarily by the State of New Mexico, with a $1.5 million investment in the model and associated science over the last three years. This leverage, in addition to supporting system dynamics modeling, has supported science efforts to improve estimates of water budget components. The model is acting as a focal point for decision makers by being the central theme of discussions to make it part of the New Mexico State Water Plan. The system dynamics framework is of particular interest to the Interstate Stream Commission because of the ability to intersect water with energy, population, and climate scenarios for improved water planning. The model will be demonstrated in March 2017, and the Interstate Stream Commission will make a determination if it will be part of the NM State Water Plan to be released in 2018. The model has helped the Interstate Stream Commission formulate a plan for an interactive web-based part of the State Water Plan that will potentially include direct access to the system dynamics water budget model. Water planners, researchers, and the interested public will be able to test the impact of future population, climate, and energy scenarios on water supply and demand for improved science based water planning. In addition, the largest utility in the state, Public Service Company of New Mexico, has been briefed on the results of the Attitudes and Perceptions Survey and utility staff members have been informing future surveys. The SNSN Team also hosted a System Dynamics training course in the summer of 2016 for 10 students from three universities, which was instructed by two of the premier national experts in SD modeling, Vince Tidwell and Leonard Malczynski of Sandia National Laboratories.

Cross-Cutting Research

An additional emphasis of *Energize New Mexico* is collaboration among research components. In Year 4, there were a number of noteworthy cross-component collaborations.

Bioalgal/Uranium: Bixby (UNM, Bioalgal) and Cerrato (UNM, Uranium), and Ali (UNM, Uranium and Geothermal) as well as several additional researchers, have been collaborating to examine the impact of fire ash on aquatic ecosystems. Work has included analysis of heavy metals in tree tissue, fire ash, and soils. This work has resulted in one publication (Cerrato et al. 2016), two grant proposals (one funded), one undergraduate honors thesis, and two projected Masters theses.

Bioalgal/Geothermal: Bixby (UNM, Bioalgal) and Crossey (UNM, Geothermal) are working with a graduate student to examine the relationships between biological organisms and geothermal springs in the Valles Caldera to examine the impact of flow and episodic acidification on algal taxa over time.

Uranium/Osmotic: Rubasinghege (Osmotic, NMT) has begun working with Frey and Cadol (Uranium, NMT) to examine the solubility of metals-bearing dust in bodily fluids. An undergraduate has begun the investigation for her senior thesis during Year 4, and STEMAP students and a graduate student will continue the effort in Year 5.

Uranium/Geothermal: A paper was published in *Environmental Science & Technology* in Year 4 that details the work members of the Uranium and Geothermal teams (Avasarala, Cerrato, Crossey, Ali) did in response to the Gold King Mine Spill on the Animas River (Rodriguez-Freire et al. 2016).

Uranium/Social & Natural Sciences Nexus: PhD student Katie Zemlick is co-advised by faculty from the Uranium (Thomson) and Social & Natural Science Nexus (Chermak) teams. For her dissertation, she is modeling the impact of economics and policy on uranium mining. This work is generating important discussion among economists, engineers, economic geologists, and the geologic community.

Osmotic/Geothermal: Work continues between the Osmotic (Huang) and Geothermal (Person, Kelley) Teams with Masson Greenhouse to both utilize geothermal energy for direct use and treat that water for irrigation purposes.

III. Solicitation-Specific Project Elements

Accomplishments from the Diversity, Workforce Development, Cyberinfrastructure, External Engagement, Evaluation and Assessment, Sustainability, and Management components are detailed below. At the end of Year 4, we anticipate 95% of these activities will be complete, as outlined in the project's Strategic Plan.

Diversity (95%)

Our overall project diversity goal is to have 50% representation by women and underrepresented minorities (URMs) in all NM EPSCoR-supported programs. We achieved this goal in Year 4, with a total of 55% female or URM project participants. In Year 4, we updated our Diversity Strategic Plan (https://www.nmepscor.org/sites/all/documents/DiversityPlanY4_final.pdf) and revised goals to be more ambitious, as we had met two of our three primary diversity targets. We also created a new program to recognize our faculty, staff, and graduate student mentors through the NM EPSCoR Mentoring Award, whose criteria includes successfully mentoring diverse students. Winners will be honored at our April All Hands Meeting. Additionally, we solicited proposals for Diversity Innovation Working Groups (D-IWGs) in August 2016 and received three submissions, but none were recommended for funding by our review panel. We have released another solicitation and expect to award two D-IWGs in March 2017.

Natives in STEM is a program that was co-founded with NM EPSCoR and the American Indian Science & Engineering Society (AISES) to increase the visibility and belonging of Native people in the STEM community. This year, Natives in STEM completed a website (http://www.nativesinstem.org/) that hosts six professional profiles; an additional 11 profiles have been created and will be added to the website. Natives in STEM also released its second poster, of a female Oglala Lakota Engineer, Otak Conroy-Ben (Fig. 5), and 2,500 posters have been distributed nationwide to Bureau of Indian Affairs schools, two- and four-year colleges, including tribal colleges, and to STEM organizations. Additionally, the Natives in STEM project collaborated with the New Mexico Tribal Libraries Program, Explora Museum, and the NASA Astrobiology Program in Year 4 to host STEM Events in three Navajo communities, which were attended by over 50 people. These events featured three Navajo STEM professionals as keynote speakers, a Navajo cultural and NASA activity, and Explora hands-on science activities. Project outreach has expanded, and in January 2017, Natives in STEM was featured on Native America Calling, a national radio show about issues specific to Native communities. The NM EPSCoR Diversity Coordinator also attended the SACNAS, AISES, and AIHEC national conferences this year and presented on Natives in STEM. In the remainder of Year 4, profile videos will be produced by a professional videographer and posted to the Natives in STEM website.

Figure 5. Natives in STEM Second Poster

Workforce Development (90%)

Growing Up Thinking Computationally (GUTC; Pontelli, Cota): NMSU hosted the GUTC program in Year 4, shifting the emphasis of the program to communities in the southern part of New Mexico and to in-school curriculum support. The in-class implementation allows for a wider diversity of students to be served, as compared to students who choose to participate in afterschool clubs. Teachers that receive the program's professional development training are able to integrate computational modeling and thinking into middle and high school STEM classes. So far in Year 4, GUTC has hosted two Computer Science Teacher professional development events: 1) providing 12 high school teachers from the Las Cruces Public School district with the technical expertise and instructional materials to teach an effective CS Principles course; and 2) providing 11 teachers from 6 high schools in the Las Cruces Public School

District with an overview of Computational Thinking and instruction in the Python programming platform.

Throughout the academic year, the program is pairing five NMSU undergraduate computer science majors with five high school teachers to integrate computational thinking into course curriculum. Each high school teacher engages in a semester-long experience to develop several modules aimed at 1) embedding the core principles of computational thinking in the existing core curriculum, and 2) using computational principals and methods to more effectively present the core content. Data is collected in the form of pre/post tests, and will be analyzed at the end of the school year. The remainder of work to be completed in Year 4 includes the continuation of the in-school implementation, a Spring Professional Development Workshop in Las Cruces, Women in Computing conference, and a presentation given by Cota (NMSU) at the National Science Teachers Association annual conference. A delayed transfer of this program in Year 3 created a late start to programming, and the GUTC team is working on a plan to catch up on spending.

STEM Advancement Program (STEMAP; Heagy, Chee): The STEMAP program engages students from primarily undergraduate institutions (PUIs) in an 8-week summer research experience at a research university with *Energize NM* researchers. The 2016 cohort had 13 students, 92% of which were female or URM. The program began with one week of training at NMT in Socorro and ended with student presentations to colleagues, PIs, faculty, NM EPSCoR, friends, and family. After their summer research experience, students participated in a Fall webinar series that focused on using campus resources, making effective presentations, networking at conferences, mentorship, demystifying graduate school, and options for STEM-related career pathways or extended research at their home institutions. Three students at Western New Mexico and Eastern New Mexico Universities also continued their research during the academic year through STEMAP+, a program that provides them and a PUI faculty mentor with a research stipend. The collective support for the students led to conference presentations by STEMAP students at the SACNAS, AISES, and NMAS conferences and a 1st place undergraduate presentation award at the National AISES conference for Derrick Platero from San Juan Community College.

