Building a Prosperous Future in which Agriculture Uses and Produces Energy Efficiently and Effectively

James R. Fischer
US Department of Agriculture
Washington, DC

The current energy situation presents the United States and the world with challenges and opportunities. In moving forward with renewable energy and energy efficiency, in meeting the challenges of oil dependence, national security, and global warming, we should remember that the greatness of the United States has always been its ability to cultivate human talents and apply them in developing new technologies. The history of American agriculture is an excellent example of this. Advances in crop and animal sciences have led to ever-increasing yields, lower energy intensities, and more abundant, affordable food. Blessed with substantial agricultural lands, the United States has made the most of our opportunities and fed a large and growing country, and the world as well.

Our new challenge, and our new opportunity, is energy. Science and education will develop and sustain the bio-economy. Cooperative, interdisciplinary efforts will be required to address technical and market issues in the physical, biological, and social sciences, and efforts will be needed at all levels of the development continuum, from basic research to commercialization. Education will be required to introduce youth to agricultural-energy issues, to train the workforce of the bio-economy, to develop the next generation of professionals and researchers, and to inform consumers about new types of energy sources and products. The US Department of Agriculture (USDA) is undertaking numerous efforts in these areas of science and education. Others should make a point of directing their talents and technologies to support this. This is the path forward for us. This is how we can move beyond a petroleum economy to make oil dependence a thing of the past, and safeguard our environment for future generations. We can achieve our goals through scientific research and development (R&D), and by educating the next generation to create the bio-economy.

The Energy Situation: Challenges

Oil Dependence

Many American adults have memories of the two oil price shocks of the 1970s, which contributed to high inflation and unemployment. Fears of similar supply-related disturbances have led to a new correlate to national security called "energy security." Generally speaking, this is the ability of the nation to obtain energy reliably and affordably. In practice, the term is most often used in connection with oil imports. While the economy is less vulnerable to oil-supply disruptions or price spikes than it was three decades ago, geopolitical and oil-market concerns are strong.

In 2006, the United States imported about 60% (on a net basis) of the crude oil and petroleum products it used. Concerns are heightened because a significant share of current imports comes from the Middle East. Most of the world's long-term supplies of less expensive crude oil deposits are in that region, so the share is expected to increase. Since the terrorist attacks of 2001, concerns have grown. The war in Iraq, additional terrorist attacks around the globe, and specific attempts to attack oil facilities in the Middle East make markets and governments insecure about supply disruptions.

This is an even greater danger when markets are tight. Increasing demand from China and other countries has stretched production capacity and played a significant role in higher oil prices. With little spare capacity, supply disruptions could have more dramatic effects, and the risk of oil-price volatility is greater than ever.

Oil is a finite resource. It was deposited in geologic processes over millions of years. There may still be a large volume of it left, but it is certain that it is running out. The term "peak oil" refers to a kind of tipping point in world supply. The peak is the point where the maximum production is reached. After that, exploration to find new sources and new technologies to produce more from existing wells are insufficient to continue to increase production. The decline may be steep or gradual, but it is inevitable. Production in the United States reached its peak in 1970, but the world as a whole has not yet reached that watershed.

Human use of oil has been outstripping our ability to extract it. The world consumes about two barrels for every barrel discovered. It took approximately 125 years to use the first trillion barrels of oil, and we are on pace to use the second trillion barrels in about 30 years. Production has exceeded new finds for the last two decades. Many experts are bearish on oil's future. For example, oil magnate T. Boone Pickens is not optimistic about continued increases in mankind's oil use. He thinks that global oil production cannot be increased much above its current level, that we are at or near peak oil. He believes that changes resulting from decreasing oil supply are not likely to be abrupt, but that changes will play out over time.

Climate Change

Global climate change is also a growing concern with the use of fossil fuels, including oil. In recent years the scientific consensus regarding anthropogenic warming of the earth's climate has solidified. A growing body of evidence demonstrates that human activities are warming the earth, and that there are serious resulting impacts. Recent working group reports of the Intergovernmental Panel on Climate Change (IPCC) conclude that there is "very high confidence" that human activities have resulted in warming (IPCC, 2007a) and there is "high confidence" that these effects are taking place (IPCC, 2007b).

