# BIOMASS RESEARCH AND DEVELOPMENT
# TECHNICAL ADVISORY COMMITTEE
# 2011 RECOMMENDATIONS

## FEEDSTOCK RECOMMENDATIONS

1) **Productivity**

- *Problem Statement*: Maximizing efficiency or yield is critical to the introduction of bioenergy crops. To support genetic improvement there is a need to continuously expand the genetic base. Importation of new germplasm is one mechanism to expand the genetic base. The current quarantine process is recognized as a bottleneck to importation.
- *Recommendation*: Potential pests, pathogens and invasiveness associated with emerging bioenergy crops needs to be addressed by quarantines to achieve more efficient quarantine practices.
- *Recommendation:* Update procedures for collecting, treating and evaluating plant accessions to minimize risks associated with germplasm introduction.

- *Problem Statement*: There is a need to develop optimal management practices for sustainable bioenergy crop production.
- *Recommendation*: Continue and expand upon fundamental agronomic and silvicultural research for dedicated/purpose-grown energy crops (woody and herbaceous).
- *Recommendation*: Conduct research on new bioenergy feedstocks to investigate production potential and assess potential environmental impacts of future production.
    - Examine impacts of feedstock production on wild communities.

2) **Long-term Commitment**

- *Problem Statement*: The current 3 year research funding cycle is inadequate to provide long-term assessment of emerging dedicated/purpose-grown energy crops (both woody and herbaceous). Five-year cycles or longer are needed to support research and development on sustainability of long-term production of bioenergy crops.
- *Recommendation:* Per peer review evaluation, prioritize existing long-term trials rather than establishing new trials.
- *Recommendation:* Undertake long-term measurement of greenhouse gasses and ecosystem services from various emerging feedstocks. This should be performed through long-term horizon programs. These could be modeled after programs such as the National Ecological Observatory Network (NEON) at NSF and USDA Watershed Program. This will better inform LCA models.
- *Recommendation*: Evaluate opportunities through field trials and tech-economic studies for biofuel crops in non-irrigated semi-arid lands.

3) **Improving Biomass Logistical Systems**

- *Problem Statement*: Feedstock production is very distributed and low density. Design and implementation of logistical systems the densify feedstocks and deliver to processing nodes is a limiting factor to creating a lignocellulosic-based biofuels industry.
- *Recommendation:* Need well-developed logistical models to deliver feedstock to processors in a cost-effective manner; including integration of national efforts.
- *Recommendation:* Develop densification systems and assess their energy efficiency.
- *Recommendation:* Linking feedstocks to end uses is critical to determining the optimum logistics system.
- *Recommendation:* Need research to evaluate the processes needed to increase the energy density of feedstocks, and to determine impacts on chemical composition and conversion, including lignin separation, and potential synergies between logistical operations and downstream conversion operations.

4) **Indirect Effects**

- *Problem Statement*: There are currently more stringent system boundaries applied for biofuels than competing types of transportation fuels.
- *Recommendation*: Perform analysis on the indirect effects across all fuel types including petroleum. This analysis should include current and future fuel sources including fossil fuels (e.g. tar sands, deep sea oil).
- *Recommendation*: The Committee recognizes the current work underway on indirect land use and recommends that the current research continue to completion.

5) **Access to Land Use Information**

- *Problem Statement*: Although there is substantial acreage that could be used for bioenergy production, effective decision making on use is impaired by insufficient information on current use patterns.
  *Recommendation*: Develop a dataset on land use that identifies land that can be used for bioenergy initiatives.

6) **Algae and Other Organisms**

- *Problem Statement*: The economic and environmental viability of photosynthetic algae is unknown. Water needs are a key concern for the viability of algae as a feedstock.
- *Recommendation*: Perform a techno-economic engineering and systems analysis for photosynthetic algae including LCA and environmental analysis.

## CONVERSION RECOMMENDATIONS

### 1) Conversion Technology Database

- *Problem Statement:* DOE/USDA and the Merit Review Process lack a comprehensive database of conversion technologies and the technical focus of various universities, companies, and institutes.
- *Recommendation:* Conduct a domestic and international assessment of innovative conversion technologies and incentives to accelerate technology deployment in order to assess the position of the United States relative to other countries and to broadly leverage promising technologies.
- *Recommendation:* DOE should maintain a domestic and global database that should be a resource for merit reviews and publicly available to ensure that the federal government reduces redundancies and to guide content of future solicitations.

