

# Communication

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## Genome Management Information System: A Multifaceted Approach to DOE Genome Research Facilitation and Communication

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**Project Goals: Help build the critical multidisciplinary community needed to advance systems biology research for DOE energy and environmental missions and foster industrial biotechnology. The Genome Management Information System (GMIS) contributes to DOE Genomics:GTL program strategies and communicates key GTL scientific and technical concepts to the scientific community and the public. We welcome ideas for extending and improving communications and program integration to represent GTL science more comprehensively.**

Concerted communication is key to progress in cutting-edge science and public accountability. With support from the Department of Energy's (DOE) Office of Science, the Genome Management Information System (GMIS) has for 19 years been the main communication resource supporting the pioneering Human Genome Project (HGP). However, since 2000 our primary focus has shifted to helping plan, implement, and communicate DOE's Genomics:GTL (GTL, formerly Genomes to Life) program enabled by the HGP. The goal of GTL is to attain a predictive, whole systems-level understanding of microbes and plants to help enable biobased solutions to DOE missions. Our mission is to work with DOE staff and the broad scientific community to communicate biological science challenges and findings to stimulate advances at interdisciplinary interfaces, democratize access to the growing bounty of resources and data, and drive more-informed scientific and societal discourse. Our goals focus on three areas: (1) facilitate GTL planning, research, and communication; (2) respond to com

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munication needs of related projects; and (3) continue to communicate about DOE genomics research and potential applications.

Technical communication integrating all facets of GTL research is critical for spurring innovation at the most rapid pace and at the lowest cost. Such communication is important to achieving DOE missions and, ultimately, fostering U.S. competitiveness through growth in the industrial and environmental sector of the estimated trillion-dollar biotechnology industry spurred largely by DOE genomics research.

Throughout the HGP (1989 to 2003), GMIS strategic networking and communication helped promote collaborations and contributions from numerous fields and reduced duplicative scientific work in the growing genomics community. GMIS staff and the resources we created became the primary "go-to" source for information on all things genomic for much of the scientific world, the media, and the public. A large collection of award-winning, informative literature; websites; large-format exhibits; and graphics forms the core of these resources, which are assessed frequently for value, timeliness, and cost-effectiveness. Hundreds of thousands of document copies have been distributed. In addition, last year alone, GMIS websites received some 20 million page views (224 million hits), many from people who are just learning of the HGP through new textbooks or news coverage of the latest gene discovery. Through our resources, networking at various professional scientific and related education meetings, and strategic partnerships, we continue to broaden our reach and focus the attention of numerous people in the national media, government, academia, industry, education, and medicine on DOE genomics programs.

For the scientific community, communication and research information integration are even more important for GTL than for the HGP, which relied on one dominant technology—DNA sequencing—and produced one major data set—DNA sequence. This next generation of biology is far more complex and involves a wider array of technologies, many just emerging, with new types of data sets that must be available to a larger, more diverse research community. Moreover, disparate groups of interdisciplinary scientists must be engaged to achieve the productive dialogue leading to research endpoints that will ensure the success of GTL. The stakes are high: GTL resources and data have the potential to enlarge

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the research community working on biotechnological approaches to DOE missions, resulting in more rapidly evolving scientific thinking and progress in these and related areas of critical global importance. The extensive experience, scientific knowledge, and professional credibility gained during the HGP years now place GMIS in a prime position helping tackle an even greater challenge: Helping the Office of Biological and Environmental Research—within the Office of Science—develop the scientific understanding, data, and tools for GTL systems biology in support of DOE mission applications. Communication strategies must be dynamic and evolve along with programmatic needs.

Since 2000, GMIS GTL communication and research integration strategies have included helping facilitate numerous scientific workshops to develop GTL program plans; producing GTL symposia at national scientific meetings; and creating numerous informational resources and tools used by scientists, program administrators, and others. Two important research plans we have produced with the research community are: *DOE Genomics: GTL Roadmap: Systems Biology for Energy and Environment* (August 2005) and *Breaking the Biological Barriers to Cellulosic Ethanol: A Joint Research Agenda* (June 2006). Other work in progress this fiscal year includes a new GTL strategic plan, an overview of the DOE Bioenergy Research Centers, a climate plan and a plan emanating from a carbon cycle workshop. We also plan to enhance the GTL web presence.