Projections of possible effects are uncertain, but many governments have initiated activities to limit, and eventually halt, growth in concentrations of greenhouse gases in the atmosphere. The Kyoto Protocol, ratified by 166 countries and other governmental entities, took effect on February 16, 2005. Although criticized widely, the Protocol is a significant step in global action to mitigate emissions. The United States never ratified it, and has not enacted mandatory emissions controls at the federal level, but instead has emphasized the importance of scientific and technological advances in achieving similar goals.

State and local governments have taken steps to mitigate emissions. California has passed legislation that requires a 25% cut in carbon emissions by 2020 to reduce emissions to 1990 levels. California and four other western states also agreed, in February 2007, to set a cap for carbon emissions for their region before the end of 2007 and to set up an emissions-trading system by August 2008. Seven northeastern states have agreed to mandatory limits on carbon dioxide emissions from power plants. This action aims at a target of stopping the increase in emissions by 2009, and reducing them by 10% from 2005 levels by 2019. Other states and cities have also taken action, and there is movement for federal leadership in this area.

A lawsuit filed by several states and environmental groups seeking to compel the Environmental Protection Agency (EPA) to regulate greenhouse gas (GHG) emissions from motor vehicles reached the US Supreme Court. The Court decided on April 2, 2007, that EPA did have authority under the Clean Air Act, and ordered EPA to reconsider regulation of GHG emissions from new cars and trucks. This bolsters activity already underway for federal regulation. Many legislative initiatives have been introduced to Congress, and companies including Shell Oil have called for federal action to ensure consistent nationwide regulatory treatment of GHG emissions.

Energy Use and Economic Development

Energy consumption is fundamental to modern economies and to daily life in developed countries. Energy consumption and affluence are tightly linked. Some developed countries use energy more efficiently than others, but these two variables track very closely in a regression analysis. Developed economies will use more energy as their economies continue to grow, and, over the next several decades, developing countries are expected to exponentially increase their energy use as their economies modernize. The two largest developing economies, China and India, will be the future world leaders in emissions. As the world's population grows toward 10 billion or more this century, greater energy use and its resulting GHG emissions will be an inevitable result.

How Well We Use Energy

Where we get energy now and how well we use it is an indication of our current energy status and what direction we need to move in. Non-renewable energy sources supplied about 94% of US energy in 2001. Petroleum, natural gas, and coal each supply about a quarter to a third of the total, and nuclear energy supplies under 10%. We use renewable energy for only about 6% of our energy needs. More than half of this is biomass—mostly in the form of wood chips and other wastes and residues used in the forest products industries, like paper-making. Hydroelectricity represents another large segment of the renewable share, with other sources like wind, solar, and geothermal contributing smaller shares. Renewable energy, with its many positive attributes, could make up a significantly larger share of the total.

We lose about three-fifths of available energy resources in the process of conversion to useable forms, whether for mechanical work as in an automobile engine, or in burning fuel to make electricity. We could reduce demand considerably if we used energy more efficiently. Perhaps our best energy resource is the energy we waste.

The Energy Situation: Opportunity and Responsibility

A number of areas show promise for the use of renewable energy and energy efficiency—both non-biological and biological. Renewable energy sources, including wind, solar, and geothermal, are likely to play an increasing role in our energy mix. Wind power in the United States has grown to more than 11,600 megawatts, and its costs have fallen to a few cents per kilowatt-hour, in a competitive range with fossil-fired electric generation. Technological development may increase output and decrease costs for smaller wind turbines operating in lower wind-speed environments, opening more potential markets. Solar power costs are higher, but have also fallen dramatically over the years. The worldwide solar industry has been booming, to the extent that prices for inputs such as silicon have increased with high demand. Geothermal energy, for electricity generation and direct supply of heat, has also increased, especially in the western United States.