Through the first three STEMAP cohorts, we have worked with 38 students from 14 different PUIs across New Mexico. Of those we have been able to track, 15 students have transferred to 4-year universities, 9 have graduated or will graduate by May 2017, and 2 are in graduate school. Two students from the 2016 cohort who transferred from two- to four-year colleges continued working with their STEMAP mentors as undergraduate research assistants.

Externships (Hart, Bixby): The externship program is a research opportunity allowing graduate students to spend a semester (or summer) at a partnering New Mexico university, research facility, or industry partner. Seven graduate students participated in the Year 4 externship program across four research components: Solar, Osmotic, SNSN, and Uranium. The externships involved four academic research institutions, LANL, the NM Energy, Minerals, and Natural Resources Department, and the USGS NM Water Science Center.

Post-Doc Leadership Workshop (Jakle, Hart): The NM EPSCoR Post Doc Leadership workshop is an innovative 3-day intensive, residential program designed to enhance the professional skills of post-doctoral scholars in STEM disciplines. A workshop was held at the Sevilleta National Wildlife Refuge from January 9-12, 2017, with 19 post docs from research institutions in New Mexico (including both national laboratories) and the partner states of Nevada and Idaho. A workshop evaluation, which was completed by 100% of participants, rated the event very highly, and post docs indicated that they gained skills that they will use again in meeting facilitation and leadership, proposal preparation and how to get funded, communicating research to the media, Post Doc career building, research ethics, effective teaching in higher education, and mentoring in higher education.

Faculty Leadership & Professional Development Institute (FLPDI; Connealy, Hart, Chee): FLPDI comprises opportunities for faculty from PUIs to support STEM learning, especially among URMs. In Year 4, the NM EPSCoR State Office took over this program from SFCC and redesigned it to include two faculty development workshops and two webinars per year, in addition to faculty agreements that require them to disseminate information to their colleagues at their host institutions and promote relevant EPSCoR programs on their campuses. In December, teams of two faculty members from 12 PUIs participated in a two-day training offered in conjunction with the National Association for Partnerships in Equity (NAPE) on Growth Mindset. After the workshop, the faculty shared resources with faculty learning communities at their home institutions. In the spring, FLPDI will host another workshop with NAPE on self-efficacy. An additional 18 faculty from seven PUIs participated in day-long tours at five NM EPSCoR research laboratories at UNM, NMT, and NMSU and were exposed to work taking place at major research institutions and explored potential collaborations.

Creative Startups (aka ICCE or GCCE; Loy, Youngs, Slater): The Creative Startups Accelerator was launched in 2014 with seed funding from NM EPSCoR and now is located in two sites domestically (Albuquerque and Winston-Salem, NC) and in Kuwait. They have graduated 41 startups in the first two cohorts, and the program has close to 80 mentors. The curriculum offers 12 modules including leadership of new ventures, financing for startups, marketing and branding, and legal issues. To date, the startup companies that participated in the first Accelerators have raised $6.5 million in private investment, generated $8.2 million in new revenues, and created over 140 jobs in New Mexico. Seventy percent of these startups are women- or minority-owned. In 2015, Creative Startups received a Kauffman Foundation grant to help it evaluate and expand the program with additional programs and in new regions. Additional accomplishments can be viewed in their 2016 impact report: http://www.creativestartups.org/sites/default/files/CreativeStartups_2016ImpactReport_PrintFriendly.pdf.

Cyberinfrastructure (95%)

In Year 4, the Cyberinfrastructure (CI) team (led by Savickas, Benedict, Baros, UNM) worked with the research teams to integrate research data products and associated metadata into the publically accessible NM EPSCoR data portal (https://www.nmepscor.org/data_portal/browse-data). A streamlined and improved interface allowed for significant acceleration in the integration of project data. Over 600 new research datasets were added in Year 4, and the portal currently holds over 700 datasets that represent all research areas. The data portal was also refined to improve search capabilities and the team created a user dashboard with graphs so that researchers can quickly see how many datasets they have entered as well as obtain a total for different collections. User-friendly data pickers and error messaging with form validation were also added to the dataset upload form. In response to feedback from researchers, the CI team refined the metadata entry interface and created a cloning script where a researcher can enter one dataset into the system and the script can clone and modify specific metadata fields and apply those changes to hundreds of other researcher datasets. This greatly reduces the workload on the researchers. CI graduate students also created 12 help videos that are linked on every data entry page within the dataset upload tool so that researchers can view and answer any question they have about data entry.

NM EPSCoR is now hosting and providing ongoing support for the NM Bureau of Geology & Mineral Resources' geothermal geodatabase, online mapping application, and data access interface. *Energize NM*–generated geothermal datasets are being integrated into the system as soon as the research team provides them. The published data services for data products in the data portal and the geodatabase systems support direct access by statistical analysis and modeling applications, desktop and web mapping systems, and desktop and web-based data visualization tools.

In Year 4, the CI team also refined the process by which data from the NM EPSCoR data portal is fed to the DataONE network (OCI-083094, ACI-1430508) for enhanced discoverability and UNM's institutional data repository for data preservation. They added the capability to search for all datasets targeted for registration with DataONE, while simultaneously monitoring dataset embargo dates in order to protect researcher's data before publication. In addition, they modified ElasticSearch document

schemas, as well as associated changes to the Pyramid API code in order to flag specified data records intended for inclusion in DataONE.

The CI graduate students (Diller, Zhang, Valentin) also created a Metadata Field Guide to help researchers obtain critical metadata while out in the field. The pocket guide has waterproof pages and contains valuable information to help them identify the metadata they need to collect. Two CI graduate students attended the American Geophysical Union conference and presented their work on NM EPSCoR's Research Data web portal and dataset entry form.

External Engagement (100%)

Informal Science Education Network (ISE Net; Marino, Novak, Connealy): NM ISE Net activities increase the capacity of informal science education organizations and personnel to support STEM learning in NM and communicate *Energize NM* research to the public. Network meetings highlight best practices and promote networking both among ISE professionals and NM EPSCoR researchers. More than 35 individuals from 16 different ISE organizations and three higher-ed institutions (NMSU, Mesalands Community College, and UNM) participated in two network meetings over the past year: one in conjunction with the statewide STEM Symposium for K-12 teachers (Albuquerque) and a stand-alone two-day meeting (Las Cruces). Trainings support ISE professional capacity; as part of the Reflecting on Practice program, ISE Net hosted two trainings: Five Big Ideas about Learning, and Working with Diverse Learners in an Informal Science Context. ISE Net members also helped instruct the Teacher Professional Development workshop in Alamogordo (see Sustainability section).

ISE Net mini-grants provide funding of up to $3,000 for NM ISE Net organizations to communicate *Energize NM* research to a public audience. In Year 4, three mini-grant projects were awarded. The mini-grant awarded to Explora supported youth interns to visit bioalgal labs at NMSU and UNM, and two Teen Science Cafes on Geothermal and Bioalgal topics that engaged researchers from UNM. A joint project between the NMT Uranium Research Team and the National Museum of Nuclear Science and History resulted in a public science day at Laguna Pueblo to share results of Uranium Team research and also supported the development of an exhibit slated to open at the Nuclear Museum in 2017. The third mini-grant supports collaboration between Albuquerque Biopark and Bioalgal Research Team members to develop algae education materials for Tingley Beach, a city-owned facility used for public recreation.

