D. Project Description

D.1. Status and Overview

Strengths

Inter-institutional Collaboration. Since 1992, Kansas NSF EPSCoR has provided the seeds and watched the growth of increasing inter-institutional collaboration, beginning with the establishment of research “clusters” in the mid-1990s. The current focus on renewable energy and climate change builds on multi-institutional initiatives of both Phase IV and Phase V. In Phase IV, with a theme of Life Sciences, three Centers were established: Ecological Genomics, Lipidomics, and Biodiversity. Phase V consisted of one major initiative, Ecological Forecasting, consisting of over 100 researchers. This initiative has helped to place Kansas in a key position for the one of the first sites for the National Ecological Observatory Network (NEON). The Ecological Forecasting initiative serves as the foundation for an even more ambitious Phase VI, in which the social sciences will join the natural sciences and will play a major role in addressing global climate and energy issues.

NSF-funded Centers. Kansas NSF EPSCoR has provided seed funding for projects that have become NSF-funded Centers, which illustrates the power of research infrastructure building provided by NSF EPSCoR. The Center for Environmentally Beneficial Catalysis (CEBC), an Engineering Research Center (ERC) was established in 2003 and the Center for Remote Sensing of Ice Sheets (CReSIS), a Science and Technology Center (STC), was established in 2005. The emphasis of the large scale project proposed here, merging research in renewable energy sources with global climate change, fits well with the missions these two Centers.

Building Research Infrastructure at KU, KSU, and WSU. Leaders at all three of the major research universities within Kansas have supported infrastructure building. KU has two new buildings on West Campus, a Structural Biology Center (Phases I and II, 2004 and 2008), that houses an 800 MHz NMR spectrometer and other state-of the art multi-user research equipment. In 2006 a Multidisciplinary Research Building was built to promote interdisciplinary collaboration. A new Pharmaceutical complex on West Campus is planned for 2010. Kansas State University recently added a major wing, Chalmers Hall, on its biological sciences building, and the University has completed a $54 million BSL-3 research laboratory facility on the north side of campus. This facility complements a multi-building cluster that houses research and educational activities in the Department of Grain Science and Industry, including the Bioprocessing and Industrial Value Added Program (BIVAP) building designed to promote linkages between the University and industry. Wichita State University, with strengths in engineering and aeronautics has added two new Engineering Research Buildings. One building houses sponsored research programs from the College of Engineering and the other the National Institute for Aviation Research.

State. The State of Kansas has made a number of investments in the sciences over the last decade that is making a difference for researchers in the State. In 2002, the University Research and Development Act (Kansas HB2690) authorized $130 million in bonds to fund four research facilities at the state universities.[1] In 2004 the Kansas Economic Growth Act (KEGA)[2] was legislated to establish a Kansas Bioscience Authority (KBA).[3] This act authorized over $500 million in bioscience research. The 2007 Kansas Economic Development Plan recognized the importance of agriculture and alternative energy (including biofuels) to the Kansas economy.[4] The Kansas Energy Council, appointed by the Governor and charged with the development of a comprehensive state energy plan, published the Kansas Energy Plan in early 2008.[5] In her 2008 State of the State address Governor Kathleen Sebelius noted,[6] “*Our nation is in the midst of a bio-energy revolution that will fundamentally change the way we produce and consume energy.*” She recommended the creation of a Bioenergy Research Grant program, “*to spur development of innovative new technologies producing the most cost-efficient renewable fuels,*” and also called for the State to pursue a comprehensive climate change action plan.

Kansas Technology Enterprise Corporation (**KTEC**) is a private/public partnership that was established in 1987 to promote technology based economic development through several strategies, including support of research at the state universities.[7] KTEC has consistently provided state matching funds even when not mandated. A key value in partnering with KTEC is that it is well-positioned to assist with private sector collaboration and commercialization efforts.

Kansas Bioscience Authority (**KBA**) was established as a result of the Kansas Economic Growth Act in 2004. Currently it is a $581 million initiative with goals of providing Kansas with world class research capabilities by seeding center initiatives and attracting eminent scholars and rising stars to the State, by helping to expand bioscience research and industry, and by attracting new industries to Kansas.[3]

Agriculture is a key commodity in Kansas, which is historically an agricultural state. According to *Kansas Farm Facts 2008*,[8] Kansas is second in the nation in wheat production, is the top producer of grain sorghum, and ranked eighth in the U.S. for corn grain produced. Other major crops grown in the state are sunflowers, hay, summer potatoes, and soybeans. Unfortunately, the fertile farmlands and prairies are at risk because of dwindling aquifers, another key reason for understanding climate change through research.

Barriers

Industrial Base. Kansas has not historically had a strong industrial base. However, the establishment of KTEC and the KBA is serving to address this deficiency by attracting more industries to Kansas and also by promoting and supporting start-up companies.

Cyberinfrastructure. The Great Plains Network (GPN) was funded in 1997 by NSF EPSCoR and consisted of six EPSCoR states: North Dakota, South Dakota, Nebraska, Kansas, Oklahoma and Arkansas.[9] However, cyber needs still exist for the Midwest states, and some of these needs may be addressed by the new Track II initiative. In the meantime, there has been discussion among computational leaders at KU, KSU, and WSU about launching a statewide assessment of Kansas' needs. At the same time the GPN has called for a meeting this winter for discussion of a regional assessment and a plan for the future.

Opportunities

The State of Kansas is in a unique position to utilize both its strengths in research in the natural and social sciences and its history of collaborative research to address the global challenges of energy and climate. With the level of support available from KTEC, KBA, and the individual universities, Kansas can leverage NSF dollars to attack these two global challenges.

D.2. Results of Prior Support

The major outcomes of previous NSF EPSCoR funding for Phases IV and V are provided in Table 1. In order to put past accomplishments in perspective to the proposed initiative, a section of the anticipated outcomes for Phase VI is added at the far right of the Table. Kansas first received NSF EPSCoR support in 1992. From Phase I through the current Phase V increasingly complex collaborative networks have been successfully formed. Kansas NSF EPSCoR was also a leader in the formation of one of the early cyberinfrastructure networks, the Great Plains Network (GPN). In Phases II – IV faculty start-up awards were initiated, known as *First Awards*. These awards will be reinstated in Phase VI. Multi-user equipment and education awards also played major roles in the early phases in building research infrastructure. In education, for example, Kansas NSF EPSCoR has provided funding to a program at Emporia State University that introduces young girls to possibilities of careers in math and science. In Phase V new educational opportunities were funded for K-12 students, high school teachers, Community Colleges, and Native American students through Education and Diversity Awards. Kansas NSF EPSCoR has also helped to leverage funding for the McNair program, which encompasses KU, KSU, and WSU and funds research at the undergraduate level for underrepresented and underprivileged students.

Table 1. Results of Prior Research for Phases IV and V and Anticipated Results for Phase VI.

AREA	***PHASE IV (2003-2006)***	***PHASE V (2006-2009)***	***PROPOSED FOR PHASE VI***
Natural Sciences	• Three state-funded centers created: o Ecological Genomics o Lipidomics o Biodiversity	• Single major initiative in Ecological Forecasting • Konza Prairie designated as a potential site for NEON	• Multidisciplinary, multi-institutional, multisector project on climate change and renewable energy
Social Sciences	• No Social Science involvement	• Minor Social Science involvement	• Social Science approximately ½ of project
Cyber	• Bioinformatics and biodiversity informatics initiatives launched	• Life Mapper II. Program for visualization/ predictive modeling for spread of species	• New models for climate change • Improved databases for climate modeling
Assessment	• The Implementation Group (Joe Danek) responsible for external assessment	• AAAS responsible for external assessment • New internal assessment plan launched with interviews and surveys	• Updated internal assessment plan to be continued
Economic Development	• Nanotechnology spin-off company at KSU from earlier EPSCoR initiatives	• Spin-off company at KSU from Lipidomics Center • Award to Ecological Forecasting initiative from Microsoft for modeling software	• Links to four Kansas-based energy companies plus two outside of Kansas already established
Major Awards	• NSF ERC funded: CEBC • NSF STC funded: CReSIS	• Konza designated potential NEON site • Ecological Genomics and Lipidomics self-sustaining with over $3 M Federal awards	• At least two new Centers are anticipated in Global Climate Change and Renewable Energy
Faculty Development	• First awards • Multi-user equipment awards • Planning grants	• 4 new faculty positions in Ecological Genomics	• First Awards • Emerging Areas awards • Pathways project promotes Native American faculty
Education	• Women in Science Conference funded (Emporia State)	• First IGERT awarded to Kansas • Women in Science funded • Education & Diversity Awards	• McNair Scholars • Pathways REU/IGERT • Graduate and undergraduate students in the project
State Match	• $3.375 M	• $2.25 M	• $10 M

D.3. Research Program

Two of the world's most challenging problems, the accelerating impacts of global climate change and the pressing challenge of renewable energy, are closely interwoven in terms of cause and effect. Solutions to these challenges can be obtained only by comprehensive and concerted research efforts to understand all of the factors contributing to global climate change and to identify clean sources of renewable energy. In 2007 the Intergovernmental Panel on Climate Change (IPCC) received worldwide recognition as a co-recipient of the Nobel Peace Prize for its acclaimed assessment of the causes, outcomes, and mitigation of global climate change. This outstanding organization attacked the issues within three different working groups: Basic Science Drivers; Impacts, Assessment and Adaptation; and Mitigation. Two of the researchers associated with this project, Charles W. Rice, Professor of Agronomy at Kansas State University, and Johannes

Feddema, Professor of Geography at the University of Kansas served on this panel and so have a strong appreciation and understanding of all of these issues.

Researchers in Kansas are also uniquely poised to carry out a comprehensive assessment of regional issues involving climate change and sources of renewable energy, which in the longer term can be extended beyond Kansas borders. The 2007 Kansas Economic Development Plan[4] and the Kansas Energy Plan 2008[5] recognized the important roles of both agriculture and alternative energy needs to the Kansas economy. *Thus this proposal, with its in-depth assessment and research into climate issues and renewable energy, fits well with the State's economic development and science and technology plans for the future.*

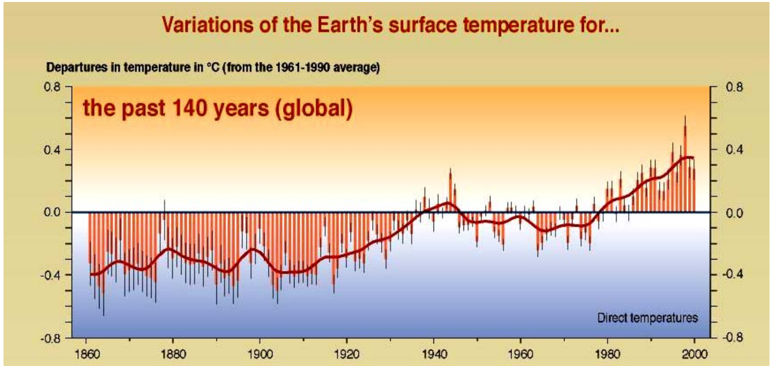

Figure 1. Global surface temperature variations from IPCC (Fig. 2-3).[10]

The Earth's global climate is determined by incoming energy from the Sun and by the properties of the Earth and its atmosphere. Changes have occurred in the atmosphere and surface that alter the global energy budget of the Earth and therefore cause the climate to change. *The total radiative forcing of the Earth's climate and the rate of increase are unprecedented in more than 10,000 years and are due to increases in the concentrations of* CO_2*,* CH_4 *and* N_2O.[10] In fact, global temperatures have been increasing over the past 150 years (*Fig. 1*). The International Panel on Climate Change (IPCC) stated that: "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level."[10] Moreover, according to the IPCC, most of the observed warming since the mid-twentieth century is very likely due to anthropogenic increases in greenhouse gas (GHG) emissions.