Similarly, energy efficiency will be more important, with technologies such as improved engines and zero-energy buildings coming to market. Hybrid electric drive, already commonplace, can enhance vehicle power and performance while decreasing fuel use significantly. "Plug-in" hybrids could extend the use of electricity in vehicles. With enhanced batteries, cars and trucks could run solely on electricity or fuels, or a combination of both. Further in the future, fuel cells powered by hydrogen could replace the internal combustion engine altogether. Zero-energy buildings are structures that integrate energy efficiency technologies and on-site renewable electricity generation to produce at least as much energy as they use, selling power into the electricity grid at times. Such buildings might have highly insulating coated windows, light-emitting diode (LED) lighting systems, and other efficiency measures, along with solar panels integrated into roofing tiles and connected to the electrical system.

The food system includes numerous opportunities to employ these renewable generation and efficiency opportunities. For example, wind turbines are now present on many farms and ranches, with more potential to supply land and wind resources from agriculture. Efficiency advances in buildings and vehicles would also benefit many parts of the agricultural value chain, both pre- and post-harvest.

There are also opportunities unique to agriculture. For example, genomics could produce a greater array of nitrogen-fixing crops, reducing the need for fertilizer. This can be understood as an energy efficiency technology, saving natural gas through agricultural science.

Biomass is already being used for energy and other products, but there is great potential for more. Trends are upward. Table 1 shows the markets available to current biomass resources. Grains and oilseeds are the primary biomass resources being used to produce transportation fuels—ethanol and biodiesel—as well as other biobased products.

On the other-hand, wood is the primary biomass feedstock used to generate electricity. Non-hydro renewables currently generate only 2% of US electricity, and of that 2%, most (71%) is generated by woody biomass; 13% wind; and 16% geothermal.

Table 1. Current biomass resources and markets.

Feedstock source	Product markets		
	Transportation fuel	Chemicals & materials	Electricity
Grains	Ethanol	Starches, sugars, animal feeds, organic chemicals	
Oilseeds	Biodiesel	Industrial oils, animal feeds, organic chemicals	
Wood		Paper, pulp, wood products	Steam cycle C-firing with coal; anaerobic digestions; landfill gas; combustion with steam cycle

Biofuel use, although still a small fraction of US consumption, is growing rapidly; 131 ethanol plants are now operating[1], with eighty-two under construction or expansion. The industry has a production capacity of more than 7 billion gallons per year (BGY). The United States produced nearly 5 billion gallons of ethanol in 2006. Biodiesel production has surpassed 200 million gallons per year, with more potential to expand. Biodiesel potential is not considered to be nearly as large as ethanol potential, however.

The demand for biofuels is so large that effects are already being felt in the agriculture industry, such as higher corn prices. Ethanol consumption was small relative to the size of the gasoline market, about 3.5%, but it represented a larger and growing share of corn production, about 14%, in the 05/06 marketing year (Fig. 1).

[1]November 2007 figures.

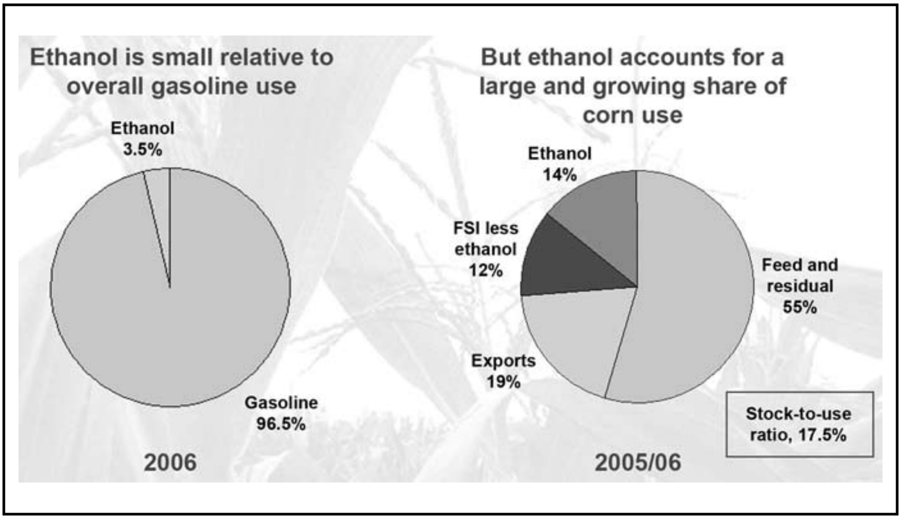

Figure 1. Ethanol in gasoline and corn markets.