Museum Exhibits (Marino, Hastings, Walther): The first *Energize NM* museum exhibit opened in Year 4 at the NM Museum of Natural History and Science. The exhibit, "Get Going with Green Goop," includes short videos of NM EPSCoR bioalgal research sites, an interactive game to grow algae, and 3D diatom models. To date, more than 90,000 people have visited the museum since the exhibit opened and have had the opportunity to interact with the exhibit.

In preparation for an exhibit that will open in early Year 5, Explora Science Museum has conducted a series of design sessions with NM EPSCoR researchers to help them communicate their research and develop hands-on tabletop demonstrations to engage the general public. Exhibit design work is ongoing and includes formative evaluation.

Staff from the National Museum of Nuclear History and Science have met several times with faculty and students from the Uranium Team to plan for development of the 2018 exhibit on Uranium. The exhibit will introduce several key aspects of uranium in our society and environment and will feature aspects of the Uranium Team's research. The exhibit will be titled "What's up with U?"

All museum exhibits will adhere to design specifications that were jointly created by the three museums, so that in the future the exhibits can travel together to other ISE Net institutions.

Project Communications (Willoughby, Serna, Allen): In Year 4, the website team used data to improve the communication effectiveness of the project website (nmepscor.org). Data from Google Analytics as well as monthly meetings of the web team were essential to shape updates and changes to the website. Website content was updated regularly and included 26 blog postings about project activities authored by

students and staff. Total pageviews for nmepscor.org, for Year 4 to date are 6,500. Social media vehicles are linked to the website: NM EPSCoR has 277 Facebook likes and 435 followers on Twitter, an increase of 10% and 23% respectively, from Year 3 figures. Our Mailchimp listservs (general, diversity, and education outreach) reach 1,037 unique subscribers, an increase of 16%. Email notices sent to our general list are opened by 24% of users, compared to an industry standard of 15.6%. In addition, a collaborative effort among the website team and the NM EPSCoR Public Relations Specialist designed and developed a standalone website for the NM EPSCoR Year 3 annual report (https://www.nmepscor.org/annual-reports/year3/index.html). Analytic results for the annual report website show that there were 220 unique views since its initial publication in August 2016. In Year 4, a number of videos were also added to website content and to our YouTube channel.

Evaluation & Assessment (100%)

Our external evaluator, Kirk Minnick and Associates, completed the Year 3 External Evaluation report (uploaded as separate attachment to RPRR system), which the Management Team reviewed and has used in its discussions of program progress. Minnick has also attended several of the workshops and meetings in Year 4 and provided individual activity evaluation reports, which are being used to review and, as appropriate, revise those activities. The Exhibit Evaluator, Elsa Bailey, is working with both Explora and the National Museum of Nuclear History on Science to provide formative assessment during exhibit development.

The External Advisory Board met twice in Year 3 (September 2015 and May 2016) and is scheduled to meet in late Year 4 (May 2017). In addition, in November 2016 we hosted a AAAS panel from the Research Competitiveness Program. The panel reviewed our current project and potential future directions for program sustainability.

Sustainability (100%)

Faculty Hires: The final NM EPSCoR faculty hire was made in Year 4, and Hatim Geli joined the Social & Natural Sciences Nexus group as Assistant Professor of Landscape Hydrology at New Mexico State University. This hire had been delayed due to a hiring freeze at NMSU. NM EPSCoR was able to leverage four budgeted faculty hires into six new faculty members that support the Uranium, Solar, and Social & Natural Sciences Nexus research teams.

Teacher Professional Development Institute (Connealy, Novak): The primary activity in this program is a week-long energy institute for upper elementary and middle school teachers, plus two follow-up workshops. This year's institute was conducted in southeast NM at the Space History Museum in Alamogordo; follow-up workshops occurred at the state science teacher conference in the fall and Roswell in the spring. A total of 21 teachers from five school districts participated in the Teacher Institute that was facilitated by instructors from seven different ISE Net organizations. The large majority (80%) of the teachers showed substantial gains in energy knowledge as measured by a pre- and post-test assessment. Additionally, they rated the Institute very high as compared to other professional learning experiences, with more than 40% reporting it as the best professional development they had ever experienced. We are currently planning and recruiting for the final 2017 Teacher Institute in Taos.

Interdisciplinary Innovation Working Groups (I-IWGs; Jakle): I-IWGs provide a venue for researchers, educators, and nationally recognized experts to address grand challenges that require an interdisciplinary approach to transform science. Three I-IWGs took place in Year 4:

(1) *Optimizing the Use of New Mexico's Renewable Energy and Water Resources (Kelley, Gomez-Velez, Person)*: This event brought together a team of 19 experts in hydrology, geophysics, geochemistry, engineering, environmental science, applied education, and social sciences—including a state regulator and industry member—to explore the challenges associated with the shift toward diminishing water supplies and the widespread use of renewable energy in New Mexico. The main goal was to identify ways to take advantage of our geothermal, solar, and wind resources, in combination with

bioalgal and other water treatment technologies, to effectively and responsibly use unconventional water resources. The group also explored potential collaborations with the Pueblo of Jemez.

(2) *Preliminary Meeting of a New Mexico Working Group on Smart Grids and Smart Buildings (NM-WGSGSB*; *Pontelli, Ranade, Galves*): This I-IWG brought together an interdisciplinary team of researchers and scientists evaluating sustainable energy generation and capacity within the paradigm shift of power delivery to energy delivery, using smart grid and smart building models. The group collaboratively analyzed and evaluated the important ideas and theories behind energy delivery, demand response, communication, security, negotiation, and data mining within smart grids and buildings.

(3) *Contained Human Presence along the Rio Grande Corridor: Historical Sustainable Development to Inform Future Urban Morphogenesis as the Climate Changes in the American Southwest (Uviña, Marrow)*: An interdisciplinary team from UNM, NMSU, Universidad Nacional Autonoma de Mexico UNAM, and the U.S. Fish and Wildlife Service explored how the available ecosystem services and human technologies for the provision of energy and freshwater shaped settlements along the Rio Grande corridor. They sought answers to the question: how might the history of settlement prior to and during the Spanish presence help inform future settlement morphogenesis as the climate changes in the Southwest? Findings from the I-IWG are informing a number of grant proposals and course redesign, along with community events.

Additional I-IWGs will be solicited in April 2017 and will take place in Year 5.

Infrastructure Seed Awards (Jakle): In Year 4, *Energize New Mexico* awarded its three final Infrastructure Seed Awards. These $50,000 awards are meant to increase the access of undergraduate students, especially women and members of underrepresented groups, to research experiences by increasing non-PhD granting institutions' capacity to provide research experiences for students. Through a competitive process, awards were made to:

(1) *New Mexico Highlands University: "Development of Novel 2D and 3D Aromatic Materials with Extended π-Systems for Organic Solar Cells."* This research project is exploring development of synthetic methodology towards aromatic cores with up to 15 fused rings, their preparation and investigation of the properties by experimental and computational methods, which has applications for solar energy. Time-dependent density functional theory (TD DFT) calculations for selected aromatic cores with seven fused cores were carried out by graduate student, Luis Garcia. An undergraduate student, Taylor Herrera, also recently joined the computational part of the project, and he will carry out TD DFT calculations for the proposed 3D cores. This seed award has supported collaboration with EPSCoR-researcher and junior faculty member Yang Qin (UNM), and in January 2017 a proposal with NMHU and UNM PIs was submitted to NSF to support further applications of this work.

(2) *Central New Mexico Community College (CNM): "Undergraduate Internships that Generate Science Outreach and Education Modules on the Topics of Southwest Energy Use and Development*." CNM is working with Explora on this award and recruited 12 CNM, STEM-majoring students into a science-outreach education internship. The students received training during the fall to learn the best practices for designing and implementing a science education outreach module (patterned after the successful Portal to the Public [#1224129] science training). The students were also trained on the topics of Uranium remediation and environmental contamination by two local experts, Dr. Jose Cerrato (Uranium Team co-lead, UNM) and the Chief Scientist of the NM Environmental Department, Dennis McQuillan.