However, the impact of human-induced climate change is not restricted to temperature. Findings from an analysis of the past two millennia suggest that human-induced warming may greatly exacerbate future droughts in the central United States.[11] Thus, precipitation alterations are likely with much uncertainty about both the amount and direction of change. An additional concern is whether the nature of the statistical distribution of precipitation events may change; 20th century data suggests that an increase in more extreme events is ongoing, a trend that is expected to continue based on Global Climate model outcomes.[10] While much of the earth will receive greater precipitation, certain areas will receive less; Kansas is located at one of those transition zones. Even with greater precipitation, changes in temporal distribution and intensity could alter hydrologic cycles/soil moisture and thus impact natural and human systems.

Closely linked with climate change issues is the dependence of the world on fossil fuels for energy (*Fig. 2*). Finding sufficient supplies of clean energy for the future represents one of society's most pressing challenges.[12] Our energy demand, driven primarily by the world's population growth, is projected to double to about 30 Terawatts by 2050 and more than triple by the end of the century. The challenge to meet this demand cannot be addressed with incremental improvements in existing energy generation schemes.

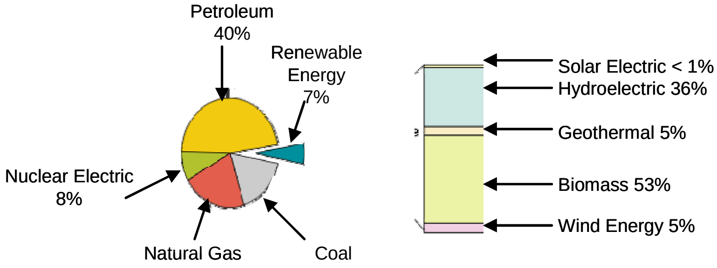

Figure 2. Percentage breakdown of current fuel sources.

Compounding this challenge is the growing need to protect our environment by providing clean energy sources. Technology breakthroughs and revolutionary developments are needed, and it is here that nanotechnology can play a pivotal role.[13,14] Sunlight is a compelling solution to our need for clean, abundant sources of energy in the future. Disappointingly, solar energy accounts for only ~1-2% of the current world's energy use. This includes solar electric, solar fuel (including biofuels and artificial photosynthetic devices), and solar thermal. The huge gap between our present use of solar energy and its enormous underdeveloped potential presents a grand challenge. However, by combining recent advances in two very relevant fields, biology and nanoscience, new technologies can be created using nanoscale design for the fabrication of energy materials and devices that rival the complexity and functionality of natural systems. The net result will be to increase the basic understanding of solar energy capture and conversion processes through photovoltaic devices and biofuels with high efficiency, low cost and minimal environmental impact.

An innovative, multi-institutional, and multi-disciplinary approach will be used to address the twin scientific challenges of renewable energy and global climate change. A versatile research team of agricultural engineers, agronomists, anthropologists, biologists, chemists, economists, chemical and civil engineers, computer scientists, geographers, mathematicians, physicists, and sociologists will carry out a comprehensive assessment of climate change and renewable energy issues. With this discipline-diverse workforce in place, the three-pronged approach used by the 2007 Nobel-Laureate Intergovernmental Panel on Climate Change will be employed (1) to lay a strong foundation of *basic science*, (2) to understand the *impacts* of climate change and energy needs, and (3) to provide *mitigation* pathways for a new and brighter future. The roadmap below (*Fig. 3*) shows the strategy that will take this project from the "grass roots" agricultural level in evaluating climate change in Kansas to opportunities for the more efficient utilization of biofuel crops and ultimately to harnessing solar energy through nanotechnology.

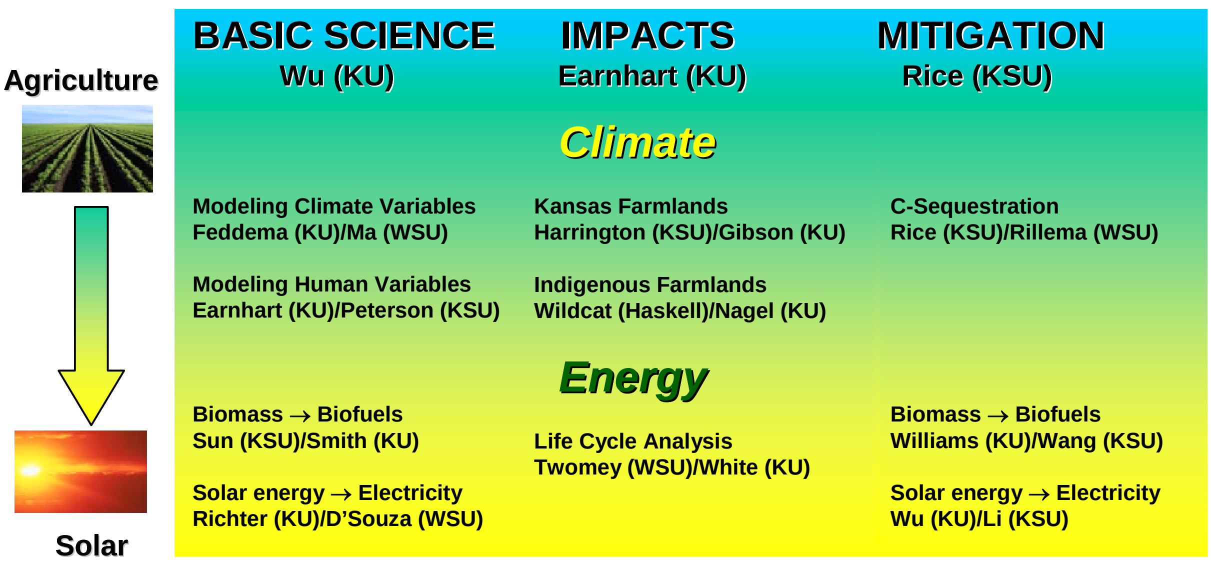

Figure 3. Roadmap for Climate and Energy: Basic Science, Impacts, and Mitigation.

The project is divided into three Working Groups: Basic Science, led by Judy Wu, Professor of Physics (KU); Impacts, led by Dietrich Earnhart, Professor of Economics (KU); and Mitigation, led by Charles W. Rice, Professor of Agronomy (KSU). Team Leaders for the subproject "Targets" are also provided in the Roadmap, each Target having two team leaders at different institutions. Together this comprehensive assessment of two interlocked global issues constitutes a single major, transformational research initiative.

Working Group on Basic Science

This Working Group will develop a deeper understanding of the fundamental basic science. It will provide a fundamental understanding of climate change causes and processes and the underlying chemical and physical principles in biomass and solar energy utilization.

Target 1. Modeling Climate Variables. Team Leaders: Feddema (KU), Ma (WSU). A number of human constructed and managed systems are based on the idea that the climate system fluctuates within an unchanging window of variability. This assumption of stationarity may no longer be valid.[15] In addition, while precipitation totals might increase in some areas, available water for plant growth might decrease due to greater evaporation and/or changes in precipitation intensity. *Unfortunately, results from climate models suggest that Kansas and the Great Plains lie in a zone of uncertainty in moisture response,*[16] *with wetter conditions to the east and increased dryness to the west and south of Kansas.* Given the location of Kansas within a region of significant transition in modeled climatic impacts, developing a better understanding for potential outcomes for the Great Plains requires development of more scale-appropriate climate models and/or statistical downscaling to understand the implications, mitigation opportunities, and adaptations that climate change will require of the residents of the Great Plains. Although a number of attempts have been made to evaluate the effect of human land cover change on the climate system, there is still significant uncertainty about the overall effect of combined human impacts on climate.[17,18]

The objective of the modeling group is to develop relevant climate change scenarios for Kansas and the central Great Plains for use by other groups participating in this project. Scenarios will be developed from the IPCC Fourth Assessment Report (AR4) Atmosphere-Ocean Global Circulation Models (AOGCMs) climate simulations.[10] Because precipitation is the limiting factor for most Kansas economic and ecological resource activities, these efforts will allow for a better understanding of potential changes to precipitation regimes across the state under different climate change scenarios. Our overarching objectives are to assess the joint variability and feedback mechanisms that exist among soil moisture, vegetation and regional precipitation, including (1) soil moisture and/or vegetation feedback on regional precipitation, (2) how seasonal rainfall and its timing differ under various climate change scenarios, (3) how the spatial distribution of precipitation, vegetation cover, and soil moisture will evolve as the climate changes, and (4) the implications for regional water and carbon cycling.

Aim 1. Meso-scale Modeling of Climatic Change. Coordinated observational and numerical modeling approaches will be employed. The observational effort will center on expanding an existing eddy correlation station network capable of measuring regional climate change scenarios spanning three different Kansas ecosystems: a woody encroachment site, a natural prairie, and a new site to be located in western Kansas in the vicinity of irrigated farmland. The modeling component of the study will comprise two approaches: statistical downscaling of AOGCM results for the Kansas climate system, and a regional meso-scale modeling methodology to represent in greater detail and fidelity the potential changes in the precipitation gradient across the state. Experiments will include simulations of different surface boundary conditions and atmospheric forcings based on Global Circulation Model (GCM) experiments.

In addition to addressing the immediate goals of the project, these efforts will expand the observational and modeling research infrastructure for the state of Kansas. Field studies that compare the impacts of irrigated surfaces on the local circulation and precipitation will not only validate our model studies, but will also enhance existing eddy-correlation network in Kansas with three distinct ecosystems being simulated. Downscaling methods that demonstrate the changes in precipitation regime across the strong precipitation gradient that defines the boundary between the wet and dry climates of the contiguous United States will also be evaluated. The goal of this part of the project will be to provide a detailed climate impact analysis of projected climate changes for Kansas that include changes in the water balance and its associated impacts on water resources and human systems and on the carbon cycle.