Corn's use for ethanol has more than tripled in 6 years, and continued strong growth is likely. A share of 20% of the corn crop is expected for 2006/07. Projections for 2010 indicated that 2.6 billion bushels will be required for ethanol—1.2 billion bushels more than in 2005. Demand has caused corn prices to spike to over $4.00 per bushel, and the outlook is for continued high prices. Concerns have been raised over the availability and cost of corn grain for livestock feed globally.

The size and speed of the increase in corn demand for ethanol production is unprecedented in its effect on the US feed-grain market and its implications for other agricultural markets. The question of sustainability must be addressed. How markets adapt to this increased demand is likely to be one of the major developments of the early twenty-first century in US agriculture.

While a target of 35 billion gallons of alternative fuel has been set for 2017, it is worth noting that the entire current US corn crop would produce only about 27 billion gallons. If the United States commercializes other feedstocks, notably cellulosic feedstocks, corn would become one of several crops or wastes used to make ethanol, and pressure on agricultural markets might ease. The raw material is potentially available: a potential of more than one billion dry tons per year of cellulosic feedstock, available on a sustainable basis, has been established (Fig. 2) (USDA and DOE, 2005).

The utilization of cellulosic feedstocks to manufacture fuel, electricity, heat and valuable co-products is now taking a high priority in agricultural and energy circles. This is a tremendous opportunity for agriculture to usher in a bioenergy future that can help address energy security and environmental challenges, and to profit in doing so. This opportunity is also an important responsibility. The challenges we face are daunting, and agriculture can contribute significantly in meeting them. It is our duty to do so.

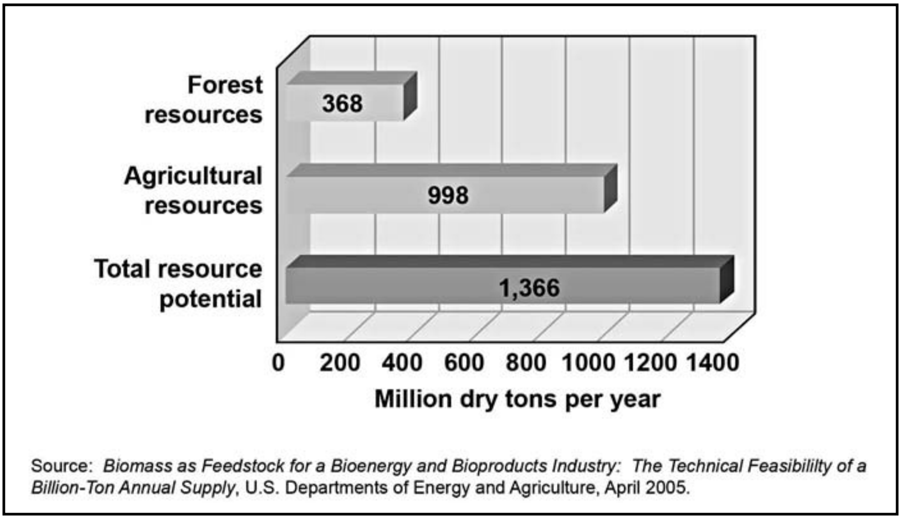

Figure 2. Annual biomass resource potential from forest and agricultural resources.

Initiatives and Goals

Over several decades, energy policy has been enacted to develop renewable sources and promote efficiency. In recent years, there has been a renewed push for transformation of the energy sector, as evidenced by several initiatives and goals that have been established.

Federal Activity

Federal legislation and other developments have been directed at energy challenges over the past three decades. Significant federal legislation beginning in the 1970s focused on energy directly or environmental issues that impacted energy. Tables 2 and 3 list some of the major energy-related legislation in this period.

Table 2. Federal energy legislation and other developments.