### 2) Separations technologies

- *Problem Statement:* There is a critical gap in the existing solicitations portfolio on separations technology. Improved separations technology can significantly reduce capital and operating requirements, as well as life-cycle emissions.
- *Recommendation:* Conduct a review of the status of chemical and physical separations R&D, with the goal of identifying gaps and opportunities in product purification (e.g., alcohol and water).
    - R&D should focus on reducing capital expenses, operating expenses, energy intensity, etc. for separations technology.

### 3) Prescriptive solicitations

- *Problem Statement:* Proscriptive solicitations can be too narrowly focused and limit the potential of promising new technologies.
- *Recommendation:* Solicitations should not exclude feedstock blending for conversion processes that can excel if they utilize multiple feedstocks in their development to reduce the risks involved with introducing multiple new technologies—for example, cellulosic sugars blended with traditional carbohydrate feedstocks or MSW blended with agricultural or energy crop feedstocks.
- *Recommendation:* Solicitations should allow for as much flexibility as possible in biofuel output requirements. Solicitations focused on minimum biofuel output requirements for a new commercial biorefinery (100%, 51%, etc.) can be arbitrary and not economically viable for some technologies. Diversification and flexibility are often needed to make plants economically viable, though strategic intention of such solicitation must be preserved.

4) **Scale of supply/conversion systems**

- *Problem Statement:* DOE solicitations often do not take into account variations in the optimal size range (energy, environment, and socioeconomic) for different technology pathways using different feedstocks.
- *Recommendation:* DOE (including the Loan Guarantee Program) should incorporate more flexibility in the size requirements for commercial plants.
    - No technology can jump more than 1 scale, and work should progress in methodical scale increases; reflect on solicitation processes to ensure that projects have first demonstrated lab success before pilot and firm piloting results at appropriate scale before demonstration/commercial deployment.
    - Small-scale systems can be commercially viable and still generate profits. Any minimum size requirements should be explained in the funding opportunity announcement.
    - Biomass scale-up requirements are different than those for petroleum refineries and need to be better understood.

5) **Drop in fuels – Definition**

- *Problem Statement:* There appears to be no formal, standardized definition of "drop-in biofuels", and how this definition differs from that of "advanced biofuels," which are defined in the Energy Title of the Energy Independence and Security Act of 2007 as "renewable fuel, other than ethanol derived from corn starch, that has lifecycle greenhouse gas emissions, as determined by the Administrator, after notice and opportunity for comment, that are at least 50 percent less than baseline lifecycle greenhouse gas emissions".
- *Recommendation*: Develop a clear definition of the term "drop-in biofuels" that emphasizes the distinction between this group of biofuels and "advanced biofuels." The definition should be well connected to the societal drivers (e.g., reduction in greenhouse gases and deployment without extra infrastructure investment), and DOE should attempt to maintain consistency of usage throughout agencies.

6) **Drop in fuels - R&D on H2 production**

- *Problem Statement:* Many technology platforms require H2, research investment is needed to explore ways to produce H2 for conversion processes from biomass, and incorporate scalability needs and cost reductions. (e.g., innovative membrane technologies and process intensification). In general, new methods are needed to chemically reduce biomass.

- *Recommendation:* Begin investment on potential opportunities to produce cost-effective H2 for catalytic upgrading of intermediates derived from thermochemical and biochemical processes for production of renewable drop-in fuels.

## 7) Merit review

- *Problem Statement:* The merit review process often suffers from a lack of technical industry perspectives on the challenges involved in commercial production and scale-up.
- *Recommendation:* Invite more private industry experts, particularly those with commercial scale-up experience, to participate in the merit review process (except for exploratory programs).

## INFRASTRUCTURE RECOMMENDATIONS

### 1. Drop-in Biofuel Timing and Viability

- *Problem Statement:* First and second generation ethanol blend fuels provide immediate GHG and energy diversity benefits. Third generation and later "drop-in" biofuels hold the promise of future GHG and energy diversity benefits and we must continue to invest in these. Resolution of immediate implementation issues associated with first and second generation fuels is being deferred on the grounds that drop-in fuels will preclude the need to spend time, money and effort to resolve these issues. These issues include vehicle and other end-use device fuel compatibility issues, distribution issues, and interaction with complex emission, fuel economy, and CO2 regulations.