Aim 2. Statistical Analysis/Downscaling. Statistical and probabilitical methods and design-efficient computer algorithms will be used to characterize the present climate variability, and extreme events will be used to analyze the nature of the tails of climate variable distributions over Kansas and the Great Plains. As part of this analysis the process of data collection, dissemination, and analysis from large scale climate sensor networks and climate models will be optimized. Statistically-based spatio-temporal random field techniques will be used to capture climate variability, and to apply statistical downscaling methods to estimate fine resolution climate change information. These statistical models will provide better insight into the spatial and temporal variability of key climate variables under present conditions and will compare these to similar analyses using GCM data to guide future scenarios. By combining GCM results with statistical downscaling techniques, significant changes in climate variability or other abrupt changes in the system can be assessed. This work will provide background information that provides better estimates of the uncertainty of climate projections. Historical climate data will be used to collect and screen original comprehensive measurements of temperature, wind velocity, precipitation, and moisture in Kansas from measurement stations across Kansas from 1900 to 2007. These data will be used to perform extreme distribution analyses and to classify extreme weather events. The extreme values analyses will then be linked to extreme weather events such as heat waves, floods, and blizzards.

Spatio-temporal statistical methods will be used to link the frequency and intensity of extreme events to climate statistics in the historical records. This will include a sensitivity analysis to evaluate how this relationship has changed historically. From these relationships we can provide estimates of changes in extreme events from future climate projections from GCMs.

Space-time models for temperature and precipitation in Kansas from the historical climate records will be the major outcomes of this research. Daily high and low temperatures in Kansas, particularly extreme events such as 1) early season heat and its effects on wheat yield, 2) July heat for corn, and 3) heat waves for cattle and humans will be collected. A spatio-temporal model will also be developed for soil moisture. A major focus will be on developing spatio-temporal models to improve downscaling techniques for precipitation across the moisture boundary from eastern to western Kansas. We expect to produce an appropriate model to capture observed variability of precipitation from data networks and NEXRAD data.

Target 2. Modeling Human Variables. Team Leaders: Earnhart (KU), Peterson (KSU). Meso-scale modeling of climate change tells an essential part of the story. Research described in this section examines another essential, if often overlooked, aspect of climate change: the human dimension. Current research demonstrates how social networks and knowledge cultures shape farmer values and knowledge[19,20] which, in turn, guide decisions that alter land use.[21-23] Indeed, farmers are "independent environmental managers".[24] An interdisciplinary research team of economists, sociologists, anthropologists, geographers, and regional planners will examine how farmers understand and interpret science-based information about changing climate patterns and will explore how farmers make multidimensional decisions about land use. Understanding such decisions is essential if we are to develop policies that respond to changes brought on by global warming but, as importantly, in developing mitigation strategies that account for the economic and social factors that guide farmer decisions.

The driving factors behind farming land use decisions will be identified by examining the land use decisions made by Kansas farmers over the period between 2000 and 2012. Within this broad context of land use decisions, the focus will be on farmers' decisions to grow crops for renewable energy production (hereafter "biofuel crops"). This includes first-generation biofuels, such as corn-based ethanol, derived from traditional food and feed crops, and second-generation biofuels, such as switchgrass, which represent designated fuel crops and use cellulosic sources. While many factors drive land use decision, we propose to focus on: the availability of water; perceptions of sustainability with respect to both water and soil productivity; the loss in surface water quality created by the conversion of Conservation Research Program land and other lands held within similar government programs; presence and quality of social networks and farmers' values and histories; government policies that promote or restrain certain land uses (e.g., corn subsidies); and economic factors, such as food crop prices and biofuel crop prices. The project will involve the integration of various data sources, particularly three data sources on farmers' land use decisions (*Aims 1 – 3*). For all three data sources, information will be gathered over multiple years to explore the rapid changes expected in the agricultural arena, especially the market for biofuels.

Aim 1. Satellite Remote Sensing Data. Researchers will examine satellite remote sensing data on land use and land cover at the 250-meter resolution level for cultivation trends from 2000 to 2008. These data are extracted from the Moderate Resolution Imaging Spectroradiometer (MODIS 250) database and will provide the backdrop to document changes through the funded period of 2009-2012. The mapping accuracy of MODIS 250 of Kansas land use is 90%.[25-27]

Aim 2. Surveys of Farmers. A second research team will survey a disproportionate, stratified sample of farmers from across Kansas in three waves: 2011, 2012, and 2013. The initial wave of the survey will be accessed from the 2007 Agricultural Census from Kansas Agricultural Statistics. Moreover, six communities will be targeted based on our assessment of the trends in land use between 2000 and 2008 as provided by the MODIS 250 data. Prior to the first wave of the survey, 40 farmers will be interviewed in order to re-affirm the scope of our analysis and to field test the development of our survey instrument. In the initial wave, we will oversample these six target communities in order to generate a sufficiently large sub-sample in each community. At least one of these target communities will include Indigenous Peoples Land in Kansas, and will be closely coordinated with the student team working with Native farmers (see **Impacts**, **Target 2**). Our goal is to secure 340 completed surveys from each of the six target communities. From the rest of Kansas, our goal is to secure 460 completed surveys, for a total of 2500 surveys. For the second and third waves of the survey, we plan to concentrate exclusively on the six target communities. For each community, in both waves, 75 farmers from the initial wave will be tracked, for a total of 450 farmers. Surveys will be administered using mailed questionnaires, with mail and phone reminders.

Aim 3. Interviews of Farmers. A subset of the surveyed farmers will be interviewed face-to-face. In order to connect more strongly the interviews with the survey, we will interview farmers within the six identified target Kansas communities in two waves implemented in 2011 and 2013, with a three-month delay between the survey and interviews. For each community, our plan is to interview 36 farmers, for a total of 216 interviews in each of the two waves. By integrating these three data sources on land use decisions, a deep, longitudinal database will be developed that facilitates a rich depiction of land use decisions. These interviews will be tape recorded and transcribed. The research team will use computer aided qualitative data analysis to code and interpret findings. A major focus of this analysis is to reveal the meaning systems and causal mechanisms behind farmer judgments revealed in the changes in land-use and survey.[28]

Aim 4. Integration of Data Sources. Working together across research teams, qualitative and quantitative data on farmers' perceptions of sustainability, the presence and quality of social networks, farmers' values and histories, and farmers' expectations over future developments in the markets for biofuel crops will be integrated with land use data. With these integrated data sources, the research team will develop and estimate empirical models of farmer household decisions that integrate sociological phenomena, especially social networks and farmer values, into our understanding of economic decisions. The results of these studies will be coupled with those obtained by examining the driving factors behind farming land use decisions made by Kansas farmers over the period between 2010 and 2012.

Target 3. Biomass Utilization by Materials Design. Team Leaders: Sun (KSU), Smith (KU). Recent legislation has called for this nation to annually produce 36 billion gallons of renewable fuel by 2022 to help address concerns over climate change and energy security. The production dilemma between biofuel and food has also become acutely important. Therefore, conversion of aquatic biomass into biofuels offers major economic, environmental, and strategic benefits. Algae biomass were initially considered as a potential replacement fuel source for fossil fuels in 1970s, but was eliminated in 1990s due to prohibitive production costs and the challenges of commercial development of algae-based fuel production. To date, the main challenge of using algae for biofuels is the high cost associated with algae oil production, which is partly due to the lack of effective technologies for algae cell disruption, drying, oil extraction, and residue utilization. Developing environmentally friendly chemicals and polymers from algae residues as co-products would significantly sustain algae biofuel production.

Aim 1. Bionano Switches. The efficiency of the conversion of algae carbohydrates to sugars will be improved utilizing glycozymes with bionano switches. We recently developed an improved EcR gene switch that showed lower background in the absence of an inducer, increased sensitivity, a higher magnitude of induction upon addition of the inducer and activity in a variety of plant species (Arabidopsis, tobacco and soybean, and possibly for Algae) by adopting a two-hybrid format (*Fig. 4*). There are three tasks in this aim: 1) produce and optimize transgenic algae expressing lignin peroxidase (*LIP*) from *Phanerochaete chrysosporium,* the cellobiohydrolase gene (*CBH1*) from *Trichoderma reesei,* and endo-β-1,4-glucanase (E1) from *Acidothermus cellulolyticus*, under the control of a highly sensitive, tightly auto-regulated EcR gene switch; 2) analyze changes in cell wall morphology and polymerization as a consequence of LIP, CBH1, and E1 presence, tempering time, pretreatment and enzymatic hydrolysis; and 3) convert transgenic algae into fermentable sugars at various pretreatment conditions.

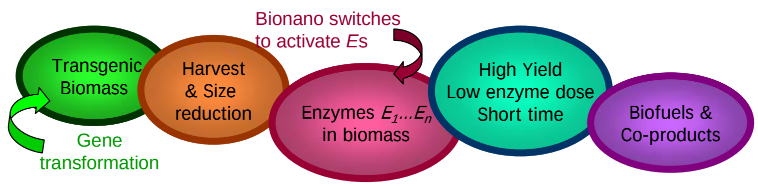

Figure 4. Schematic description of bionano switches.

Aim 2. Functionalized Nanocatalysts. Functionalized nanocatalysts will be designed and synthesized. The interface between the nanocatalysts and cellulose will then be studied to improve conversion efficiency of algae carbohydrate to sugars for fuels and chemicals. There are four tasks in this aim: 1) synthesize and characterize acid-functionalized nanoparticles designed to be efficient lignocellulose hydrolysis catalysts; 2) elucidate the role of acid site strength on lignocellulose hydolysis; 3) develop novel, separable catalysts for hydrolysis of lignocellulosic materials; and 4) study the hydrolysis mechanism at the interface between nanoparticles and the cellulosic surface.

Naturally occurring hydrolysis enzymes are composed of three parts: a catalytic site, a cellulose-binding domain, and a linking region.[29] The proposed novel artificial catalyst is composed of three parts: a magnetic core, a mesoporous silica coating on top of the core, and acidic groups grafted onto the silica. The magnetic core allows easy separation following hydrolysis through the use of a magnetic field. The silica coating provides silanol groups that may enhance interaction with crystalline cellulose through hydrogen bonds. This coating can also be easily be functionalized with hydrophobic groups (such as vinyl groups[30]) to modify the interaction of the acid-functionalized nanoparticle with cellulose and with acidic groups that will catalyze hydrolysis. The acid groups will include carboxylic and sulfonic acids, allowing the acid strength to be tailored to allow cellulose hydrolysis without subsequent degradation of sugars. Nanoparticles like Fe_2O_3 have previously been synthesized and used to catalyze the deprotection reaction of benzaldehyde dimethylacetal.[31,32] Synthesized nanoparticles will be characterized by infrared spectroscopy, Raman micro-spectroscopy, transmission electron microscopy, x-ray photoelectron spectroscopy, and titration to determine their acidity. They will be used to hydrolyze model compounds (cellobiose and cellulose), for pretreatment of lignocellulose, and to hydrolyze pretreated lignocellulose. The sugar concentration, byproduct formation, and structure of cellulose and lignocellulose will be studied following hydrolysis or pretreatment.

Target 4. Solar Energy Utilization by Materials Design. Team Leaders: Richter (KU), D'Souza (WSU). The proposed research addresses the solar energy harnessing challenge by synergistically bridging the recent advances in the two most relevant fields, biology and nanoscience, to create new technologies with the ultimate capability of nanoscale design and fabrication of energy materials and devices rivaling the complexity and functionality of natural systems. The overarching scientific goal of this Target is to develop new basic knowledge about the energetics and functional properties of natural and artificial photosynthetic complexes and to use this knowledge to create more efficient photovoltaic cells. The photovoltaic (PV) solar cell (SC) is currently the dominant technology for converting solar energy into electricity. The key critical issues are low efficiency and high cost and will be addressed via development of new materials and novel concepts of devices inspired by natural photosynthesis to reach unparalleled energy conversion efficiency at low cost.