In addition to helping drive communication within the scientific community, GMIS will continue to leverage the high level of public interest in the HGP and genomic science with our established and future resources to inspire a similar wonder at the challenging new task before us: Learning how genomic “parts” (i.e., genes and regulatory components) work together to produce the processes of life. GTL pursues this grand scientific challenge via investigations in microbial and plant systems, whose sophisticated biochemical abilities have yet to be understood and tapped. We will communicate the excitement of these investigations and their potential applications beyond the interested research community to broader audiences.

“Interdisciplinary research... is a mode of research by teams or individuals that integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines or bodies of specialized knowledge to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline or area of research practice.” [National Academy of Sciences, National Academy of Engineering, and Institute of Medicine of the National Academies, *Facilitating Interdisciplinary Research*, The National Academies Press, Washington, D.C., 2005.]

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# Ethical, Legal, and Societal Issues

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## Meeting the Demand for Biofuels: Impact on Land Use and Carbon Mitigation

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**Project Goals:** We propose to conduct an integrated, interdisciplinary research project that will investigate the implications of large scale production of biofuels for land use, crop production, farm income and greenhouse gases. In particular, this research will examine the mix of feedstocks that would be viable for biofuel production and the spatial allocation of land required for producing these feedstocks at various gasoline and carbon emission prices as well as biofuel subsidy levels. The implication of interactions between energy policy that seeks energy independence from foreign oil and climate policy that seeks to mitigate greenhouse gas emissions for the optimal mix of biofuels and land use will also be investigated. The objectives of this research are to (a) determine yield and greenhouse gas mitigation benefits, in the form of soil carbon sequestration and displacement of carbon emissions from gasoline, of each type of feedstock, (b) examine the optimal allocation of existing cropland for feedstock production, the mix of feedstocks that should be produced and the spatial pattern of land use in the U.S. at various expected prices of gasoline, market prices of carbon emissions, and biofuel subsidy levels, and (c) investigate the optimal plant sizes, transportation patterns and areas to locate bio-refineries.

We propose to conduct an integrated, interdisciplinary research project that will investigate the implications of large scale production of biofuels for land use, crop production, farm income and greenhouse gases. In particular, this research will examine the mix of feedstocks that would be viable for biofuel production and the spatial allocation of land required for producing these feedstocks at various gasoline and carbon emission prices as well as biofuel subsidy levels. The implication of interactions between energy policy that seeks energy independence from foreign oil and climate policy that seeks to mitigate greenhouse gas emissions for the optimal mix of biofuels and land use will also be investigated. This project will

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thereby contribute to the ELSI research goals of sustainable biofuel production while balancing competing demands for land and developing policy approaches needed to support biofuel production in a cost-effective and environmentally friendly manner.

The objectives of this research are to (a) determine yield and greenhouse gas mitigation benefits, in the form of soil carbon sequestration and displacement of carbon emissions from gasoline, of each type of feedstock, (b) examine the optimal allocation of existing cropland for feedstock production, the mix of feedstocks that should be produced and the spatial pattern of land use in the U.S. at various expected prices of gasoline, market prices of carbon emissions, and biofuel subsidy levels, and (c) investigate the optimal plant sizes, transportation patterns and areas to locate bio-refineries.

We will undertake this research by integrating a biophysical model, Integrated Science Assessment Model (ISAM), and an economic model, Agricultural Policy Analysis Model (APAM), together with detailed GIS data on soil and climate at a 1km x 1km level for all corn producing states in the U.S. ISAM will be used to simulate yields of various row crops, such as corn, soybeans and wheat, as well as two bioenergy crops, switchgrass and miscanthus. It will also be used to determine the carbon sequestration rates with alternative land uses and tillage practices and the life-cycle carbon emissions of alternative feedstocks. Agro-zones with homogeneous growing conditions will be defined using the crop productivity estimates obtained from ISAM. Profitability of alternative land uses and tillage management choices in each zone will be determined. These together with the zone specific information on life cycle carbon emissions of alternative feedstocks will be used to determine the profit maximizing land use decisions for each agro-zone. APAM embeds a dynamic regional land use allocation model within a national model with demand and supply for row crops that determines equilibrium prices. The regional and the national models are solved iteratively each time period, with equilibrium outcomes in a given year affecting land allocation decisions in the next. These will be used to determine optimal land allocation decisions over a 20-year horizon. Following the determination of the optimal land use allocation for feedstock production, we will develop a location choice model that will identify the optimal locations for bio-refineries and optimal transportation pattern. Based on the distances (thus, transportation costs) from production sources