1978	Public Utility Regulatory Policies Act (PURPA)
	Energy Tax Act (ethanol blends $0.40/gallon tax exemption)
1992	Energy Policy Act (tax credit for renewable energy production)
1998	Energy Conservation Reauthorization Act (included biodiesel credit)
	Alternative Motor Fuels Act (encouraged cars fueled by alternative fuels)
2000	Biomass R&D Act (DOE/USDA joint R&D biobased industrial products)
2002	Farm Bill (First energy title in Farm Bill history)
2004	Job Bill (included biodiesel fuel tax credit)
2005	Energy Policy Act of 2005 (RFS, production tax incentive through 2007)
2006	State of the union—“addicted to oil”
	Advanced Energy Initiative
2007	State of the union—“20 in 10”
	Biweekly energy briefings to USDA secretary
	Farm Bill—increase budgets for bioenergy R&D

Table 3. Federal environmental policies impacting energy.	
1990	Clean Air Act (CAA) (first major environmental policy to have an impact on renewable energy)
2006	EPA requires the use of ultra low sulfur diesel fuel (15 parts per million sulfur)
2010	Non-road diesel fuel regulations will take effect

One example illustrates the effect of well-constructed public policies to help achieve energy goals. A production tax credit (PTC), applicable to electricity generated by wind turbines, was set at a level—$0.15 per kilowatt-hour, with subsequent upward adjustments for inflation)—that provided just the incremental economic incentive to cause state-of-the-art wind technology to compete with alternatives. The evidence of its influence is the dropoff in wind farm construction during lapses that occurred between expiration and renewal of this policy in 2000, 2002, and 2004 (Fig. 3).

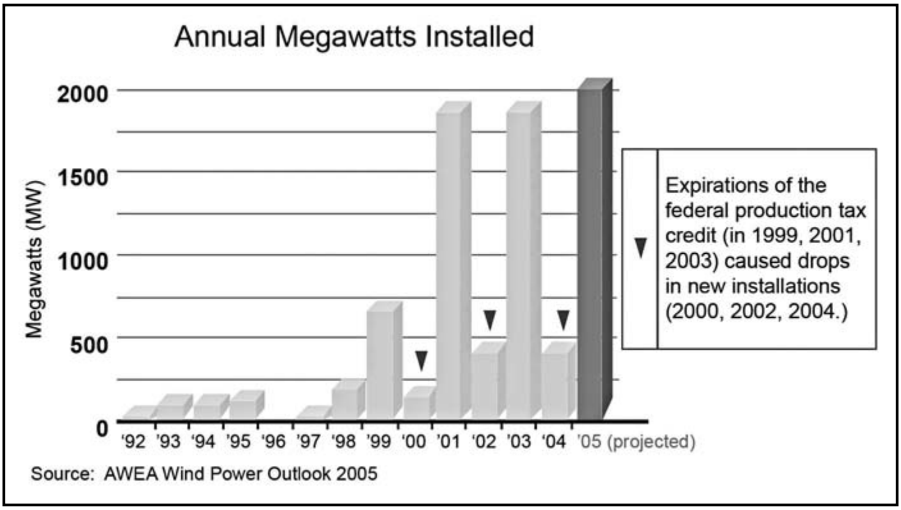

Figure 3. Effect of production tax credit (PTC) on the US market.

Initiatives

In addition to the legislation, regulation, speeches, and other notable activities listed in the tables, a number of plans and goals have been initiated by the federal government and other groups in recent years.

One of the most prominent is the Advanced Energy Initiative (AEI). Key components of the AEI include "chang[ing] how we power our automobiles" and "chang[ing] how we power our homes and offices." One focus is on advanced battery technologies to improve hybrid vehicles, including plug-in hybrids that could both draw from and contribute to the electric power grid. Another focus is reducing the cost of producing ethanol from cellulose. With lower costs for conversion, developments in feedstocks, and in infrastructure and vehicles, there is the potential for tens of billions of gallons of cellulosic ethanol in the next decade or decades. A third area in transportation is the development of hydrogen fuel cells. Practical, safe, powerful, and cost-effective hydrogen fuel cell-powered vehicles—especially if hydrogen is generated from renewable sources—could be the future of transportation. The AEI also targets residential and commercial building energy use, focusing on clean coal, nuclear and renewable energy.

The Biofuels Initiative was developed to target a goal the president set in his 2006 state of the union speech—to replace more than 75% of our oil imports from the Middle East by 2025. This initiative has been accompanied by a proposed near doubling (from $89.8 to $179.3 million) of the budget of DOE's Biomass Program, in the FY 2008 budget request, compared to the FY 2006 appropriation, to accelerate cellulosic ethanol development and related technologies. The budget for USDA also includes a proposed increase of $50 million per year for 10 years for energy in the Research, Education, and Economics mission area.