The goals of this Target are to 1) create new inorganic and hybrid inorganic/organic platforms with markedly enhanced solar energy capture efficiency; and 2) create engineered biosystems with improved capacity for energy capture and conversion to biomass. The project strongly emphasizes interdisciplinary team research in the following five major task areas: (a) excitation energy transfer (EET); (b) electron transfer (ET); (c) electron migration; (d) photocatalysis and e) energy storage and transformation.

Aim 1. Natural Photosynthetic Processes. This aim focuses on the study of natural photosynthetic processes in plants and microbes from the standpoint of creating biomimetic systems and engineering plants and microbes for improvement in light harvesting efficiency leading to increased biomass. Studies will focus on electronic structure, EET and ET processes of Photosystems I and II (PSI and PSII) complexes of higher plants obtained under different illumination conditions and/or nutrient supply. Spectral hole burning (SHB)[33-35] and single photosynthetic complex spectroscopy (SPCS) will be used to study the Qy-excited state electronic structure, EET, and ET dynamics at low-temperature.[36-40] In addition, a combination of site-specific mutation, chemical cross-linking, and single molecule fluorescence spectroscopy will be used to identify the dynamic process of non-photochemical quenching by which overall photosynthetic efficiency is balanced against over-excitation leading to photodamage. This process is governed by the magnitude of the proton motive force across the photosynthetic membrane.

Aim 2. Solar Energy Capture by Nanocomposites. The goal of this aim is the fabrication and analysis of nanocomposite (wholly artificial) solar energy capture systems including polymer-based nanoparticle composites, ruthenium complexes and thin film materials. Exciton dynamics in organic/inorganic composite thin films will be examined by near-field scanning optical microscopy (NSOM), ultrafast and terahertz spectroscopy[41,42] and hole-burning spectroscopy.[33-35] This work will focus on charge separation and migration in composite materials including CdSe and CdTe quantum dots dispersed in thin films of semiconducting polymers (i.e. polythiophenes).[43-46] The NSOM imaging knowledge acquired by our groups[47,48] will be employed for initial investigations of the spectroscopic, morphological and organizational properties of these composites.

Aim 3. Hybrid Photosynthetic Materials. The goal of this aim is the fabrication of bioinspired/biomimetic broad band energy capture systems for artificial charge-separation, donor-acceptor assemblies, and fabrication of hybrid photosynthetic materials. Using porphyrins and phthalocyanines as electron donors, and fullerenes and carbon nanostructured materials as electron acceptors, innovative architectures coupling light-harvesting, photoredox, and photocatalytic components will be constructed (*Fig. 5*).[49-52] Transient and persistent hole-burning spectroscopy,[33-35] time-resolved emission and transient absorption studies will be performed to understand 1) the relationships between electronic communication and the molecular interactions within the supramolecule, and 2) to probe photoinduced electron transfer leading to long-lived charge separated states. The work will lead to construction of nanocomposite materials in which functional biomolecules are integrated with non-biological structures including carbon nanotubes and other photovoltaic materials.

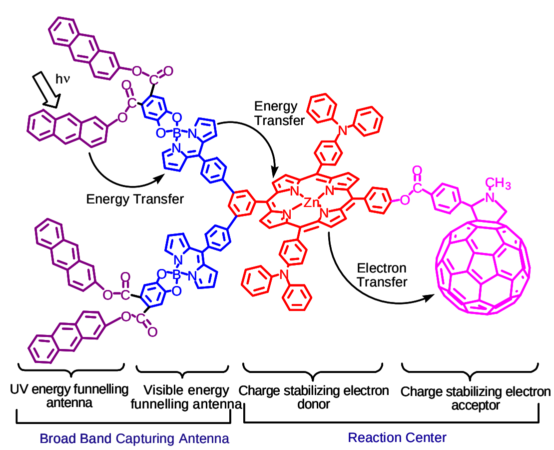

Figure 5. Biomimetic photosynthetic reaction center.

Aim 4. Novel Physics for Multiple Carrier Excitation. Another aspect of this part of the project will be multiple carrier excitation in nano-crystals for high efficiency third generation SCs. Impact ionization with quantum efficiency up to 7 has been reported in nano-crystals.[53] Using nano-crystal structures in SCs, the power conversion efficiency can potentially be increased over the theoretical limit.[54] There is an urgent need to study the impact ionization and carrier dynamics in order to identify the limiting factors and to find out solutions. We will use our recently developed ultrafast laser techniques to study impact ionization and carrier dynamics in PbSe and Si/SiO_2 quantum dots. Carrier dynamics with high spatial and temporal resolutions (1 nm and 100 fs)[49] in *single* quantum dots will be investigated for the development of new materials and optimization of the design and fabrication of novel SCs by taking advantage of multiple carrier excitation.

Working Group on Impacts

Impacts, assessment and adaptation data on both climate and renewable energy will be collected within this Working Group. The recent Climate Change Science Program (2008)[55] identified key questions regarding climate change and land resources: 1) What factors influencing agriculture, land resources, water resources, and biodiversity in the United States are sensitive to climate and climate change? 2) How could changes in climate exacerbate or ameliorate stresses on agriculture, land resources, water resources, and biodiversity? What are the indicators of these stresses? Based on these questions we have two study targets, climate change and integration of renewable energy sources.

Target I. Kansas Farmlands. Team Leaders: Harrington (KSU), Gibson (KU). Improving our understanding of climate change impacts on natural and human systems is a major objective of this part of the proposal. By focusing on the agricultural sources, it leads naturally to a better understanding of the energy impacts of agriculturally derived biofuels. Given the amount of private land holdings in Kansas, it is critical that we obtain improved information on human decision making in response to the multiple drives of change. Local vulnerability to change will be assessed using the IPCC ‘three component’ vulnerability conceptualization that addresses exposure, system sensitivity, and local adaptive capacity. We will obtain knowledge from local stakeholders regarding vulnerability to change through interviews and surveys. Results from water budget modeling will allow us to provide stakeholders with locally relevant information on possible changes in soil moisture and the extent of moisture deficit periods. Water budget modeling on a daily time step and with local soil water holding capacity will greatly assist communication with stakeholders.

Aim 1. Impacts on agricultural ecosystems and adaptation: In this aim climate impacts on native and agricultural ecosystems using crop measurement, remote sensing methods, and crop modeling scenarios will be assessed. Remote sensing contributions will include an improved ability to assess changes in land cover and varying agricultural land management practices. We will continue to improve and verify remote sensing indicator statistics, such as the Normalized Difference Vegetation Index (NDVI), for monitoring change in the landscape. Land cover has an impact on the local expression of climate change and climate changes will likely impact native and human-constructed land cover/uses. We will examine how climate change and Land Use and Climate Change (LUCC) combine to impact water use, especially irrigation from the High Plains aquifer. Anticipated changes in LUCC will also be used to characterize changes in ecosystem services and biodiversity.

Climate variability and change will affect both the productivity of crops and available water resources. An improved understanding of past climate variability and observed crop yield changes, combined with improved probabilistic forecasting will help management decisions at individual farm or regional levels. We will conduct a critical analysis of past climate change and climate variability (extreme events) and long term county level crop yield data. Crop simulation models will be linked to the climate scenarios to better understand the impacts of potential climate variability on crop yields.

A number of outcomes of this research will provide valuable information for the future planning. Stakeholder-relevant vulnerability will be assessed. The development of water budget scenarios of how climatic change will impact moisture surplus and deficits within the region and communication of implications will also help meet local stakeholder needs. Other outcomes will be updated measurements of vegetative response to climate variability and change; development of improved/appropriate remote sensing technologies to monitor impacts of climate change on Kansas natural resources and land use; improved crop modeling that addresses local and regional impacts of climate change: assessment and use of simulation models in aiding management decisions; development of regionally relevant land use and cover change scenarios, an assessment of feedbacks and impacts of LUCC on water resources, irrigation, ecosystem services, and biodiversity; and last but not least the development of a spatially-explicit understanding of variations in local sensitivity and adaptive capacity to climate variation and change.

Aim 2. Farmers' Land Use Decisions. This research will provide valuable information for understanding the potential for adaptation in response to global climate change within the US agricultural sector. To deliver this information, our analysis proposes to assess how the unprecedented context of climate change influences land use decisions. Data will be generated on hypothetical future land use decisions by incorporating into our survey instrument vignettes that prompt the surveyed farmers to consider alternative climate contexts (e.g., more precipitation in winter months but less in summer months). Farmers will be instructed to select a land use option (e.g., increase cultivation by 10%). These data on hypothetical land use decisions supplement our household-level information on farmers' actual land use decisions.

Target 2. Indigenous Farmlands. Team leaders: Wildcat (Haskell), Nagel (KU). In coming decades, farmers across the U.S. will seek research findings to help them grapple with the varied effects of climate change. This is especially true for indigenous farmers who often combine traditional and commodity crop agriculture and livestock production, and many of whom subsistence fish and hunt on native lands. There has been little systematic research on the impacts of climate change either on specific reservations or across the many and diverse social, cultural, economic, georegional, and ecological systems in Native America (for exceptions see Hanna's[56] and Krakoff's[57] comparison of legal and policy approaches climate change impacts on tribes in four regions: Florida's Everglades, Alaska, Desert Southwest, Pacific Northwest). This project will begin to address the gap in knowledge needed by tribes to assess climate models' predictions for indigenous communities and to develop strategies to respond to climate-related events and changes.

REU tribal college students will acquire the skill set needed to combine scientific and traditional knowledge about the history of climate and the trajectory of climate change in reservation lands. They will use the facilities at Haskell's GIS lab to learn to access datasets gathered by a variety of remote sensing techniques and to analyze remotely sensed data on Native communities of interest to them. They also will learn oral history data collection and analysis and survey research techniques to conduct "local sensing" studies of climate changes in tribal communities by interviewing Native farmers, traditional medicine practitioners, and tribal elders. By combining remote and local sensing data, REU students will develop unique datasets for a number of reservation communities; these data can be added to and evaluated by other researchers and by REU students as they pursue advanced degrees.

In an effort to respond to this gap in knowledge, the Smithsonian Institution's National Museum of the American Indian has begun a website listing Native environmental research and advocacy organizations (International Institute for Indigenous Resource Management, Native American Environmental Protection Coalition, National Tribal Environmental Council). There are only a half-dozen organizations listed and most of these were founded in the last decade, and are dedicated not to research, but to network-building, conferences, and providing information about US government programs and policies of interest to Native communities.

Target 3. Life Cycle Analysis. Team Leaders: Twomey (WSU), White (KU). Our approach to innovation in renewable energy is to team fundamental scientists working in biofuels with scientists working in solar electric conversion. As the intellectual issues are probed more deeply, considerable overlap in basic needs for knowledge is evident, especially in the fundamentals of multiphoton gathering steps. Also, we propose that solar-electric devices should be coupled with bioengineering in order to store solar energy, for example, to enhance nighttime production of algae for higher efficiency production of biofuel feedstocks.