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of the feedstock and the railroad/road network, certain locations may be more suitable for corn and corn-stover based biofuel plants, while others may be more suitable for producing biofuels by using perennial grasses. The framework developed here will be used to examine the policy implications of various levels of biofuel subsidies, carbon prices and gasoline prices for land allocation between food and fuel production as well as for greenhouse gas emissions.

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### The Biofuels Revolution: Understanding the Social, Cultural, and Economic Impacts of Biofuels Development on Rural Communities

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**Project Goals: The goal of this project is to provide a better understanding of the socio-economic and cultural implications of biofuels development for rural communities, and to contribute to more informed policy development regarding bioenergy. This goal will be accomplished through an in-depth analysis of the impacts of ethanol production on six rural communities in the Midwestern states of Kansas and Iowa.**

A new wave of economic growth is currently sweeping across rural communities in the Midwest region of the U.S., fueled by the construction and expansion of ethanol biorefineries and the expansion of biofuel crop production. While the expansion of the biofuels industry promises to bring jobs and economic vitality to rural communities, it is also creating dilemmas for farmers and rural communities in weighing the benefits of income growth and job growth against safety risks, increased pollution, and the potential of overextending water supplies. Presently, there is little empirical knowledge about the social, cultural and economic impacts of biofuels development on rural communities. This research is intended to help fill these lacunae through an in-depth analysis of the social, cultural, and economic impacts of ethanol biorefinery industry on six rural communities in the Midwestern states of Kansas and Iowa. The goal of this project is to provide a better understanding of the socio-economic and cultural implications of biofuels development for

rural communities, and to contribute to more informed policy development regarding bioenergy.

#### Research Questions:

1. To understand how the growth of biofuel production has affected and will affect Midwestern farmers and rural communities in terms of economic, demographic, and socio-cultural impacts.
2. To determine how state agencies, groundwater management districts, local governments and policy makers evaluate or manage bioenergy development in relation to competing demands for economic growth, diminishing water resources, and social considerations.
3. To determine the factors that influence the water management practices of agricultural producers in Kansas and Iowa (e.g. geographic setting, water management institutions, competing water-use demands as well as producers' attitudes, beliefs, and values) and how these influences relate to bioenergy feedstock production and biofuel processing.
4. To determine the relative importance of social-cultural, environmental and/or economic factors in the promotion of biofuels development and expansion in rural communities.

#### Research Methodology

The comprehensive methodology will include: demographic analysis; field research involving in-depth personal interviews and focus groups with key informants and selected community groups; a general population opinion survey of community residents; and a content analysis of local newspapers and print media. These four methodological procedures will generate an extensive and detailed database of the nature of biorefinery development in the six rural communities serving as case study sites. Where possible, the findings derived from one method will be "triangulated" with the findings derived from other methods. Taken together, the data resulting from this study will provide a more detailed and comprehensive understanding of the social, economic, and cultural impacts of ethanol biorefineries on rural than has heretofore been developed. The research will lead to completion of six detailed case studies of rural communities that are current or planned locations for ethanol biorefineries.

#### Preliminary Findings

A substantial number of rural communities in Kansas and Iowa have undergone decades of stagnation and decline in terms of the size of their population and

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employment base. A key policy issue is whether ethanol refineries are being located in those rural communities where they could have the most beneficial impact in terms of attracting population, generating new jobs and increasing incomes? Preliminary findings indicate that as of October, 2007, ethanol refineries have been located in non-metropolitan counties that had significantly lower poverty rates in 2000 compared to those rural counties without a refinery. In addition, non-metropolitan counties where ethanol refineries have located were found to have: (a) significantly smaller percentages of households that are working poor; (b) significantly greater levels of aggregate income; (c) significantly greater increases in real aggregate income over the 1989-1999 period; (d) significantly higher median household incomes; (e) significantly larger employment bases; (f) significantly larger total populations; (g) significantly more urbanized populations; and (h) significantly higher percentages of crop acreage devoted to corn production. These findings suggest that at this juncture, ethanol refineries are serving to reinforce the structural advantage of larger, more urbanized non-metropolitan communities with greater wealth and larger economies. In turn, this implies that unless this pattern changes, smaller non-metropolitan communities within the two state area will be at a further disadvantage as a result of biofuels development.