The Biomass Research and Development Act of 2000 created the Biomass Research and Development Initiative. Its vision is that by 2030, "a well established, economically viable, bioenergy and biobased products industry will continue new economic opportunities for the United States, protect and enhance our environment, strengthen US energy security, provide economic opportunity, and deliver improved products to consumers." By 2030, this initiative's ambitious goals are that there will be 68 billions gallons of biofuels, constituting 20% of the market for liquid vehicle fuels, 10 quadrillion BTUs (quads) of electricity generated from biomass sources, and 55 billion pounds per year of bioproducts.

The most recent of these initiatives is the National Biomass Action Plan. This is an inter-agency effort of the federal government, led by USDA and DOE to coordinate R&D activities across the government related to biofuels. Representatives met in a workshop in November 2006 to define agency roles and activities, identify gaps in R&D and synergies across agencies, and to assess budgets. A report of the conclusions from the workshop is forthcoming.

Goals

Many goals have been set to motivate public- and private-sector efforts in developing biomass energy. Goals have been set by both governmental and non-governmental groups.

DOE set a goal, in response to the president's 2006 state of the union address, to displace 30% of 2005 gasoline usage with biofuels by 2030. This has been called the "30 by 30" goal, and envisions 60 billion gallons annually of biomass fuels in 23 years.

In his 2007 state of the union message, the president articulated a nearer-term goal related to transportation fuel. Called the "20 in 10" goal, it calls for reducing US gasoline usage by 20% by 2017. Three-quarters of this amount (15 percentage points of the 20%) would come from substituting biofuels and other alternative fuels, with the remainder from vehicle efficiency.

A non-governmental group has issued a call for "25×'25"—the use of energy from the agricultural sector, plus wind and solar power, to provide 25% of US energy needs by 2025, representing an estimated 32 quads of bioenergy in 18 years.

The Aspen Institute, a non-partisan, non-profit organization, has set a very ambitious goal of 100 billion gallons of ethanol produced in the United States annually by 2025.

NABC has also set several goals. For liquid transportation fuels, it targets biofuels for 50 billion gallons by 2025, and 100 billion gallons or more by 2035. For organic chemicals, the aim is for glucose produced at $0.04 per pound and competitively priced ethylene, most likely produced with genetically modified organisms. In the area of organic materials, NABC envisions new fiber crops with functional improvements and higher yields, produced with genetically modified organisms (NABC, 2007).

Creating the Bio-Economy

NABC has recognized what is needed in agricultural biotechnology through its history. The organization has been at the forefront in creating a bio-economy. Earlier visioning documents have contributed significantly to the national biomass conversation. Policy suggestions from NABC documents have been incorporated into national policy, as in the Biomass R&D Act of 2000.

The latest in a series of visioning documents, the recently released "Road Forward" strategic planning document, sets out a roadmap for the required technical progress (NABC, 2007). New feedstocks will be required, including residues, dedicated energy crops, and others, to provide a large, sustainable supply. New technologies to convert feedstocks into fuels and other products will also be needed. Both biochemical and thermochemical conversion are under study. Finally, demand for bioenergy and bioproducts will need to match growing production capacity. Markets include transportation fuels, electricity and heat, and industrial chemicals and materials.

Meeting ambitious policy goals and realizing the bio-economy will require many technological advances. It is a large task and we must identify the Road Forward to accomplish it. The Road Forward for the energy future is *Science and Education*. Our country has been defined by its talent and its technology. The history of American agriculture is an excellent example of this. Advances in crop and animal sciences have led to ever-increasing yields, lower energy intensities, and more abundant affordable food. Blessed with substantial agricultural lands, the United States has made the most of its opportunities and fed a large and growing country, and the world as well. Now we are turning to agricultural technology's new challenge: energy.