Aim 1. Assessing the Importance of Biofuel Crops. We propose to assess the importance of biofuel crops in the State of Kansas. First, by scrutinizing the MODIS 250 data on land use / land cover, we propose to establish the current cultivation of biofuel crops as of 2008, identify the preceding trend of cultivation between 2000 and 2007, and measure future cultivation from 2009 to 2012. Second, we propose to examine three specific land use decisions relating to biofuel crops: (1) to switch from food crops to biofuel crops; (2) to switch from no crop cultivation to biofuel crop cultivation, especially the conversion of conservation programs land; and (3) to expand the cultivation of biofuel crops. Third, our analysis proposes to assess how changes to the reasonably new market for biofuels affect land use decisions. Specifically, we propose to generate data on hypothetical future land use decisions by incorporating into our survey instrument vignettes that prompt the surveyed farmers to consider alternative biofuel market contexts (e.g., 50% increase in the switchgrass price) and then instruct the farmers to select a land use option (e.g., increase cultivation of a biofuel crop by 10%). Fourth, to complement our analysis of household-level land use decisions to grow biofuel crops, we propose to examine the cultivation of biofuel crops on a county scale using publicly-available government sources.

Aim 2. Environmental Impacts and Benefits. We also propose a holistic approach in analyzing environmental benefits and impacts. How will solar energy be most efficiently used in the life cycle of engineered plants and their conversion to biofuels compared with artificial solar-electric generation and transmission? Will it be most efficient and with the least harmful environmental impacts to tightly couple these technologies? Only a holistic approach will give us the answer to these questions. Also, since nanotechnology will be important, especially in improved solar-electric devices, environmental basic science, concepts, and knowledge of the interactions of the chosen nanomaterials with the ecosystem must be continually assessed; indeed, the choice of nanomaterials and their large scale manufacture must be considered early-on in the research and development.[58-63]

While the benefits of biofuels are important, society must also appreciate the trade-offs associated with the cultivation of biofuel crops, including the loss of water available for other uses and loss of surface water quality polluted by agricultural runoff. Based on our quantitative empirical assessment of actual and hypothetical land use decisions, we propose to predict the expected impacts on groundwater use and surface water quality due to future land use decisions as derived from likely future scenarios (e.g., increases in crop prices), while placing these impacts in the context of current water conditions.

Working Group on Mitigation

This Working Group will examine the applied/engineering aspects of the project that address the pressing question of how to reduce global climate change and in the process design clean sources of renewable energy. Results from the Basic Science Working Group and a better understanding of the short and long term impacts from the Impacts Working Group will provide foundations for this Working Group.

Target 1. C-Sequestration. Team Leaders: Rice (KSU), Rillema (WSU). Soil C sequestration and reduction in N_2O emissions are the most cost effective and feasible short-term options to mitigate the increasing atmospheric CO_2 concentration.[10, 64-66] In agriculture, strategies to increase soil C include higher biomass input through improvement of the cropping systems.[64,67-70] Carbon stabilization and sequestration in soils is mediated by soil biota, structure, texture and mineralogy and their interactions, and also by land management.[71] Complex interactions among different ecosystem control mechanisms make it difficult to accurately estimate the potential limit for C sequestration. Warming may reverse soil C storage and aggregation; therefore understanding mechanisms is needed to assess the vulnerability of soil C in the light of climate change. Previous work by the research team and others has identified the critical factors needed to understand the terrestrial C cycle and other Earth system processes including: current and past land cover; historic land use practices; net primary productivity; and crop and grassland productivity.

Aim 1. Quantification of C cycle and Earth system processes. Our approach will build on the previous work as a baseline to quantify the effect of C cycle and other Earth system processes on GHG emissions and will provide reduction. At present, such analyses contain a large margin of error because of complexities associated with projecting and verifying C and N emission and sequestration rates even at local to regional scales. This research effort will generate improved quantification of biogeochemical fluxes that will assist in developing adaptation, and/or mitigation strategies. Adaptation strategies include short-term tactical crop and soil management decisions.

The complex interactions of different mechanisms of C control in ecosystems makes it difficult to accurately estimate the potential limit to C sequestration. Also, climate change may reverse soil C storage and aggregation; therefore an understanding of the mechanisms is imperative to understanding the vulnerability of soil C and aggregate structure in the light of climate change. Thus this group will 1) investigate the relative contributions of chemical and biological mechanisms to aggregation and soil C protection and 2) determine the feedback effects of climate change on the vulnerability of the protected carbon.

Aim 2. Soil and Aerosol influence on Global Warming. This group will investigate the interrelationships among soil physical, chemical, and biological characteristics and soil processes on GHG and aerosol emissions. We will employ new sensor and measurement technologies to enhance our understanding of the biological, biogeochemical, and physical processes involved in GHG and aerosol sources from agriculture and provide mitigation options.

These studies promise to provide advances in understanding local GHG and aerosol fluxes in order to properly assess the local contribution to global warming potential and to target mitigation strategies. Furthermore, possible management (adoption or mitigation) strategies to minimize impact of climate variability and change on stability and productivity of crop yields will be identified. As a result, these studies will provide critical information for decision/policy makers to device long-term strategies to cope with climate variability and change and will ultimately result in a portfolio of scientifically sound adaptation and mitigation strategies for Kansas and the Great Plains.

Aim 3. Land Use and Mitigation. Within the context of mitigation through sequestration, an understanding of land use and land cover is critical to assessing C sequestration and emission reductions. Our proposed research promises to deliver valuable information on past, current, and future land uses and covers. First, the MODIS 250 data provide rich information on past and current land uses and covers over the period 2000 to 2008. Second, by integrating three data sources on land use – satellite remote sensing, surveys, and interviews – we propose to develop a deep, longitudinal database that facilitates a rich depiction of land uses and covers over the period 2010 to 2012. Third, an examination of the actual and hypothetical land use decisions promises to facilitate the generation of more accurate predictions of regional future land use, including those based on policy scenarios, since our results are based on a richer understanding of farmers' decision-making processes and draw upon responses that consider climate conditions that lie beyond the current range of conditions.

Aim 4. C-Sequestration by Materials Design. A second study will involve development of composite materials for the photoconversion of both CO_2 and water into fuels such as hydrogen and methanol using solar energy. Hydrogen production by water splitting using visible light at nanoparticle interfaces and by ruthenium(II) quaterpyridinium complexes as *sensitizer-relay-assemblies* (SRA's) in sacrificial systems for water will be explored. (Quaterpyridine and quaterpyridinium ligands are noted for interesting self-assembly properties.)[72] Recent advances in CO_2 activation using low-valency Mo and W compounds containing ethylene has resulted in the preparation of coordinated acrylic acid by insertion of CO_2 into ethylene.[73,74] The barrier to removal of acrylic acid from the coordination sphere may be circumvented by photochemical excitation where population of the d-d excited state weakens the bonding between the metal center and the ligand resulting in ligand lability. Successful catalytic production of acrylic acid, used in excess of 50,000 metric tons per year,[75] would represent a significant achievement.

Target 2. Biomass → Biofuels. Team Leaders: Williams (KU), Wang (KSU). This research will address the challenges in clean biofuel by developing an innovative, high-yield, low-cost system for oil extraction from algae and residue utilization. Besides oil, algae naturally contain both proteins and carbohydrates as main residues. The goal of our research is to make algae a sustainable biomass feedstock for biodiesel, bioethanol, polymers, and chemicals.

Aim 1. Optimizing algae growth. This aim will integrate ecological and physiological approaches to optimize algae growth conditions and characterize algae oil yield and quality. First a physiological approach will be applied to algal growth, investigating the growth conditions that maximize daily lipid production. The lipid and non-lipid portion of algal suspensions will then be characterized in order to identify commercially viable co-products. Biodiesel will be produced from algal lipids and the resulting fuel properties will be correlated to lipid profiles. Finally field algal ponds will be operated in order to investigate ecological competition within these growth systems.

Aim 2. Increasing biorefining efficiency. In this aim a high-efficiency, low-cost algae biorefining technology will be developed for fuels and chemicals. Oil body distribution and association with the protein matrix in algae cells will be studied. The mechanics of algae cells disruption will be investigated and an innovative highly efficient wet-milling technology for algae cell disruption will be developed. Solvent flow diffusion in and out of algae cells will also be investigated and a high-yield and low-cost system for oil extraction from concentrated algae biomass will be developed that can be scaled up utilizing existing oil extraction facilities. Algae protein solubility will be determined to develop cost effective method for separating proteins from carbohydrates. Subsequently we will characterize the physical, chemical, and structural properties of algae proteins and develop functional protein polymers and chemicals with potential applications for adhesives, surfactants, coatings, and smart materials.

Target 3. Solar Energy → Electricity. Team Leaders: Wu (KU), Li (KSU)
*Aim 1***:** *Nanoengineered PV Technology.* The goal of this aim is to utilize nanoengineered PV technology to reduce cost and improve performance. Photoelectrochemical (PEC) PV using dye sensitized TiO_2 nanoparticle (NP) films is the most successful wet chemical method to convert sunlight into electrical energy (up to 15% efficiency),[76] but limited by the slow random walk carrier diffusion through the NPs. NW arrays.[77,78] Vertically aligned nanowires (NW) arrays have been explored to improve the charge transfer and dye regeneration, but are still limited by the inherently low conductivity and the small aspect ratio of the NW materials. We will explore a novel nano-architecture supported by high-aspect ratio vertically aligned carbon nanofibers (VACNF)[79,80] which is coated with a thin TiO_2 layer for dye sensitized SCs. This architecture will be combined with thin layers of molecular multi-junction or quantum dots for higher conversion efficiency. Current organic PVs are limited by the low carrier mobility, short exciton diffusion length (3-10 nm), uncontrollable active layer morphology, and poor chemical stability. Network bulk heterojunction (BHJ) is the most promising architecture to solve these problems.[81,82] We will use VACNF to support an ordered BHJ for polymer PVs. We have already been able to demonstrate conformal electrochemical coating of PPy and PEDOT with strong $\pi-\pi$ stacking on the graphitic sidewall of CNFs.[80] Enhanced surface area and charge carrier mobility will be investigated.

Aim 2. Nanostructured PV Technology. One of the major challenges in achieving high efficiency nanostructured PV cells is to develop multiple energy-band designs so as to cover most of the solar spectrum, instead of the narrow band in current schemes. These broad-band nanostructured PV cells will combine the advantages of low cost in 2nd generation and the high performance of the 3rd generation PV cells. Engineered nanostructures such as <u>*NW core/shell structure*</u> *of multiple bands* may provide novel route for high efficiency broad-band nanostructures *by* reduced radial charge separation across the junction and decouple the requirements for maximum light absorption and efficient carrier extraction.[83] The radial distance can be made comparable to the minority carrier diffusion length, which will dramatically reduce bulk recombination. Since NWs can be pre-fabricated and then transferred to inexpensive substrates such as glass and plastics, allowing decoupling of the requirement of high processing temperatures for most semiconductors and the incompatibility of many substrates with such temperatures. We will focus on $In_{1-x}Ga_xN$ NWs and TiO_2/CNF, which allows the band-gap to be tuned from infrared to UV by either varying Ga content[84,85] or via attaching quantum dots and dyes.[86] Our approach is to layer-by-layer design core-shell NWs SC devices based on the fundamental physics and understand the dynamics of photons and electrons using a unique single NW device scheme.