#### For Additional Information:

Project information and research findings will be available at: [http://www.ksu.edu/sasw/kpc/biofuels/project\\_doe.htm](http://www.ksu.edu/sasw/kpc/biofuels/project_doe.htm).

## 149 Analysis of Global Economic and Environmental Impacts of a Substantial Increase in Bioenergy Production

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**Project Goals:** The goal of this research is to develop realistic assessments of the economic and environmental impacts of regional and global policies designed to stimulate bioenergy production and use. We will build on the unique strengths of the Global Trade Analysis Project (GTAP) to analyze economic impacts of alternative bioenergy policies at regional and global

**levels. We will use the Terrestrial Ecosystems Model (TEM) model to evaluate the potential for new lands to be brought into production in the wake of biofuel programs, as well as to validate environmental consequences of these policies and check their feasibility from a fundamental bio-geochemical perspective.**

#### Introduction

With the growing concerns on energy security and climate change, biofuels have witnessed rapid increase in production in rich countries particularly in the United States and the European Union. Massive subsidies offered by these countries, have resulted in large-scale implementation of biofuels programs which have profound global economic, environmental, and social consequences. Current studies do not provide much insight into how alternative bioenergy production scenarios could change global agricultural production nor the incomes of affected groups both within and across nations. The increasing importance of biofuels and lack of comprehensive studies on global impacts have opened up several research avenues. Since biofuels are produced mainly from agricultural sources, their effect is largely felt in agricultural markets and land-use, with repercussions for international trade. As the World Bank reports, nearly 70 percent of the world's poor live in rural areas in developing countries and derive their primary livelihood from agriculture. Higher biofuel feedstock prices can help the farmers who grow them, but an increase in food prices can hurt the poor as they spend a large share of their budget on food. Keeping these issues in view, this project aims to develop a realistic assessment of the economic and environmental impacts of regional and global policies designed to stimulate biofuels production and use. This project will be completed over a three-year period. The project builds on the unique strengths of the Global Trade Analysis Project (GTAP) based at Purdue University.

#### Analytical Framework

A Computable General Equilibrium (CGE) modeling in GTAP framework (Hertel, 1997) is adopted as it is best suited for studying the global, socio-economic impacts of biofuel technologies and policies. The GTAP database and its analytical framework are widely used for analysis of global trade, energy, environment, technical change, and poverty issues in an economy-wide context. In order to evaluate alternative bioenergy scenario impact on land-use, potential land for feedstock and other crops production, water availability and greenhouse gas (GHG) emissions, we utilize the Terrestrial Ecosystem Model (TEM), a widely used model in ecological research. The

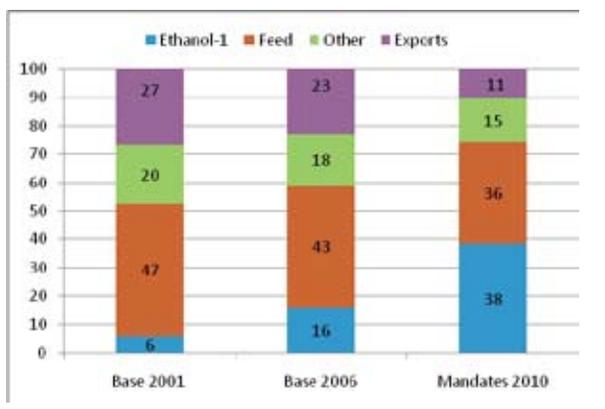
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resulting factor earnings and commodity prices from the interaction of economic and environment modules are translated through the poverty module to determine the change in poverty headcount, by population strata in a sample of 15 developing countries. In all, through this project, we will be able to empirically evaluate the impacts of biofuel policies in the U.S., EU, and Brazil on the global economy, focusing on impacts on agricultural markets, global poverty and environment.