This spring, the students are working in small groups to design and build demonstration modules focusing on 1) How Uranium moves in the environment, 2) Who is impacted by Uranium waste, and 3) How Uranium affects the health of the community. Once the demonstration modules are complete the students will present them to the public at Explora. During their presentations students will evaluate each other, and be evaluated by professionals using a rubric they have created.

(3) *Santa Fe Community College (SFCC): "Updating and Improving the Capacity to Monitor Algal Growth at Santa Fe Community College."* SFCC is engaging three student interns (100% URM) to construct a new algal PBR testing unit that incorporates the EXO Sonde data collection previously

purchased with NM-EPSCoR Seed funding. The interns will run multiple continuous growth experiments, go into the field to collect algae, and will train up to 30 students and instructors in the use of the EXO Sonde sensors in PBR cultures, wastewater and in the field. Students will also demonstrate and teach use of EXO Sondes at the Algae Testbed Public-Private Partnership (ATP^3) Workshop (in collaboration with Arizona St. U and DOE), which will be held at SFCC in May 2017.

These Seed Awards will be ongoing through mid-Year 5.

External Funding: Project personnel have pursued additional funding in Year 4, submitting 28 proposals to date for a total request of $37.1 million, exceeding our target of 19 proposals in Year 4. In Year 4, $9.4 million in additional funding has been awarded to date. Since project inception, NM EPSCoR participants have been awarded $44.1 in extramural funding from federal agencies (NSF, DOE, NIH, USGS, USFS, DOI, DOD, SBA), state agencies, and private foundations, representing a greater than 2:1 return on investment of NSF dollars into these research areas.

NSF Day: We have been unable to schedule NSF Day, which was planned for Year 3. We are on a waitlist at NSF and are hopeful to bring this event to New Mexico before the end of the grant.

Management (100%)

Program management continues to run smoothly, as recognized by the NSF Site Visit team in its September 2016 report, which stated that "The Panel members agree that the project leadership should continue doing what it is doing in terms of the management structure and activities – it is working."

Component leads reported on their progress during quarterly Management Team meetings, which include a stoplight analysis to track progress on spending, strategic plan objectives and metrics, and data upload to the NM EPSCoR data portal. The research component teams met regularly, although the frequency varied based on the team's need and pace of progress. The PI presented to the Council of University Presidents in November 2016 and the State EPSCoR Committee met in November 2016 and will meet again in late-May 2017. Sub-award fiscal training was also provided to subawardees in Year 4. As mentioned, in Year 4, NM EPSCoR hosted an NSF panel for a two-day Site Visit. The Year 4 All Hands Meeting is scheduled for April 27, 2017.

Members of the NM EPSCoR office, including the PI, Co-PI, Education and Diversity Coordinators, and Public Relations specialist conducted numerous campus visits throughout the year: UNM (host institution), New Mexico Tech, NMSU, Eastern New Mexico University (ENMU), New Mexico Highlands University, Mesalands Community College, Dine College-Shiprock, Santa Fe Community College, UNM-Valencia, NMSU-Dona Ana, NMSU-Alamogordo, ENMU-Roswell, and San Juan College.

IV. Graphic Representation of Strategic Plan Progress

See Appendix 1.

V. Special Conditions

The Energize New Mexico September 2016 Site Visit produced five recommendations for the project. Progress toward addressing these recommendations is outlined below.

1. While it is useful to conduct early research in multiple areas related to the energy theme of the project, it is important to focus on the most viable paths for maximum impacts during the remaining award period. The first five research teams should assess the technical and economic viability of their development targets and focus research efforts on the most promising areas. Describe how you will address this and include a timeline for actions.

In response to this recommendation, NM EPSCoR provided a detailed timeline, by quarter, of the progress that will be made by each team. We are tracking quarterly progress toward these targets through an added layer of reporting. The Management Team will use progress to modify metrics, research

directions, and allocation of resources, as needed, and will communicate about any possible changes with our cognizant program officer. In general, the research progress for the teams is solid and there is momentum to finish work by the end of the grant cycle. In response to the Site Visit recommendation, the Osmotic Team is now focusing primarily on GMD utilization of fabricated membranes. The Solar Team – while active in a number of research areas – is placing most of its energies into those that have proven most productive, including evaluating excited state processes, pursuing catalysts for solar fuel production, and enhancements to efficiencies of organic solar cells. Other teams are continuing with research themes set out in the strategic plan and are on track with research objectives and activities.

2. The social and natural science nexus work is well behind schedule due to the state-imposed hiring freeze, and there is concern that the team may not be able to meet all goals. Members of this team should work with the project leadership to critically assess: (i) what will be feasible over the next 18 months; (ii) which questions will provide the most insight to guide the decisions for the energy system in NM. Provide the rationale for your decision(s) and include a timeline for the remaining work to be done. Describe any impact of changes on the overall mission and goals of the project and how you propose to mitigate any negative impacts.

Major advances were made between the Site Visit and the submission of this report, and the faculty hire and post doc hire are now on board and have begun work at NMSU. The post doc has met with all members of the team and is starting model integration work. At the end of Year 5, systems dynamic components, developed at the appropriate level, will be integrated within a regional or statewide SD model, where the state focus will be on those outcomes that are at a state level interest. This is a modified emphasis of this group, which was determined in response to comments from the Site Visit panel, and we believe this approach will better help us understand the interactions, tradeoffs and outcomes of each social and natural system our project is examining. For example, the San Juan Basin energy production and economic model (county level) can be linked to the electricity generation model (state level) and the water model (basin level), which allows us to focus on the interactions of energy production and water use. Impacts on electricity generation could then be assessed at the state level in terms of jobs impacts, and economic impact through tax revenue would be aggregated to the state level.

Substantial progress has been made on the development and/or refinement of different SD modules and plans for their integration have been made within a frame that allows for differences in spatial focus and temporal dynamic changes or outcomes, as well as on the development of attitudes and preferences that can influence policy and regulatory regimes. Progress of this team is also tracked on a quarterly basis and has been satisfactory.

3. Engagement with industry will continue to be critical to the long-term success of much of the fundamental research across all teams. The creation of an active industrial advisory board with representation from each relevant energy area could assist this effort. Describe how you will address this and include a timeline for actions.

In response to this recommendation, additional members from industry or with ties to the sustainable energy industry in the state were added to the NM EPSCoR State Committee, and project leadership continues to actively seek to identify and recruit an additional industry member. A key challenge continues to be the lack of industry in the State of New Mexico to draw on. There is also an industry roundtable scheduled for our Year 4 All Hands Meeting and a follow-on discussion regarding career transfer between academia and industry. Potential panelists have been identified and will be invited over the coming weeks. One panelist, Errol Arkilic, is confirmed; he is the former Program Manager in NSF's Division of Industrial Innovation and Partnerships and current CEO of M34 Capital, a seed-stage investment firm that works with emerging entrepreneurs that are translating technology out of Academic and R&D labs. In addition to his participation in the All Hands Meeting, NM EPSCoR will co-sponsor an event with Creative Startups that will feature Dr. Arkilic, "Entrepreneur Insights: Lessons from Global Leaders," on April 26. In addition, our Externship program now is marketed to include private-sector experiences for students. Individual research teams have also strengthened efforts to engage with

industrial partners. For example, faculty from the Uranium Team who are chairing the NM Geological Society Conference have invited a member of the Uranium industry to provide the keynote address and are hosting a special session for members of industry to intact with students. This calendar year, the Osmotic Team will install a pilot Geothermal Membrane Distillation System at a commercial greenhouse, which was created in conjunction with a geothermal industry partner. Last, our New Mexico First Town Hall, scheduled for Fall 2017 on the topic of Energy Workforce Development, will require active and sustained engagement from the energy industry in New Mexico. Town Hall Steering Committee members will be recruited in March.