Aim 3: Combining Photovoltaics with Thermoelectric. This part of the project will entail the design and optimization of electricity production with an integrated solar concentrator system employing photovoltaics and thermal energy. In current PV-based solar systems, more than 60% of the total input solar energy is wasted as heat which can be partially recovered using thermal-electric converter (TEC).[87] One possibility (see *Fig. 6*) is to have a thermal diode based on *p-n* junctions monolithically integrated on the back of a PV cell. 10% to 15% improvement in the overall power efficiency is possible with this approach. The high input energy flux needed for a practical PV-TEC system can be achieved using optical concentrators. The modularity of PV-TEC systems makes them appropriate for large solar collection farms as well as roof-mounting on residential units. The novel device concepts for solid state thermal-electric conversion (TEC), the fundamental material and device physics for p-n junction based thermal diodes, and the manufacturing platform for both PV and TEC devices will be investigated.

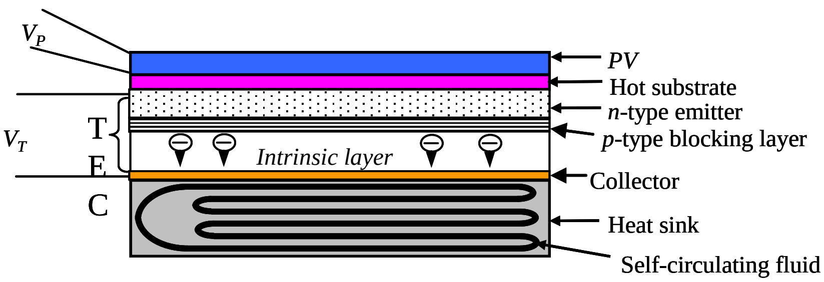

Figure 6. Layer design of a photovoltaic-thermal electrical converter (PV-TEC)

D.4. Diversity Plan

There are many aspects of diversity inherent in this proposal. There is institutional diversity with the three major Regents universities within the State participating in all aspects of the project. Additionally for the first time, a Tribal College, Haskell Indian Nations University, will play a major role both within the scientific scope of the project as well as in Workforce Development. There is also an unusual breadth of disciplinary diversity, possibly unlike any previous undertaking in the State.

The current state of both gender and race/ethnicity in the three State institutions involved is that the numbers of women are increasing: undergraduate - 50%; graduate - 50-60 % (social sciences) and 30-40 % (natural sciences with slightly less in engineering); faculty - 40-50 % (social sciences) and 20-25 % (natural sciences, less in engineering). With the exception of Haskell, the statistics for race/ethnicity are considerably less: undergraduate – less than 15 %; graduate - less than 10 % (with a higher percentage in social sciences); faculty – less than 5 %. Haskell's student population is virtually 100 % Native American, and there is hiring preference for Native Americans that comes from the Wheeler-Howard Act (Indian Reorganization Act) of 1934.[88] This means that approximately 75% of the faculty are Native American.

A significant focus on individual diversity, including gender, race (primarily Native American from Haskell and other Tribal Colleges), and other underrepresented groups (from the McNair Program) is a target of this proposal. The presence of the McNair and tribal college students and Native American faculty will provide a friendly environment for attracting additional diversity to the program. The research team leaders include both women and men, of whom one is Native American. Women and men also make up the Governing Committee, which includes an African American and a Native American.

The plan is to continue in an active recruitment mode to enlist other underrepresented groups at all levels. Targeted are Tribal Colleges, the McNair program, and other programs such as the Summer Research Opportunities (SUROP) program at KSU. This latter initiative brings minority undergraduate students to campus each summer. More information about Diversity is including in the Workforce Development Plan, D.4 below since a major effort of this project is to leverage talent for the future by training a more diverse workforce.

D.5. Workforce Development

The training of students is a major component of this project. As with most funded research projects training at the undergraduate, graduate, and postdoctoral levels will occur. This project will provide additional breadth, however, to participating students, since there is such a gamut of disciplines involved. The University of Kansas has just received the first NSF IGERT grant ever to come to our State as described in greater detail below. However, in addition to the more normal avenues for workforce development, two initiatives will target two different underrepresented groups. The first of these is part of the ongoing McNair Scholars Program, which provides funds to underrepresented and disadvantaged students. The second is a “Career Pathway” initiative that will first target the Native Americans, but which can act as a prototype for other initiatives targeting other underrepresented groups.

Aim 1. McNair Program. The objective of this program is to assist students who are members of underrepresented groups by providing research opportunities and encouragement in pursuing graduate school and careers requiring advanced training in the Science and Engineering disciplines. With this goal in mind, it is the program’s intention to fully prepare participants for graduate school and to provide them with opportunities to conduct studies and research in the laboratories of faculty members disciplines related to the Climate and Energy project of Phase VI of Kansas NSF EPSCoR. The eight week research program will be coordinated by the McNair Scholars Program at the University of Kansas, Kansas State University, and Wichita State University and so includes research opportunities at all three of the major research institutions in the State.

Each year six students will be recruited from NSF EPSCoR jurisdictions (not necessarily Kansas) and selected for participation in the summer research internship. Requirements will include a strong grade point average, evidence of ability to conduct independent research, and intent to pursue a career in science, engineering or mathematics. Students selected for participation will be members of underrepresented groups as defined by NSF. The Kansas McNair Scholars Programs will be responsible for providing the EPSCoR students with a variety of activities and support as they participate in the eight week summer research internship including GRE preparation sessions, weekly colloquia and research seminars, individual advising with McNair staff, and writing consultation sessions. Providing these activities to the EPSCoR students will give them a social support network and the structure needed to complete a rigorous research project. The EPSCoR students will also be offered the opportunity to attend and present their research findings at McNair conferences, including Heartland Research Conference in Kansas City, Missouri in September.

Aim 2. Pathway to Careers. The location of their homelands in arctic and coastal regions, on the Great Plains, in the desert Southwest places Native American communities especially vulnerable to the effects of climate change, but also especially well-positioned to develop alternative energy sources such as wind and solar energy. This proposal addresses both the challenges and opportunities of changing twenty-first century climate and energy landscapes by a plan for transforming the model for developing the Native American science and technology workforce. We do not propose simply to recruit Native students into existing programs in 4-year colleges and universities, an approach that has not proved very successful for Native student degree completion. Instead, we propose to build a pathway from high schools to higher education in STEM disciplines, a strategy that takes advantage of the growing numbers and capacity of tribal colleges which will serve as stepping stones for Native students on their way to careers in science and technology.

Haskell Indian Nations University is uniquely situated as an important stop on this education and workforce development pathway. Unlike its roughly 30 sister tribal colleges, Haskell has a diverse, nationally-recruited student body and faculty representing more than 100 American Indian tribes. Native students are attracted to Haskell because of its long history and national prominence in Indian education (as its letterhead proclaims: “Haskell…the most recognizable name in Indian Country”). Haskell has the education and technical resources to provide STEM training in a supportive inter-tribal setting since it is at the center of a network of science professionals working in tribal colleges and its students have access to advanced scientific infrastructure on campus and through its partnership with the University of Kansas.

The proposed STEM workforce development pathway for American Indian and Alaska Native students will focus on Haskell's environmental science curriculum and its established GIS lab (built in collaboration with KU's NSF STC, CReSIS. The pathway plan encourages Native students from two-year tribal and community colleges to proceed to four-year tribal and non-tribal institutions, and to go on to Master's-level programs to PhD degrees, leading to STEM careers (*Fig. 7*).

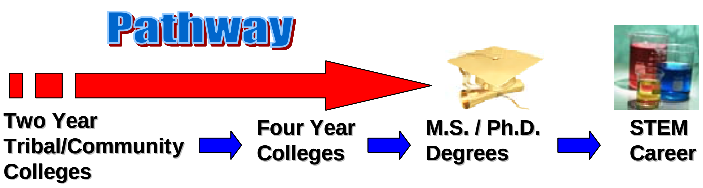

Figure 7. Pathway to careers in science and technology for Native Americans.

The pathway starts with a series of summer REU programs for tribal college students, our program will mark a course from reservation and urban Indian communities to Haskell Indian Nations University and on to the University of Kansas and other graduate institutions and ultimately back to reservation communities and Indian-serving institutions and organizations. Native students traveling on this path will attend summer climate change institutes at Haskell focused on climate change in Indigenous communities. During the summer Research Experience for Undergraduates (REU) programs undergraduate students will acquire a set of geoscience, bioscience, and social science skills needed to map the nature and consequences of climate change on native lands. Successful REU climate change institute students will be invited back a second year to serve as mentors for incoming students and to refine their research projects. Native students graduating from Haskell or other 4-year institutions will have an opportunity to pursue MA and PhD training at KU and K-State through graduate research and teaching assistantships. Tribal college faculty who are supported as mentors in the summer institute REUs and/or who are working in climate and energy-related fields and who have not completed their terminal degrees also will be eligible for graduate RA and TA funding. This program will be in collaboration with the University of Kansas NSF IGERT program, C-CHANGE: Climate Change, Humans, and Nature in the Global Environment. C-CHANGE faculty and trainees will participate in the summer REU programs and provide mentoring and research collaboration opportunities to tribal college students and faculty; the proposed program also will provide training and funding opportunities for Master's students in KU's Indigenous Nations Studies program.

In order to create an ongoing training program for American Indian science and technology education and workforce development, we propose to expand the mission of the Haskell Environmental Research Studies (HERS) center to focus on climate change and energy development on Native lands both through Kansas facilities at Haskell, KU, K-State, and Wichita State as well as through collaborations between these institutions and the tribal colleges from whom we recruit students and whose tribal lands serve as research sites for REU student projects.

D.6. Cyberinfrastructure Plan.

Cyber-development will play a major role, especially in the climate-oriented research. This part of the project will be overseen by Chris Brown, KU and John Harrington, KSU. Funds to enhance the cyberinfrastructure will facilitate significant improvements in the areas of data gathering, data analysis, and visualization. Data mining of heterogeneous datasets (and related training) will provide further opportunities to project researchers. Briefly, all Climate themes entail working with large data sets and associated analysis tools that need to be linked in novel cyberinfrastructure arrangements. To surmount these issues, flexible pipelines are needed that are reconfigurable on the fly. Hardware and networking upgrades are needed to support climate-related activities.

In terms of expanded datasets, first, a multiple date, large, and detailed land-use/land-cover and corresponding socio-economic survey dataset will be generated. This will necessitate a data outreach coordinator who will work with project researchers to develop a portal wherein land-use/land-cover change and certain socio-economic dataset products will be available to a wide range of stakeholders and researchers. These activities will create a cyber community that will facilitate cyber collaboration among the researchers and improved knowledge of available opportunities.