**Research Progress and Preliminary Results**

We have incorporated three explicit biofuels sectors such as corn-based ethanol, sugarcane-based ethanol, and vegetable oil based biodiesel, in to the GTAP data base (Dimaranan, 2007 and Taheripour et al., 2007). In order to introduce biofuels as energy substitutes/complements into the GTAP model, we use GTAP-Energy model (Burniaux and Truong 2002; McDougall and Golub, 2007) linking with Agro-ecological Zones (AEZs) (Lee et al., 2005) for each of the land using sectors. The GTAP-E model with biofuels and AEZs provides a clear picture regarding the impacts of growing importance of biofuels on global changes in crop production, utilization, prices, factor movements, trade, land-use change etc. For validation of the model, we project a hypothetical biofuel economy forward in time and compare the model predictions with historical evidence from 2001 to 2006. We focus on three main drivers of biofuel boom in the U.S.: hike in crude oil prices, replacement of MTBE by ethanol in gasoline additives, and subsidy for ethanol. Using this historical simulation, we calibrate the key elasticity of energy substitution between biofuels and petroleum products in each region. With these parameter settings, the model does a reasonably good job of predicting the share of feedstock in biofuels and related sectors in the major biofuel producing regions.



**Figure.** Disposition of Coarse grains in the U.S. (%)

As an illustration, we analyze the impact of implementation of biofuel mandates for 2010 in the U.S., and EU. The European Union has set the goal to reach a biofuel share of 5.75% in transportation fuels market by 2010. The United States is considering a target to reach about 35 billion gallons of biofuels by 2017. We adopt these targets for a “mandates” simulation for the year 2010. Both of the regions are expected to substantially increase the share of agricultural products utilized by the biofuels sector. For example, the corn share in ethanol production could double from 2006 levels in the U.S. (Figure). Similarly, share of oilseeds going to biodiesel in the EU triple with doubling the price of these feedstocks from 2006 levels and sharply reducing their exports from these two regions. In the EU, the majority of the biodiesel driven demand for oilseeds is met from imports, with import volume rising by more than \$4 billion. These increases in biofuels demand also have profound influence on agricultural production and land-use. An 11% increase in corn acreage from 2006 in the U.S. results in significant falls in wheat and soybean acreage along with other crops, livestock, and forestry land use. The acreage devoted to oilseeds in the EU increases by 21%, which comes at the cost of forestry and other crops. The combined impact of U.S. and EU biofuel mandates puts considerable pressure on agriculture and forest lands throughout the world. Due to slight decline in import of petroleum products, the trade balance improves for the U.S. Overall, the biofuel mandates in the U.S. and EU are likely to have significant and lasting impacts on the global pattern of agricultural production and trade.

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### Intellectual Property and U.S. Public Investments in Research on Biofuel Technologies

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**Project Goals: PIPRA will map the intellectual property landscape of biofuels with a focus on "cellulosic" ethanol. We will determine the different technological approaches to making biofuels, the degree to which these approaches are covered by patents, and show how patent ownership is distributed across the public institutions and industries. Further, we will assess possible strategies, such as research consortia sharing agreements, patent license clearinghouses and patent pools, to co-ordinate access to multiple technology components considered necessary for future developments.**

Increased interest in the replacement of fossil fuels with biofuels to combat global warming and increase national security has resulted in a surge in biofuel research whose outcomes are adding to an already complex intellectual property (IP) landscape. An understanding of the biofuel IP landscape can be used to better inform policy makers, sponsors, institutions and researchers to promote and conduct commercially viable research which will support the maximization of returns on research investments. To increase this understanding we, at the Public Intellectual Property Resource for Agriculture (PIPRA) group, are mapping the IP landscape of biofuel technologies focusing on bioethanol production from cellulosic biomass. This landscape will be used to analyze global patenting activity including identifying the predominant patent

applicants, technology advances and geographical patenting trends.