The USDA is engaged in programs in science and education in an effort to lead the agricultural community in meeting this challenge. The focus of energy science and education programs include both renewable energy (biobased and other renewable energy) and energy efficiency—both pre-harvest or traditional agricultural, and post-harvest, or including the rest of the food system. The three goals to be accomplished are:

- Develop comprehensive *research* programs that effectively explore the role of agriculture as both a user and producer of energy.
- Establish energy science *education and extension* activities related to agriculture with university and industry partners as well as federal and state agencies.
- Initiate comprehensive *technology-transfer* programs for agriculture energy research for agriculture producers, suppliers, and users.

Traveling in the HOV Lane

Going down the road quickly toward a bright energy future will take a lot of cooperation. It's as if different scientific disciplines are driving in separate cars and in separate lanes down a highway. With so many cars, there is a lot of traffic, and the going can be slow at times. But if the different disciplines ride together in the same vehicle, they can take the HOV lane and move faster. In creating the energy future, many approaches will be necessary. Varied research will be required. A unified, interdisciplinary approach will be necessary to address the multi-faceted challenges we face, drawing on expertise in physical, biological, and social sciences. In the physical sciences, research questions include the lower energy density of biomass compared to fossil fuels, the emissions characteristics of fuel combustion, and gasification or pyrolysis of a variety of biomass feedstocks, to name a few examples.

In the biological sciences, research will address issues such as the need to increase feedstock yields, the requirement for regionally specific, environmentally sustainable, and cost-effective feedstocks; the cell wall problem, *i.e.* the recalcitrance of cellulose to break down into the sugars needed; and the development of microorganisms, enzymes, and biochemical pathways for conversion of feedstocks to fuels and products.

Research needs exist also in the social sciences. For example, policymakers and others need assessments of the economic impacts of bioenergy and bioproduct expansion on agricultural, energy, and other markets, in North America and globally. Consumer acceptance of new fuels and new bioproducts, such as 1,3 propanediol (PDO), used to make DuPont's Sorona® polymer, must be gauged, with understanding developed of the most efficient ways to educate consumers to accelerate market acceptance.

In addition, many of the problems that need to be addressed are multi-faceted, and need even more cooperation than the coordination of different fields. The interactions necessary will require the building and nurturing of inter-disciplinary teams.

In another scenario, the cars traveling in separate lanes are government, industry, and academia. These different groups, also, need to get into the same vehicle and travel in the HOV lane. Government can make policies to help speed the development and adoption of new technologies, in areas like tax and financial incentives to public education. Government can also play a pivotal role in coordinating the efforts of different sectors. Industry can be a key player in developing technologies, and is absolutely central in determining how technologies will come together and flourish in the marketplace. Academia is very good at doing research in the physical, biological, and social sciences. With all of these key players moving together, they can make much better progress than if each were traveling alone.

R&D Continuum

Developing new technologies to the point of commercialization requires a continuum of activities, from the initial idea to the mass market. Activities are required in basic research, development, demonstration, deployment, and commercialization to move new ways of providing energy services, chemicals and materials along a development pipeline. For example, while research on the fundamental character of cell-wall structures is ongoing, industrial, academic, and government interests must work in concert to set up demonstration plants to prove the feasibility of continuous processing of a new conversion technique, while elsewhere market researchers work to define consumers' requirements for committing to biofuels in their vehicles.

Education

Educational activities will ensure that the next generation of researchers, workers, and consumers are prepared to carry on running and expanding the bioeconomy. Education should begin with youth. For example, teacher-training and instructional materials can be developed for classroom use. USDA and others can reach out to youth groups already active in agriculture. The National Association of State Universities and Land Grant Colleges (NASULGC) and DOE have worked with 4-H clubs. Youth educators in seven states were trained in Washington, DC on curricula pertaining to energy and lighting to be taught in a 4-H after-school program. These partners are also working with the Future Farmers of America (FFA) to introduce energy science into high-school curricula.

Higher education activities are also needed. The Department of Labor has predicted that the retirement of scientists will soon leave the country about five million scientists below recent levels. Technical schools can train young people to be the technicians of the bioeconomy—for example, to operate collection and storage facilities for energy crops, or to run testing procedures to ensure biofuels have the right chemical specifications.

Undergraduate courses and majors will help train future professionals. In the same way that large numbers of students began earning certificates or even majoring in environmental studies in the last one or two decades, the bioeconomy will need courses with titles such as "bioenergy engineering" or "energy crop agronomy."