Not only will this project be of interest to Kansas stakeholders, but neighboring jurisdictions will also be able to take advantage of increased databases. To accomplish these objectives, additional land-use/land-cover research and the acquisition of greater computer processing, analysis, and storage capacity are necessary. The MODIS 250 m land-use/land-cover datasets from 2000-2012 will first be assembled for the State of Kansas, after which similar classification techniques will be applied in an effort to expand the dataset to include the states of Oklahoma, Nebraska, and Iowa. Likewise, the socio-economic data collection effort among farmers will be expanded within Kansas, generating panel data for additional regions, in order to increase the explanatory power of models that characterize farmers' land-use decision-making.

A *data outreach coordinator* at the Kansas Biological Survey's Applied Remote Sensing Program will collaborate with other project team members to create a cyber community centered on exploration and visualization of the project's land-use/land-cover and socio-economic datasets. A wide range of stakeholders will be targets of the data outreach effort, including producers and other land managers, agri-businesses, public and private commodities analysts, governmental and non-governmental land resource management groups, and legislative personnel, among others. Outreach efforts will include the land change science research community across the U.S. and abroad.

Web-based geographic information systems (GIS) tools will allow users to explore the project's extensive datasets through analysis and visualization. Web tools will also be developed to aid interested users in collaborating in the study of land-use decisions and land-use/land-cover change in Kansas and neighboring states like Nebraska and Iowa that are experiencing similar agricultural dynamics, due to the increased attention to bio-fuel development and energy independence. Climate researchers, including the project's own team, and those studying biogeochemical cycling in changing agricultural systems, will find the MODIS 250 m data useful in regional modeling work. With respect to social scientists, few have the expertise in satellite remote sensing to generate such spatially and temporally explicit land-use/land-cover datasets on their own. The data outreach effort above will help relieve a major impediment to broader and more innovative uses of satellite data.

D.7. Outreach and Communication Plan

New to the Kansas NSF EPSCoR office will be an "Outreach Coordinator." The Outreach and Communications Coordinator will assist in the development of the overall outreach and communications plan for KNE and manage its communications and related activities in an effort to raise awareness of the Program. These activities include: the development of targeted outreach initiatives, collection, preparation and dissemination of news about the Program and related research news from around the state, public relations activities, website maintenance and in executing the overall outreach and communications plan for the Program through the website, printed and electronic publications, media relations and KNE-sponsored events.

Existing arrangements are already in place for interaction with stakeholders. The Kansas Coalition for Carbon Management is made up of agricultural and environmental groups, state and federal agencies and KSU. The mission of this coalition is to inform, educate, and motivate land managers to apply management practices that result in reduced atmospheric carbon levels. In addition the KSU Soil Carbon Center, produces a monthly eNewsletter titled "Soil Carbon and Climate Change News" that is sent out to educators, agencies, NGOs, and policymakers at state, national, and international levels.

Members of the Climate focus groups and the Energy groups will meet periodically during the year to discuss progress and future plans. There will also be a yearly symposium where members of the entire project get together at one of alternating University sites, KU, KSU, WSU or Haskell. The timing is project to be at the end of the Spring semester. There will be a summary of each of the Targets of the project by the major investigators. Student researchers will also have poster sessions. It is at these conferences where the students and faculty will learn new language of the different disciplines, and thus will become much more versatile in their scientific background.

A yearly Statewide Conference will also be held. It may or may not be in conjunction with the yearly symposium for the major project in order to maintain flexibility. This conference may in some years be multi-jurisdictional, for example with Nebraska and/or Oklahoma, on a topic that is a common research theme.

D.8. Evaluation and Assessment Plan.

Benchmarks, outputs, and outcomes for the term of the project are provided in Table 2. A narrative of the evaluation and assessment process is also provided below. The Institute for Policy & Social Research (IPSR) at the University of Kansas will be responsible for the evaluation and assessment of the Kansas NSF EPSCoR Phase VI projects.

Table 2. Process Benchmarks, Outputs, and Outcomes

Process Benchmarks	*Year*					*Outputs*	*Outcomes*
Major Initiative	1	2	3	4	5		
Climate Variables							
Recruit new research faculty and faculty mentoring in place	X	X	X	X	X	New faculty and staff contribute expertise to MI research	Enhanced workforce within the MI focus areas
Recruit and hire technical staff	X						
Purchase and install eddy-correlation station	X					Expand existing network	Long-term assessment and understanding of climate change on Kansas economy, in particular, agriculture
Simulations of surface boundary conditions & atmospheric forcings	X	X	X	X	X	Detailed climate impact analysis of projected climate changes for Kansas	
Project data collection and analysis (downscaling)	X	X	X	X	X	Space-time models for temperature, precipitation and soil moisture	
Project data collection and analysis (C sequestration)	X	X	X	X	X	Improved quantification of biogeo fluxes	Develop sound adaptation/mitigation strategies for Kansas and Great Plains
Project data collection and analysis (Soil & Aerosol)	X	X	X	X	X	Understanding of local GHG fluxes	
Human Variables							
Recruit students and post-docs and assign to research projects	X					Integration of research and education at all levels	*Well trained workforce within the MI focus areas *Mitigation strategies and policies that account for the economic and social factors that guide farmer decisions *farmers' adaptation to climatic changes
Coordinate and deploy cross-disciplinary graduate education	X	X	X	X	X	IGERT-like activities as part of graduate student curriculum	
Collection and examination of MODIS 250 satellite data	X	X				Deep, longitudinal database of land use decisions	
Survey and interview farmers			X	X	X		
Biomass							
Design and synthesize functionalized nanocatalysts	X	X	X	X	X	Environmentally friendly chemicals and polymers from algae residues	Significant sustainability of algae biofuel production
Utilize glycozymes with bionano switches	X	X	X	X	X		
Develop composite materials for photoconversion of both CO_2 and H_2O into fuels using solar energy	X	X	X	X	X	Successful catalytic production of acrylic acid,	Mitigation strategies
Develop high-yield, low-cost system for oil extraction from algae and residue utilization	X	X	X	X	X	Efficient system for the growing/biorefining of algae	Algae as a viable source of biofuel
Analysis of farmers' decision to cultivate biofuel feedstocks	X	X	X	X	X	Deeper understanding of farmers 'crop decisions	Policies to promote the cultivation of biofuel feedstocks

Photovoltaic							
Develop basic knowledge about natural and artificial photosynthetic complexes	X	X	X	X	X	Nanocomposite solar energy capture systems, functional nanocomposite materials	More efficient and low-cost nanostructured photovoltaic cells
Nanotechnology research on solar energy conversion	X	X	X	X	X		
Diversity and Workforce							
McNair							
Recruit 6 students for summer research program plus GRE preparation and Heartland Research Conference in KC	X	X	X	X	X	Prepare underrepresented students for graduate school	Broadly diverse workforce in STEM disciplines
Pathways							
Recruit students to summer REU-like program	X	X	X	X	X	IGERT-like activities	Network of climate scientists and technical experts linking research universities, tribal colleges, and indigenous communities New strategies for indigenous communities to respond to climate-related events and changes.
Recruit Tribal College Faculty members to summer program	X	X	X	X	X	Faculty members pursue terminal degrees	
Integrate REU students into MI	X	X	X	X	X	New skill sets of scientific & traditional knowledge	
Accept Native American students into IGERT C-Change program	X	X	X	X	X	Collaborative/mentoring relationships between KU and Haskell students	
American Indian/Alaska Native Climate Change Working Group symposium	X	X	X	X	X	REU students meet, network and present their work	
Cyberinfrastructure							
Database Expansion							
Hire data outreach coordinator	X					New staff contributes expertise to MI research	Greater access of cyber-infrastructure opportunities
Design and implement web-based data outreach applications	X	X	X	X	X	Applications facilitate outreach	Wider dissemination of data
Generate LU/LC datasets for web-retrieval	X	X	X	X	X	Datasets for KS, IA, NE	Enhanced collaborations
Develop web-based GIS tools for database access		X	X	X	X	Sharing of data	
Outreach and Communication							
Hire Communication Coordinator	X					Focused effort on outreach	Broader dissemination of information about KNE to the public, other researchers and key stakeholders
Symposia	X	X	X	X	X	Research communication	
Yearly Conference	X	X	X	X	X	Program outreach	
Evaluation and Assessment							
Annual reporting	X	X	X	X	X	Updated metrics	Qualitative and quantitative assessment of effectiveness of reaching goals and value to the state and stakeholders
External advisory committee meetings	X	X	X	X	X	Reviews science and pgm	
IPSR review and assessment	X	X	X	X	X	Assesses accomplishment	
Sustainability							
6-10 First Awards annually	X	X	X	X	X	Faculty proposals to NSF	Increased long-term federal funding in STEM disciplines
1-2 Emerging Area awards annually	X	X	X	X	X	Center proposals to NSF	
Submission of NSF proposals by faculty		X	X	X	X	Proposals submitted	Long-term sustainability of KNE activities
Manuscript and center grant preparation		X	X	X	X	Peer-reviewed, inter-disciplinary publications	

Three aspects of the Assessment are: (1) the database reporting from the individual researchers involved in the projects; (2) the assessment of the metrics provided by the IPSR; and (3) the evaluation provided by the External Advisory Committee on a yearly basis. The EPSCoR office maintains a secure on-line database where individual researchers submit information about publications, participants, and products. This information is updated annually and is used for NSF reporting and metrics assessment. Table 2 shows the Benchmarks anticipated for Phase VI with timing of outputs and outcomes.

The Institute for Policy & Social Research (IPSR) at the University of Kansas will be responsible for the evaluation and assessment of the KNE Phase VI projects. Dr. Steven Maynard-Moody and Genna Hurd will lead the IPSR effort. IPSR will employ the same Mixed Method Evaluation started in Phase V for KNE: analysis of the current performance measures collected for the KNE database (Fast-lane web interface); interviews of key researchers, research administrators, and outside stakeholders; and online survey of KNE project participants. IPSR has developed a methodology that captures the complex interactions of the KNE project by utilizing SAS to map the networks and connections created by the specific sub-projects, the various individuals, and the different disciplines involves with KNE. IPSR will continue to map grant proposals and awards, publications, and other research projects as well as explore other opportunities for network analysis by utilizing the KNE database. This review will continue into Years 1, 2, and 3 of Phase VI. Insights gained and methodologies developed through the evaluation of Phase V will be applied to the Phase VI evaluation and assessment. This approach will provide information required for both ongoing performance measurement and point-in-time evaluation. Results of these studies will be provided to the NSF EPSCoR office, the Management Team, the External Advisory Committee, and the Governing Committee annually.

D.9. Sustainability Plan

There will be several targets in order to achieve sustainability in the long term for this undertaking in addressing global climate change and renewable energy issues.

D.9.1. Seed Funding and Emerging Areas. Two types of seed funding will be instituted in this next Phase of Kansas NSF EPSCoR. Both initiatives should make major impact on building the research infrastructure in the State.