- *Recommendation:* Planning and analysis activities should be undertaken to compare the GHG and energy diversity benefits of near-term biofuel alternatives such as ethanol versus longer term drop-in fuel options. Consideration must include the transitional benefits and certainty of current alternatives. Pursuit of drop-in fuels as an avoidance mechanism for investment in first and second generation biofuel infrastructure must be supported by sound planning and analysis. This planning and analysis must include factors such as probability of drop-in fuel technological readiness on all available feedstocks, timing, investment and product cost.

- *Recommendation:* An action plan should be established based upon the described planning and analysis activity to establish an immediate growth pathway for first and second generation biofuels along the EISA/RFS pathway. The action plan should be formulated across DOE, USDA, EPA, NHTSA and industry to address and remove all roadblocks to growth. Industry partners must include fuel retailers, fuel distributors, fuel producers, and auto manufacturers.

### 2. Drop-in Biofuel Definition and Specification

- *Problem Statement:* There is no consistent and broadly recognized definition for drop-in fuels. Specific technical definitions for "drop-in" fuels are critical building blocks for research on the fuels themselves as well as infrastructure issues and end use adoption.

- *Recommendation:* Agencies are advised to engage in research, planning and analysis activities to develop clear definitions of different categories of "drop-in" fuels:

- Drop-in fuels for spark-ignited engines (gasoline engines)
- Drop-in fuels for compression-ignition engines (diesel engines)
- Drop-in fuels for jet-aviation engines
- Drop-in fuels for Combined Heat and Power (CHP)

- *Recommendation:* Agencies are advised to engage in collaborative research with standard setting organizations, such as ASTM, CRC, trade associations and the military for end use devices (Auto Alliance, Small Engine Manufacturers Association, American Petroleum Institute, Department of the Navy, etc.) as the definitions for drop-in fuels are developed. Consider comparable standard setting process for other industries, such as the pharmaceutical industry (for bio-similar products).

## 3. Octane of Low and Mid-level Ethanol Blend Fuels

- *Problem Statement:* The opportunity to raise the octane value of commercial gasoline-ethanol blend fuels has not been realized with the transition to E10 blend fuel in the U.S.

- *Recommendation:* Agencies are advised to undertake planning and analysis to realize the tank-to-wheel efficiency potential of mid-level ethanol blend fuels by increasing the required octane rating of those blends. As certification fuels are adjusted to reflect ethanol blends found in the field, gasoline blend-stocks should be adjusted to allow the certification fuels to have higher octane characteristics. This would allow improved thermal-efficiency and optimization of engine size (lower displacement and weight) over time as auto manufacturers take advantage of those fuel characteristics in new model design. Octane requirement increase for ethanol blend fuels can and should be pursued regardless of policies related to Flex Fuel or Ethanol Tolerant Vehicles.

## 4. Near Term Recommendations for Higher Blend Ethanol Fuel Use:

- *Problem Statement:* Biofuel growth along the RFS trajectory is falling behind. Planning and analysis activities should be immediately undertaken in key areas to increase the compatibility of the car parc at a rate that can support growth along the RFS trajectory. Failing to take immediate action will result in lost energy independence opportunity and lost CO2 reduction opportunity. Vehicle and fuel compatibility choices should be designed to account for the fuels that vehicles are most likely to see in the field (E10-15), while enabling growth in ethanol concentration over time per the RFS, without durability or other consumer

dissatisfaction issues. Certification fuels should reflect field fuel realities with appropriate accommodation for energy density.

- *Recommendation:* Option 1 – Define and implement a new category of vehicles defined as Blend Optimized Ethanol Tolerant Vehicles.

  In light of EPA's approval of E15 for use in model 2001 vehicles and later, adopt the design of a regulatory framework for fuels which vehicles are likely to use, while accounting for planned increase in the amount of ethanol in gasoline-ethanol blend fuels over time per the RFS.