4. Interactions with some students indicated that they did not know about opportunities for employment or graduate school after completion of their degree. The research advisors should take an active role in providing guidance on career pathways including graduate programs, post-docs, or professional positions. Given the list of potential employers in NM and the surrounding region, could students be directed to look for summer or academic-year internships with NM partner organizations and industries, or to pursue other job opportunities? Are undergraduate and master's students receiving guidance on jobs and also where they might want to consider going for further training should they wish to pursue a higher degree or post-doc? How could student guidance be improved? Please comment and describe any plans that could be taken to better advise and place students in graduate school or professional positions.

We engaged our Management Team on this issue and had a discussion about the role of advisors as career mentors. All agreed that a student career roundtable with members of industry and those that have bridged academia and the private or government sectors – including EPSCoR alumni—at our April 2017 All Hands Meeting will be a useful pursuit. We have also created a NM EPSCoR mentoring award, which includes criteria for working to advance professional goals, heightening the importance of this aspect of advising. Individually, teams are tackling this issue through invited working professional alumni panels at their departments and a mixing hour with students and industry. We are also improving career pathway support for all NM EPSCoR students through a student-oriented newsletter that provides information three times per year on job and professional development opportunities, career resources, and other helpful information (Fig. 6).

Summer schools are educational internship opportunities for undergraduate and graduate students. The goal of summer schools is to improve career prospects and build a recruiting pipeline into the many IS&T areas at LANL. There are several programs to choose from—deadline to apply is January 27, 2017.

Figure 6. Excerpt from Student Opportunities Newsletter.

5. The number of peer-reviewed publications is low, given the size of the RII Track-1 award and the number of researchers involved. Please consider and describe how each team will work to improve the respective publication record in the remaining 18 months. Include a realistic timeline for actions.

Each team provided a timeline of publications in response to this Site Visit recommendation. Progress on these papers is now tracked as part of quarterly progress reporting. While some of these targets have not been met, the continued accountability puts pressure on the researchers to prioritize these papers, and the 37 peer-reviewed papers produced so far in Year 4 (for a full list, please see RPRR system) exceeds those of all other grant years and exceeds the annual goal set in the *Energize NM* Strategic Plan of 25 papers in Year 4. In total, our project has published 88 peer-reviewed papers, and we expect a continued stream of papers throughout the remainder of the grant and to greatly exceed the 92 paper goal set in our strategic plan.

There are no Jurisdiction-Specific Terms and Conditions for this award.

VI. References

Avasarala, S., Ali, A., Gonzalez-Pinzon, R., Blake, J., Lichtner, P., & Cerrato, J. (In review). Reactive transport of U and V from abandoned uranium mine wastes. *Environmental Science & Technology.*

Bartley, M. L., Boeing, W. J., Daniel, D., Dungan, B. N., & Schaub, T. (2016). Optimization of environmental parameters for Nannochloropsis salina growth and lipid content using the response surface method and invading organisms. *Journal of Applied Phycology*, *28*(1), 15-24.

Cerrato, J. M., Blake, J. M., Hirani, C., Clark, A. L., Ali, A. M. S., Artyushkova, K., ... & Bixby, R. J. (2016). Wildfires and water chemistry: effect of metals associated with wood ash. *Environmental Science: Processes & Impacts*, *18*(8), 1078-1089.

Henkanatte-Gedera, S. M., Selvaratnam, T., Karbakhshravari, M., Myint, M., Nirmalakhandan, N., Van Voorhies, W., & Lammers, P. J. (2016). Removal of dissolved organic carbon and nutrients from urban wastewaters by *Galdieria sulphuraria*: Laboratory to field scale demonstration. *Algal Research*.

Jarvis, J. M., Sudasinghe, N. M., Albrecht, K. O., Schmidt, A. J., Hallen, R. T., Anderson, D. B., ... & Schaub, T. M. (2016). Impact of iron porphyrin complexes when hydroprocessing algal HTL biocrude. *Fuel*, *182*, 411-418.

Leonard, D. P., Pan, H., & Heagy, M. D. (2015). Photocatalyzed reduction of bicarbonate to formate: Effect of ZnS crystal structure and positive hole scavenger. *ACS Applied Materials & Interfaces*, *7*(44), 24543-24549.

Muppaneni, T., Reddy, H.K., Selvaratnam, T., Phaniraj Dandamudi, K., Dungan, B., Nirmalakhandan, N., Schaub, T., Omar Holguin, F., Voorhies, W., Lammers, P., Deng, S. (2017). Hydrothermal liquefaction of Cyanidioschyzon merolae and the influence of catalysts on products. *Bioresource Technology*, *223*, 91-97.

Reddy, H. K., Muppaneni, T., Ponnusamy, S., Sudasinghe, N., Pegallapati, A., Selvaratnam, T., ... & Holguin, F. O. (2016). Temperature effect on hydrothermal liquefaction of Nannochloropsis gaditana and Chlorella sp. *Applied Energy*, *165*, 943-951.

Rodriguez-Freire, L., Avasarala, S. M., Ali, A. M. S., Agnew, D., Hoover, J. H., Artyushkova, K., Brearley, A. J., & Cerrato, J. M. (2016). Post Gold King Mine spill investigation of metal stability in water and sediments of the Animas River watershed. *Environmental Science & Technology*, *50* (21), 11539-11548.

Selvaratnam, T., Henkanatte-Gedera, S. M., Muppaneni, T., Nirmalakhandan, N., Deng, S., & Lammers, P. J. (2016). Maximizing recovery of energy and nutrients from urban wastewaters. *Energy*, *104*, 16-23.

Steenbock, T., Shultz, D. A., Kirk, M. L., & Herrmann, C. (2016). The influence of radical bridges on electron spin coupling. *The Journal of Physical Chemistry A*, *121*(1), 216-225.

Stinziano, J., Morgan, P. B., Lynch, D. J., Saathoff, A. J., McDermitt, D. K., & Hanson, D.T. (Accepted). The rapid A/Ci response (RACiR): photosynthesis in the phenomic era. *Plant, Cell and Environment*.

Yang, J., Zhang, Z., & Qin, Y. (2016). A molecular tetrapod for organic photovoltaics. *ACS Applied Materials & Interfaces*, *8*(34), 22392-22401.

Appendix I: Strategic Plan Progress Tables

KEY	On track	Behind schedule	Complete	Ahead of schedule	Deleted or changed	Unreported