Graduate programs will train professional practitioners and researchers. For example, a few years ago Iowa State University (ISU) introduced a Biorenewable Resources and Technology graduate program, with the cooperative work of several science and engineering departments. ISU grants MS and PhD degrees in this area.

Student competitions at all levels can motivate young people and harness their creativity. Models for these kinds of learning programs in renewable energy include the Solar Decathlon for college students and fuel cell model car racing competitions for high-school students.

Technical schools will have to train people who will make up a lot of the workforce of the bio-economy. For example, we'll need people who know how to operate collection and storage facilities for energy crops, or run test procedures to ensure biofuels have the right chemical specs.

Consumer and business education can increase market awareness and acceptance of bioenergy and bioproducts and better prepare businesses and their employees to participate in the bioeconomy. These could take the form of workshops, seminars, workforce-development classes, and consumer brochures or television programs. For example, a training session could be held for builders and their employees who want to incorporate energy efficiency and renewable energy into new homes and commercial buildings. Or a class could be held to teach fleet operators how to manage supply of renewable fuels and operate and maintain fleets of flex-fuel vehicles. Consumer education can make a big difference. This is evident with programs like the joint EPA-DOE Energy Star program's "Change a Light, Change the World" campaign. If every American changed out just five high-use light fixtures or the bulbs in them with ones that have earned the ENERGY STAR label, each family would save about $60 per year in energy costs and prevent the emission of greenhouse gases—totaling the same amount as the emissions from more than 8 million cars.

Science and Education for the Energy Challenge

Our new challenge, our opportunity, and our responsibility, is energy. The USDA is determined to apply the talent and technology of agriculture to bioenergy, and others should make a point of directing their energies to support this. The road forward toward our energy future is *Science and Education*. This is how we can move beyond a petroleum economy to make oil dependence a thing of the past, and safeguard our environment for future generations. We have to do this together—riding together in the same car and moving quickly along in the HOV lane.

The USDA has started the process of getting researchers together for a large, long-term cooperative effort. In September of 2007, USDA convened a workshop of government and academic people to plan its approach to energy science and education. Participants worked to identify a vision and goals for the effort, identify program areas of focus and crosscutting issues, establish agencies' responsibilities, and suggest a process to achieve goals.

Participants and others interested in NABC 19 should also become engaged in the cooperative effort to move quickly toward the bio-economy and the energy future. They should do things to promote the concept of the HOV, multi-lane science and education highway—create interdisciplinary teams, or even new academic departments; keep working on R&D, but also take actions to make sure lab results get moved toward the market, with technology transfer partnerships with industry or university spin-off startups, for example. Other actions that readers can take include promoting education to create a sustainable pool of talent in individual fields and crosscutting groups, oriented toward bioenergy and bioproducts. These are actions like creating new curricula, new undergraduate majors, graduate programs, or even creating an endowed chair in bioenergy. The central, critical idea is for us all to be cooperating and coordinating in an almost unprecedented way—driving together in the same car, moving in the HOV lane.

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JAMES FISCHER has spoken nationally and internationally to diverse audiences on renewable energy production (wind, solar, geothermal, biomass) as well as on improving energy efficiency in agriculture.

In 2003, he was appointed to the Board of Directors for the Energy Efficiency and Renewable Energy Programs of the US Department of Energy. As senior technical advisor (academe) he developed innovative partnerships and models of collaboration, especially with land-grant universities, the US Department of Agriculture, foundations and the agricultural, industrial and business communities. In January 2007 with his wife, Sharon, he formed James R. Fischer and Associates LLC, a company focused on technology and management issues at the nexus of agriculture and energy, assisting the USDA Undersecretary for Research, Education and Economics to coordinate energy science and education programs for the Research, Education and Economics mission area of the USDA.

Fischer, who holds a PhD in agricultural engineering from the University of Missouri-Columbia, served as a USDA research engineer in the 1970s and as a faculty member and dean at three universities: Missouri, Michigan State, and Clemson. He has published more than a hundred papers, contributed book chapters, testified before Congress, and served on peer review panels and advisory boards.