The IP landscape has been divided into sections encompassing the bioethanol production stages from the farm (including seeds/germplasm, farming techniques, storage and transport of biomass) to the ethanol plant (comprising the conversion of biomass to fermentation feedstock, fermentation and ethanol recovery). Current efforts are directed to determining the landscape associated with the enzymes involved in the release of fermentable sugars from the cellulosic biomass; a key step where production costs could be substantially reduced thereby increasing the overall energy return on investment. Preliminary analysis has revealed more than 90% of patents and patent applications have been awarded to private companies, reflecting the pattern of private relative to public funding for research in this area until recently. Furthermore, associated with changes in public policy and the increase in biofuel research, patenting activity has increased noticeably since 2002. This information can be used to form an understanding of the overall IP landscape and the need for licensing agreements for enabling technologies as well as assisting in the design of research projects with maximum freedom-to-operate.

PIPRA is a not-for-profit organization whose objective is to support innovation in public sector agriculture research institutes for commercial and humanitarian uses, by providing a wide range of technical services for improved IP management. These services include the provision of enabling technologies, generation and analysis of IP landscapes, educational services and the facilitation of licensing and material transfer agreements with member institutions. PIPRA comprises 45 institutional members in 14 countries.

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### Integrating ELSI into the Center for Nanophase Materials Sciences at the Oak Ridge National Laboratory

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**Project Goals: This project seeks to incorporate an Ethical, Legal, and Societal Implications (ELSI) activity into Oak Ridge National Laboratory's (ORNL's) Center for Nanophase Materials Sciences (CNMS) in a manner that is forward-looking, consistent with the**

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conduct of nanoscience and technology research, and valuable to the user communities of the CNMS and the other nanoscience centers.

Despite explicit language in the *21st Century Nanotechnology Research and Development Act of 2003* that encourages the integration of ELSI (Ethical, Legal, and Societal Implications) research and activities with nanotechnology research and development activities, it is not immediately obvious how to do so effectively. By “effectively,” we mean adding value but not burden to the conduct of science, taking advantage of proximity to the center to carry out ELSI research, and adopting a neutral position toward the science and its outcomes. We anticipate that an effective integration would enhance the experience **obtained by scientists through their participation** in a nanotechnology research center, improve the quality of ELSI research, and, potentially, identify new nanotechnology research topics.

This presentation describes a project that seeks to incorporate an ELSI activity into Oak Ridge National Laboratory’s (ORNL’s) Center for Nanophase Materials Sciences (CNMS) in a manner that is forward-looking, consistent with the conduct of nanoscience and technology research, and valuable to the user communities of the CNMS and the other nanoscience centers. The project responds to the abovementioned *Nanotechnology Act of 2003* and to remarks by a senior DOE official in open forum, both of which encourage the integration of ELSI with nanotechnology research and development activities. To achieve our objectives, we are: (1) conducting societal implications research on selected issues of importance to nanoscience and technology; (2) eliciting and providing ELSI-related information to the CNMS and its users and to the broader nanotechnology community; and (3) developing and implementing an ELSI consultation resource that creates the capacity to apply lessons from the broad ELSI and nanotechnology-ELSI (NELSI) literature to the specific issues and concerns that could impinge on the conduct of nanotechnology research. We are working closely with key CNMS personnel to assure that ELSI is incorporated effectively.

This presentation describes the structure of our ELSI endeavor, our methods, initial efforts, and anticipated outcomes. It emphasizes our efforts to integrate and communicate with the CNMS and nanoscience/nanotechnology research communities, and begins to identify salient ELSI topics, such as issues associated with the transition from laboratory to commercial settings and intellectual property rights.

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## 152 Lessons from Experience about Societal Responses to Emerging Technologies Perceived as Involving Risks

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The objectives of this project are (a) to consider the historical experience in the United States with developing new technologies associated with public concerns about risk, and (b) to consider how lessons learned from this experience might be relevant to societal implications of emerging technologies involving bioengineering for alternative energy production.

The research team will utilize established analytic-deliberative group processes to extract key lessons learned from the experience with “risky” technologies in the U.S. and from inferences from relevant social science literatures, producing a report on lessons learned that should be applicable to a wide range of emerging technologies. Next, it will conduct a prototype test of the possible relevance of these lessons to long-term bioengineering science and technology for innovative bioenergy production. It will then review the results and invite participation by a wider community of experts at a national workshop on the topic of the project, in collaboration with DOE and the Oak Ridge Center for Advance Studies (ORCAS).