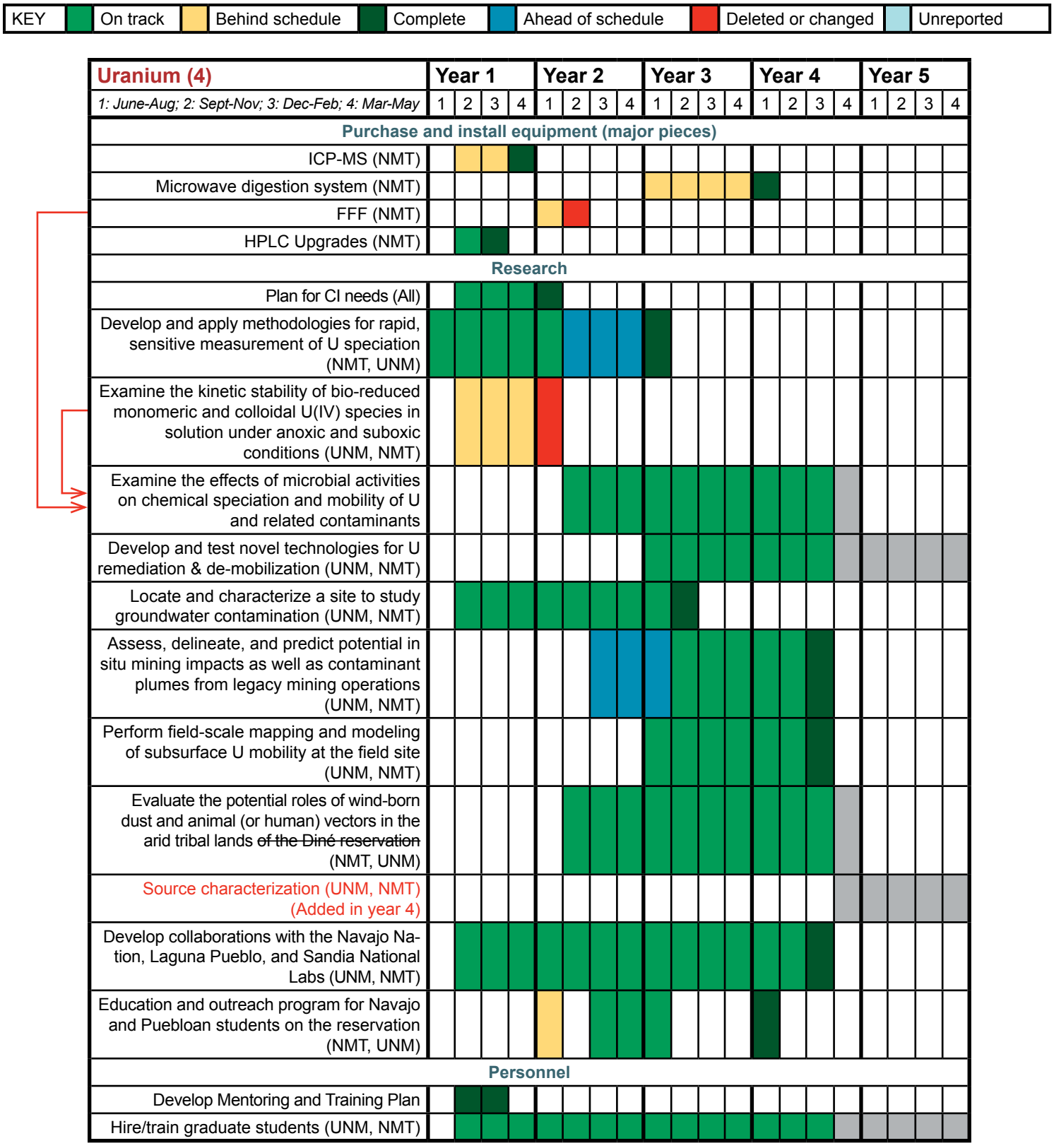
Bioalgal Energy (1)	Year 1				Year 2				Year 3				Year 4				Year 5			
1: June-Aug; 2: Sept-Nov; 3: Dec-Feb; 4: Mar-May	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
GOAL 1: OPTIMIZE BIOLOGICAL PRODUCTIVITY																				
Outdoor Algal Performance (NMSU, UNM)																				
Evaluate *Galdieria* strains																				
Reassess biomass and lipid productivity phenotypes of strains in cultivation																				
Study the responses of algae through time and physical location																				
Micro-Photobioreactors (NMC, UNM)																				
Use hydrogels to encapsulate very high-density microalgal cells along with solid-state devices and/or fluorescent proteins																				
Address optimization of giant quantum dot cell energy transfer																				
Characterize mircro-encapsulated algal-growth and biomass partitioning																				
Compare photosynthetic function between bacteria and algae in silica gel matrices																				
Compare biomass accumulation between bacterial and algae in multiple gel matrices																				
Algal Community Ecology (UNM, SNL, NMSU)																				
Evaluate how diversity and trophic interactions influence lipid production																				
Measure photosynthetic function in natural bacterial and algal communities																				
GOAL 2: IMPROVE CULTIVATION PRACTICES																				
Outdoor Cultivation (NMSU)																				
Analyze *Nannochloropsis* (CCMP1776) and a fast-growing *Chlorella* strain for winter growth in the photobioreators																				
Evaluate potential for using municipal and agricultural wastewaters in the photobioreactors																				
Process Engineering (UNM, NMSU)																				
Evaluate effects of lipids on biomass density as a potential selectable characteristic																				
Develop agent-based models of microbes with storage products in photobioreactors																				
Access how industrial, municipal, and agricultural wastewater affects system function																				
GOAL 3: ENHANCE ENERGY RETURN ON INVESTMENT AND WASTEWATER UTILIZATION																				
Extraction (NMSU)																				
Evaluate hydrothermal, microwave-assisted, and supercritical processing concepts for chemical extraction, fuel conversion, and easy nutrient recycling from process waste streams and inorganic carbon																				
Processing (NMSU)																				
Test hydrothermal processing technology on *Nannochloropsis*, *Chlorella*, *Galdieria* and also ecologically stable strain mixtures																				
Conversion (UNM)																				
Investigate transition-metal catalyzed decarboxylation processes tailored to de-oxygenation of biocrude oils in order to meet ASTM fuel standards																				
Wastewater Utilization (ENMU)																				
Test baseline performance of turf scrubber																				
Characterize wastewater for turf scrubber																				

KEY	On track	Behind schedule	Complete	Ahead of schedule	Deleted or changed	Unreported

Bioalgal Energy (1)	**Year 1**				**Year 2**				**Year 3**				**Year 4**				**Year 5**			
1: June-Aug; 2: Sept-Nov; 3: Dec-Feb; 4: Mar-May	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Test turf scrubber with wastewater, and analyze nutrient and BOD removal																				
CROSS-CUTTING INFRASTRUCTURE																				
NMSU's Chemical Analysis and Instrumental Laboratory																				
Provide Overall Project Support (NMSU)																				
Provide centralized analytic processing and training																				
Develop biological standards (new strains as needed in out years)																				
Develop Standard Operating Procedures for algal sampling and lipid quantification																				
Purchase and Install Equipment (NMSU)																				
Continuous flow hydrothermal reaction system (1-L, 0-400 C, 0-400 bar)																				
Components, fabrication and utility modification costs for 24 Outdoor Algae Cultivation Systems																				
Harvesting System (Evodos, Origin Oil or dissolved air floatation (DAF))																				
Purchase and Install Equipment (ENMU)																				
Algae turf scrubber																				
Small-scale Experimental Ecological Design Facility (SEED) (UNM)																				
Provide Overall Project Support																				
High frequency chemical analyses																				
Flexible cultivation environments																				
Stable isotope measurements																				
Purchase and Install Equipment (UNM, NMC)																				
Waters UPC2																				
Water Fraction Collector & HP/Agileat 350																				
Digital compound microscope																				
Photobioreactors																				
GC/MS																				
MIMS																				
Isotopic laser																				
Hyperspectral imaging upgrades																				
Photochemical reactor																				
Personnel (All)																				
Form collaborations in NM among groups working on algal cultivation and wastewater management																				
Develop Mentoring and Training Plan																				
Hire new faculty in engineering																				
Hire research technician to run UPC2																				
UNM/NMC student support (1 per year)																				
UNM student support (2.5 per year)																				
NMSU Faculty hire																				
NMSU student hires																				
ENMU entry-level technician hire																				
ENMU student hire																				