The first will be a reinstatement of the "*First Awards*" from Phases II-IV. These will be given to new faculty who will be encouraged to write a proposal in NSF format for funding. The selection of recipients will be based on NSF criteria. Competitions for these awards will be held once a year in the Fall, which allows for incoming faculty to write a proposal early on after arriving at their respective university. The dollar amount of the award will be a maximum of $100,000 for one year. At least six awards will be made each year. A one-to-one in-kind match from the start-up packages of the new faculty member will be mandated as a condition of the award. These awards will account minimally for $3 million in in-kind match over the five year duration of the award.

Emerging Areas awards will also be available. Awards will be given each year to faculty members who wished to develop a major multi-disciplinary, multi-institutional initiative. The award would consist of one semester of faculty salary. It could be either stand-alone, in which case the faculty member would have a single semester of leave, or in conjunction with a faculty member's sabbatical leave, in which case a faculty member could have an entire year to plan. There will be carefully delineated guidelines and outcomes for the award.

D.9.2. Education and Human Resources Development. The research described in this project will be carried out largely by undergraduate and graduate students and in some cases postdoctoral associates who will learn the methods of scientific investigation as part of the program. Additional human resource development efforts are described in the sections on Diversity and Workforce Development.

All project investigators and students will assemble in annual symposia and semi-annual workshops to share research findings, review progress, and participate in seminars and colloquia with national and international scholars. Monthly journal clubs, shared via video conferencing, will be held at KU, KSU and WSU for students and faculty to discuss current literature in related research areas.

D.9.3. Post RII Extramural Funding. Several of the project leaders are already considering submitting proposals for extended funding for multi-investigator, expanded scope of these projects. A white letter has already been submitted to DOE for a National Center for Renewable Energy Research. Should this be funded, readjustments will be made to support other parts of the project or parts that were not funded within the DOE award. Plans are underway to submit portions of the climate sections for similar initiatives.

In the long term National Center for Renewable Energy Research and a Climate Change Center are anticipated in Kansas that will be international in scope. Industrial partnerships that arise as the research proceeds and as the results become translated into new materials for solar energy capture and conversion will contribute to the sustainability of the solar energy and biomass research.

D.9.4 Expanded Collaboration. Catalyzing collaboration is a central objective of this proposal. Collaborations are already in place for both climate and energy initiatives. These include National Laboratories at Argonne, Los Alamos, NASA at Ames, and the National Renewable Energy Laboratory as well as the Notre Dame Radiation Laboratory. Several international collaborations are already in place. KSU and the Federal University of Santa Maria in Brazil have a signed MOU to share research, undergraduate and graduate students, and faculty with the focus on adapting to and mitigating climate change. KSU in partnership with the US State Department are working to coordinate mitigation research with Brazil, Australia, Canada, and New Zealand. The energy group has collaborations with a number of foreign institutions including Osaka University in Japan and the FIOCRUZ research foundation in Brazil. Partnering with industry will also play an important role for this initiative. Six companies; Abengoa Bioenergy (KS, NE, MO), MGP Ingredients (KS), White Energy (KS), ADM (IL), Nanoscale (KS) and Netcrystals (CA), have endorsed the project and expressed enthusiasm in collaborating with the research and training effort (see support letters in Section J.3). Additional partnerships with other jurisdictions and states, industries and internationally are envisioned during the course of the project.

D.10. Management Plan

The management plan is laid out to provide a broad base of oversight and guidance to the Kansas NSF EPSCoR Office. The general interrelationship of the management committees is shown in *Fig. 8* and the major responsibilities of each committee are outlined in **Table 3**. The make-up of the committees is diverse in terms of gender, expertise, and institution, and includes leading natural and social scientists in the fields of global climate change and renewable energy sources from academic institutions and national laboratories. They are listed in **Table 4** along with their affiliations and pertinent demographics. Only the Research Leaders of the major initiative involved in the management team are listed in this Table. Information about the Target Team Leaders can be found in Section J.1.

All but a few of the members of the committees remain to be identified. It should be noted that the Vice Provosts/Presidents of Research at KU, KSU, and WSU are the key and constant advisors to the EPSCoR office. The ready-availability of these three individuals facilitates the EPSCoR Director's decision-making on items not of major importance, but important enough to require some input. Internal Metrics evaluation will be provided by the Institute for Policy and Social Research, and is described in greater detail in section **D.8.**

Plans for succession for the Project Director are in place. Because of the inclusion of significant social science input, it is envisioned that co-Directorship may be an important step in the evolution of the management structure. It is planned to recruit a co-Director to the office within the first two years of the project. The length of appointment will also be determined during this phase, upon consultation with the VPs Research and the Governing Committee. An apprentice Director will be sought 1.5 years before the "retirement" of the Director (also in consultation with the VPs Research and the Governing Committee), and appointed in a role with a commensurate title. This rotation of Directors will occur on an alternating basis for both the natural and social science co-Directors, so that there are smooth transitions with changes in leadership.

Table 3. Committees and Assigments

Internal

KU, KSU, WSU VPs Research
- •Provide day to day guidance and advice
- •Oversees selection of First and xx Awardees
- •Provides information about ongoing initiatives in home universities

Management Team – 4 meetings per year
- •Coordinates the major initiative
- •Plans yearly State Conference
- •Plans yearly Symposium
- •Hones detailed 5-year implementation plan
- •Monitors progress toward benchmarks
- •Adjusts strategies during course of award
- •Provides input to annual and final reports

KNE Office (Project Director and Staff)
- •Provides statewide S&T leadership
- •Provides program management
- •Oversees external relations and
- •Insures compliance and accountability
- •Reports to NSF, KTEC, KBA, VPs Research, and State Governing Committee

Team Leaders
- •Coordinate research within individual Themes

External

KTEC and KBA
- •Provide S&T leadership for state
- •Lead State support for EPSCoR
- •Provide oversight for major initiative
- •Monitor State investment in EPSCoR

State Governing Committee
- •Provides guidance and oversight
- •Provides feedback to new initiatives
- •Provides advocacy and strategic planning for university research
- •Alerts EPSCoR to State needs

External Advisory Committee
- •Reviews progress of major initiative
- •Reviews 5-year implementation plan on yearly basis
- •Advises on metrics, goals, benchmarks and objectives for sustainability
- •Recommends changes to implementation plan based on findings in yearly report to EPSCoR office

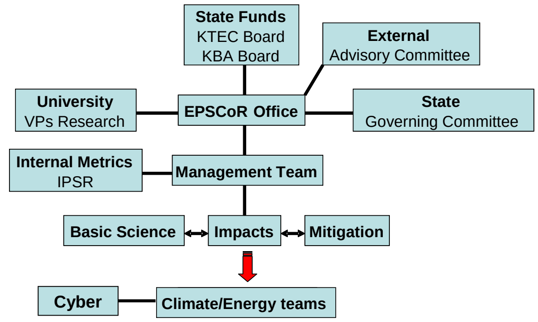

Figure 8. Management structure.

Table 4. Key Personnel

NAME	AFFILIATION	ROLE/AREA
Governing		
Ballard, B.a	Kansas Representative	KU Faculty Dole Institute
Hoelscher, A.	Mayor of Bushton, KS	Farmer and Businessman
TBD	Haskell Board of Regents	Native American
TBD	KTEC Board	
External Advisory		
Stults, R.	NREL, Associate Lab	Director for Energy Sciences
Creutz, C.	Brookhaven Natl. Lab Dean, Oklahoma State	Chemist Physicist
Sherwood, P.	Dean, Oklahoma State	Materials Scientist, Physicist
DaSilva, L.	Virginia Tech	Computer Engineer
Welch, E.	Sociology, Univ. Chicago	Social Scientist
VPs Research		
Guikema, J.s	KSU	Biologist
McDonald, D.	WSU	Biologist
Wilson, G.	KU	Chemist
Rosenbloom, J.	KU	Social Scientist
Assessment		
Maynard-Moody, S.	IPSR, KU	Director
EPSCoR Office		
Bowman-James, K.	EPSCoR	Project Director/Chemist
Byers, D.	EPSCoR	Assistant Director
Schmidt, P.	EPSCoR	Administrative Assistant
TBD	EPSCoR	Outreach Coordinator
Initiative Leaders		
Rice, C. W.	KSU	Climate, Agronomy
Earnhart, D.	KU	Climate, Economy
Wu, J.	KU	Energy, Physicist
Nagel, J.	KU	Climate/Workforce, Sociology
Wildcat, D.	Haskell	Climate/Workforce, Native American Studies

D.10.1 Jurisdictional and Other Support. The State of Kansas is committed to the role of science and technology and its benefits to the State. The major support, in addition to the understood research space and equipment that is already a part of the program, will come from the required State match. Letters of matching commitment are provided in Section J.3. In terms of hard dollar match, KTEC is committing between $2.5 and 3.0 M for the period of the grant and has agreed to $500,000 - $600,000 per year. KBA will provide $2 M, contingent on an award being made. The matching program within the KBA is relatively new, and all indications are that once a federal award is made, the KBA will accept and fund a proposal for this match. KU and KSU have committed to a hard dollar match of $1 M each over the term of the award. We did not request hard dollar match from WSU since none of the key project leaders are from WSU. Note however, that there is strong involvement of WSU, in terms of team leadership in this initiative. The remainder of the match will be in-kind, and will come from the First Awards. A one-to-one in-kind match is a requirement of these awards from the Start-up package for the incoming faculty member. A total of $600,000 - $700,000 will be allocated to these awards per year for $3 – 3.5 M over the period of the award. The in-kind match can be adjusted, for example if KTEC provides $500,000 instead of $600,000 in a given year. The two scenarios are detailed in the MINIMUM and MAXIMUM columns in **Table 5**.

Table 5. Breakdown of Hard and Soft Dollar Match

MINIMUM HARD DOLLAR		MAXIMUM HARD DOLLAR	
Hard Dollar		Hard Dollar	
KTEC	$2.5 million	KTEC	$3.0 million
KBA	$2.0 million	KBA	$2.0 million
KU	$1.0 million	KU	$1.0 million
KSU	$1.0 million	KSU	$1.0 million
Total	$6.5 million	Total	$7.0 million
In-Kind		In-Kind	
First Awards	$3.5 million	First Awards	$3.0 million
Grand Total	$10.0 million	Grand Total	$10.0 million

D.10.2. Summary Table

Table 6. Research Support Levels

Awardee	*Year-1*	*Year-2*	*Year-3*	*Year-4*	*Year-5*	*Total*	*%*
Lead Institution (KU)*	2,902,027	2,742,648	2,729,989	2,743,481	2,898,315	14,016,460	70.08
Participating Institution (KSU)	786,300	930,220	978,722	958,243	786,903	4,440,388	22.20
Participating Institution (WSU)	164,915	168,583	120,479	123,381	126,373	703,731	3.52
Participating Institution (Haskell)	146,758	158,549	170,810	174,895	188,409	839,421	4.20
Total	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	20,000,000	100.00

*Note: KU budget includes all administrative activities as well as unallocated amounts for First Awards and Emerging Areas Awards. These amounts will be distributed to the participating Institutions based on competitive awards of solicited proposals.

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