Solar Energy (2)	Year 1				Year 2				Year 3				Year 4				Year 5			
1: June-Aug; 2: Sept-Nov; 3: Dec-Feb; 4: Mar-May	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1. Build solar team (All)																				
Hire/train graduate students																				
Identify team member at NMSU																				
Hire physical or inorganic chemist																				
Incorporate new team member's expertise (NMT, NMSU)																				
2. Purchase and install equipment (NMT, UNM)																				
MCD Magnet System																				
Time Resolved Spectroscopy																				
Fluorolog spectrophotometer																				
Raman Microscopy																				
Steady State Fluorescence Spectrometer (UNM) (Added in year 4)																				
Gas Chromatog (Added in year 4)																				
3. Use nanoparticle ZnS to catalyze reduction of CO2 (NMT, UNM, NMHU, NMSU)																				
Obtain preliminary data on ZnS NPs vs. microparticle																				
Explore and develop dye photosensitizers for ZnS catalysts																				
Investigate semiconductor catalysts MoS																				
Obtain spectroscopic characterization of NP catalysts																				
Collaborate with junior faculty on solar fuel plasmonics (Added in year 4)																				
Initiate new directions toward Methanol fuel (Added in year 4)																				
4. Develop stable BHJs from a single polymer system (NMT, UNM, NMHU, NMSU)																				
Synthesis of new polymeric systems and characterization																				
Incorporate non-covalent guests/C60 porphyrins																				
Spectroscopic characterization / fluorescence lifetime																				
9. Connections between EPSCoR teams (NMT, SFI, UNM, NMHU, NMSU)																				
Outreach to K-12 students via SFI/GUTC																				
Explore collaboration w/ geoscientist for zeolite carbon capture																				
Explore collaboration w/ biologist using bioalgal carbon capture																				

Osmotic Power (3)	Year 1				Year 2				Year 3				Year 4				Year 5			
1: June-Aug; 2: Sept-Nov; 3: Dec-Feb; 4: Mar-May	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Purchase and install equipment (major pieces) (NMT)																				
Membrane Osmometer																				
Pressure Retarded Osmosis (PRO) System																				
SEM-EDS																				
Research																				
Identify potential sources of produced water (NMT, UNM)																				
Characterize the compositions of source waters (NMSU, ENMU)																				
Evaluate the achievable trans-membrane pressures (NMT, UNM)																				
Assess the design requirements of membranes and membrane modules (All)																				
Design, construct, and modify bench-scale osmotic power systems (All)																				
Develop new thin film composite (TFC) membranes and modules to maximize power generation (NMT, NMHU)																				
Investigate the occurrence, prevention, and mitigation of membrane fouling (All)																				
Perform cost-benefit analysis (NMT)																				
Personnel																				
Develop Mentoring and Training Plan (All)																				
Hire/train graduate students (NMT)																				
Hire/train post-docs (NMT)																				
Hire/train research chemist (NMSU)																				


KEY
On track
Behind schedule
Complete
Ahead of schedule
Deleted or changed
Unreported
Uranium (4)
Year 1
Year 2
Year 3
Year 4
Year 5
1: June-Aug; 2: Sept-Nov; 3: Dec-Feb; 4: Mar-May
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Purchase and install equipment (major pieces)
ICP-MS (NMT)
Microwave digestion system (NMT)
FFF (NMT)
HPLC Upgrades (NMT)
Research
Plan for CI needs (All)
Develop and apply methodologies for rapid, sensitive measurement of U speciation (NMT, UNM)
Examine the kinetic stability of bio-reduced monomeric and colloidal U(IV) species in solution under anoxic and suboxic conditions (UNM, NMT)
Examine the effects of microbial activities on chemical speciation and mobility of U and related contaminants
Develop and test novel technologies for U remediation & de-mobilization (UNM, NMT)
Locate and characterize a site to study groundwater contamination (UNM, NMT)
Assess, delineate, and predict potential in situ mining impacts as well as contaminant plumes from legacy mining operations (UNM, NMT)
Perform field-scale mapping and modeling of subsurface U mobility at the field site (UNM, NMT)
Evaluate the potential roles of wind-born dust and animal (or human) vectors in the arid tribal lands ~~of the Diné reservation~~ (NMT, UNM)
Source characterization (UNM, NMT) (Added in year 4)
Develop collaborations with the Navajo Nation, Laguna Pueblo, and Sandia National Labs (UNM, NMT)
Education and outreach program for Navajo and Puebloan students on the reservation (NMT, UNM)
Personnel
Develop Mentoring and Training Plan
Hire/train graduate students (UNM, NMT)

Geothermal Energy (5)	Year 1				Year 2				Year 3				Year 4				Year 5			
1: June-Aug; 2: Sept-Nov; 3: Dec-Feb; 4: Mar-May	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Personnel and collaborations																				
Develop Mentoring and Training Plan																				
Recruit students for yrs. 2 & 4 (UNM, NMT)																				
Develop recruiting brochure (UNM, NMT)																				
Explore wider collaborations across institutions and tribes (UNM, NMT)																				
Develop partnerships with private sector, governmental agencies, and national labs (NMT, UNM)																				
Hire/train graduate students																				
Develop outreach and educational materials (NMT, UNM)																				
Engage with Geothermal Resources Council (NMT, UNM)																				
Develop IWGs for geothermal (UNM, NMT)																				
Purchase and install equipment (major pieces)																				
Magneto-telluric system (NMT)																				
Visualization work stations (NMT)																				
Autonomous sensors/field mass spectrometers (UNM)																				
Research																				
Select geothermal systems in New Mexico for analysis (NMT, UNM)																				
Characterize the compositions of waters and gases in these systems using published and new data (UNM, NMT)																				
Assess influence of geothermal systems and systems development on potable water quality (UNM)																				
Measure the magneto-telluric signature and resistivity of the subsurface below the targeted areas (NMT)																				
Determine the temperature of these systems using published and new data and develop new techniques to determine temperatures (NMT, UNM)																				
Determine radiometric dates of geothermal deposits and fault systems (UNM, NMT)																				
Add new data to existing databases and link to other databases (NMT)																				
Make 2D geologic cross sections, 3D geologic block diagrams, and 2D and 3D conceptual model system (NMT, UNM)																				
Develop high performance 2D and 3D hydrothermal computer models (NMT, UNM)																				
Model sustainability of geothermal production over several decades (NMT, UNM)																				
Evaluate & categorize thermal energy in place and potential power sources (NMT, UNM)																				

Social & Natural Science Nexus (6)	Year 1				Year 2				Year 3				Year 4				Year 5			
1: June-Aug; 2: Sept-Nov; 3: Dec-Feb; 4: Mar-May	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Build an SD infrastructure to integrate social and natural sciences by developing energy, socioeconomic and water budgets (All)																				
Create an infrastructure to collect and use human perceptions data (UNM)																				
Develop experimental data and experimental protocols to help fill data gaps on human perceptions and choices																				
Develop and administer an initial statewide survey to provide baseline data on attitudes about energy/water issues																				
Develop a statewide dynamic water budget that is linkable through the SD model to other science and social data models (NMSU)																				
Merge existing and new water resource data to establish dynamic water budgets that researchers and policymakers can access when they need integrated current status water budgets (NMSU)																				
~~Develop statewide and regional modules (as applicable) and a statewide model that crosses disciplines, incorporating modules from disparate fields into a decision support system designed with flexible scale and focus (All)~~																				
Develop mixed statewide and regional model components that combine energy, water, and public perceptions data (Added in year 4)																				
Assemble team for data integration and modeling workshops with the CI team and for research team meetings and visits to data repositories (All)																				
Develop database of existing data sources, including socioeconomic, water, energy, legal, environmental, and physical infrastructure (All)																				
Reach out to state agencies that can contribute to the model's relevance, the utilization of our products, and future research (All)																				
Collaborate across EPSCoR research teams to integrate research into database and integrated decision support system (All)																				
Enhance collaboration with policymakers and stakeholders (All)																				
Develop Mentoring and Training Plan																				
Hire/train graduate students (UNM, NMSU)																				
Hire/train post-docs (NMSU)																				

Diversity (7)	Year 1				Year 2				Year 3				Year 4				Year 5			
1: June-Aug; 2: Sept-Nov; 3: Dec-Feb; 4: Mar-May	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Hire Diversity Coordinator																				
Complete researcher mentoring plans																				
Diversity IWG																				
Project leadership attends SACNAS/AISES																				
Attend NM LSAMP Student Research Conference																				
Gather project diversity data; report at All Hands Meeting																				

Workforce Development (8)	Year 1				Year 2				Year 3				Year 4				Year 5			
1: June-Aug; 2: Sept-Nov; 3: Dec-Feb; 4: Mar-May	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
GUTC Curriculum Units																				
GUTC Summer Professional Development Workshop (5 days)																				
GUTC Fall Professional Development Workshop (1 day)																				
GUTC Spring Professional Development Workshop (1 day)																				
GUTC Club meeting (13 weeks per semester)																				
GUTC in-school computational thinking (5 students/5 teachers) (Added in Year 3)																				
Career Connections Conferences																				
Student Roundtables																				
STEMAP web materials developed																				
STEMAP recruitment at PUIs																				
STEMAP summer program																				
STEMAP quarterly webinars																				
Externship program guidelines/application																				
Recruit & select externship students/labs																				
5 graduate students placed in externships																				
Post-doc workshop (4 days)																				
PUI Faculty Leadership and PD Institute																				
Online follow-up learning sessions for PUI faculty																				
Form four colleague research teams (CC/ Univ. Researchers)																				
Training for Undergraduate Faculty Institutional Coordinators (FIC)																				
Create/update ICCE curriculum																				
Host ICCE																				
Host ICCE Fellows in New Mexico																				
On-going ICCE Fellows support/mentoring																				

Cyberinfrastructure (9)	Year 1				Year 2				Year 3				Year 4				Year 5			
1: June-Aug; 2: Sept-Nov; 3: Dec-Feb; 4: Mar-May	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Develop Mentoring and Training Plan																				
Integrated Data Storage and Modeling Portal (UNM)																				
Develop analytic services and client interfaces																				
Provide new capabilities for socioeconomic modeling and analysis																				
Ongoing data acquisition as requested to support project research																				
Expand the systems analytic capabilities																				
Document data products and integrate them into portal																				
Include an education resources section																				
Evolve the current XML document-based data documentation model																				
Modify component services that deliver ISO metadata (Semantic-enabled)																				
Expanding Our Interoperability with National and International Data Networks (UNM)																				
Continue the Western Consortium CI Working Group																				
Expand support for web service protocols used by networks																				
Connect to external geospacial platforms																				
Register project data products with international and national registries																				
Add project data products to LoboVault																				
Enhancing Tools for Collaboration (UNM)																				
Develop next generation data-centered collaboration capabilities																				
Support an online lab notebook system																				

KEY	On track	Behind schedule	Complete	Ahead of schedule	Deleted or changed	Unreported

External Engagement (10)	Year 1				Year 2				Year 3				Year 4				Year 5			
1: June-Aug; 2: Sept-Nov; 3: Dec-Feb; 4: Mar-May	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
ISE Net Annual Metting																				
Researcher/ISE Meetings																				
ISE Regional meetings																				
Award museum programming mini grants																				
Exhibit front-end study																				
NMMNHS Exhibit planning and opening																				
¡Explora! Exhibit planning and opening																				
NMNSH Exhibit planning and opening																				
Town Hall																				
EPSCoR Annual Report (public)																				
NM EPSCoR Website revised/updated																				

Evaluation and Assessment (11)	Year 1				Year 2				Year 3				Year 4				Year 5			
1: June-Aug; 2: Sept-Nov; 3: Dec-Feb; 4: Mar-May	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Finalize Evaluation & Assessment (E&A) plan																				
Collect baseline data																				
External E&A Report																				
External Advisory Board meeting																				
AAAS Review																				
Exhibit evaluation																				

KEY	On track	Behind schedule	Complete	Ahead of schedule	Deleted or changed	Unreported

Sustainability (12)	**Year 1**				**Year 2**				**Year 3**				**Year 4**				**Year 5**			
1: June-Aug; 2: Sept-Nov; 3: Dec-Feb; 4: Mar-May	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
New faculty hires (4)																				
Teacher PD ~~(Exploratorium)~~																				
ISE-led teacher workshops																				
Follow-up teacher PD																				
NSF Day																				
I-IWGs (3/year)																				
Seed Awards																				

Management (13)	**Year 1**				**Year 2**				**Year 3**				**Year 4**				**Year 5**			
1: June-Aug; 2: Sept-Nov; 3: Dec-Feb; 4: Mar-May	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Strategic Plan development and review																				
Subaward fiscal training including Yr. 5 closeout																				
Component budget review																				
Annual CUP presentation																				
State Committee meetings																				
Campus visits (1/quarter)																				
Reverse site visit (estimated)																				
Annual reporting																				
Monthly team meetings																				
Quarterly collaboration meetings (2 teams/ quarter)																				
Quarterly Management Team meetings																				
All Hands Meeting																				

Appendix II: *Energize NM* Participant Year 4 Honors & Awards

Faculty

- Co-lead of the Solar Team, Martin Kirk, was promoted to Distinguished University Professor at UNM.
- In early 2017, *Energize NM* faculty hire and Uranium Team Co-Lead, Jose Cerrato (UNM), received an NSF CAREER award (#1652619).
- José Cerrato received the 2016 Faculty of Color Award in the "Research Category" from the Project of New Mexico Graduates of Color (PNMGC).
- In July 2016, Jose Cerrato's research was featured in a special issue of the journal of the Royal Society of Chemistry (RSC), *Environmental Science: Processes & Impacts*. The special issue, "Emerging Investigators 2016" is the fourth edition of Emerging Investigators, an initiative by the *ES:P&I* journal to support and celebrate "the best and brightest among early career scientists around the world."
- Solar Team faculty member, Hongmei Luo (NMSU), received the 2016 Distinguished Career Award from University Research Council for Exceptional Achievements in Creative Scholarly Activity. The also received the NMSU Robert L. Westhafer Award for Excellent in Research and Creative Activity.
- Co-lead of the Bioalgal Component, Dave Hanson, was appointed Associate Editor of the journal *Photosynthesis Research.*

Students

- STEMAP student on the Uranium Team, Derrick Platero, received 1nd place at American Indian Science & Engineering Society (AISES) National Conference for his undergraduate student poster.
- Uranium Team PhD Student, Sumant Avasarala, won best student presentation at the 2016 New Mexico Geological Society (NMGS) annual meeting.
- NM EPSCoR students again fared well at the New Mexico Academy of Sciences Research Symposium and students from four separate research teams placed in the graduate student (Joshi, Social & Natural Sciences Nexus, 1st Place; Folsom, Geothermal, 2nd place; Henkanatte-Gedera, Bioalgal, 3rd place) and undergraduate student poster award competitions (Hirani, Uranium, 1st place).
- Masters student John Asafo-Akowuah (NMT) received the Stewart Wallace Memorial Scholarship from the Mining and Exploration Division of Society for Mining Metallurgy and Exploration (SME) on Feb. 15.
- John Asafo-Akowuah and Ashlynne Winton (both NMT Masters Students) received second place in a poster competition for their poster "Characterization of Abandoned Uranium Mines in New Mexico" at the American Institute of Professional Geologists (AIPG) meeting in Santa Fe.
- Masters Student Matt Folsom (NMT) received the "Tarantola Memorial Award" from his American Geophysical Union session, Dec. 2016.
- Creative Startups Program Manager Julia Youngs was an invited delegate to the Global Entrepreneurship Community 2016 Conference held in Kuala Lumpur.
- Kimberly Pestovich, a sophomore in Chemical and Materials Engineering department at NMSU and undergraduate researcher on the Solar Team has been awarded a scholarship through the New Mexico Space Grant Consortium.
- Stephanie Richins, a freshman in the Chemical and Materials Engineering department, has been selected to receive an NM Water Resource and Research Institute Student Water Research Grant.