  Adopt certification fuels that reflect the field fuel waiver for 2001 and later vehicles, with adjustment for energy density; for example, E15 certification fuel for model year 2014 or later, with accompanying energy density adjustment (approximately 5%). Adjust certification fuel subsequently in five year increments, for example, adjust certification fuel in 2019 to E20, with associated further energy density adjustment (approximately 6.5%).

  Adjust the vehicle certification protocol to require vehicle optimization on the defined mid blend certification fuel while requiring tolerance of ethanol blends ranging from E0 to E85 in vehicle design. Tolerance is here defined as the ability to operate on blends from E0 to E85 without damage to the vehicle or substantial loss in drivability/performance under defined operating conditions. Emission performance, diagnostics, and fuel economy would only be demonstrated in the certification process on the certification fuel blend itself (initially E15) – not on higher blends for which the vehicle is only designed to be tolerant. This would result in vehicles being optimized on the fuels they are more likely to see in the field without the cost of full FFV functionality. This would allow the production of vehicles that are tolerant of a range of blends with greatly reduced interaction with emission and OBD (diagnostic) regulations.

- *Recommendation:* Option 2 – Pursue broader implementation of Flex Fuel Vehicles in the car parc thru incentive or mandate.

  Research, planning and analysis should be undertaken on the barriers to harmonize FFV technology with new Tier 3 / LEV 3 tailpipe/evaporative emission, $CO_2$, and onboard diagnostic (OBD) requirements administered by the EPA and the CARB in the U.S. Since new CO2 and Fuel economy regulations are designed to be technology forcing toward electrification, auto manufacturers are unlikely to produce FFVs in high volume going forward without harmonization of the new standards with FFV certification requirements and protocols.

  Vehicles that are designed to work with varying blends have different regulatory interaction than vehicles designed to work with a single or small range of blends. The

need for this accommodation is based on differences in the vapor pressure and boiling characteristics of low level gasoline ethanol blends and high level gasoline ethanol blends.

**5. Market Creation – Non-Vehicle End-Use Devices**

- *Problem Statement:* The fuel related capability of non-vehicle end-use devices must match that of vehicles with which they share fuel distribution infrastructure.
- *Recommendation:* Research should be undertaken to understand the design requirements of establishing a minimum biofuel blend capability in non-vehicle end-use devices (marine, outdoor power equipment, other). This should follow the EPA vehicle fuel waiver.

**6. Market Creation – Fuel Blends and Distribution**

- *Problem Statement:* Vehicles and other end-use devices will require different ethanol blend fuels over time due to legacy effects.
- *Recommendation:* Research should be undertaken to explore the barriers to implementing blender pumps that are capable of dispensing fuels to meet the design specification of all end-use devices (vehicles, marine, outdoor power equipment) (specifically call out certification fuels in non-vehicle end-use devices). Research should be undertaken to explore the potential benefits of implementing technology and conducting education and outreach to prevent mis-fueling of end-use devices within the flex fuel (blender) pump context. Planning and analysis should be undertaken to identify methods that successfully encourage consumer selection of the highest biofuel blend available to them. This study should include flex fuel (blender) pump configurations and consumer economic factors.

**7. Market Creation – Post Bio-Refinery Infrastructure**

- *Problem Statement:* Fuel distribution terminals and refueling stations must be configured to allow for efficient and air quality compliant delivery of ethanol and gasoline components in the blender pump context.

- *Recommendation:* Planning and analysis should be undertaken to establish the parameters of hydrocarbon fuel blend stock compatibility and feasible delivery/transportation mechanisms that could support the blender pump market model. This study must include fuel volatility compliance, tankage and transportation issues.

USDA predictions are that biofuels production will be located mainly in the southeast and east central regions. Major fuel markets are concentrated along the west and east coasts. The current transportation infrastructure is insufficient to accommodate the volumes of biofuels that will be produced. Research should be undertaken into the barriers and solutions of transporting biofuels from biorefineries to markets.

## 8. Biopower vs. Liquid Alternative Transportation Fuels

- *Problem Statement:* Biomass for electricity (pure biomass and co-firing with coal) vs. biomass for liquid transportation fuels must be explored. More planning and analysis should be focused on the relative value of using biomass to produce electricity versus liquid transportation fuels, in the short, medium, and long term.

- *Recommendation:* Research should be undertaken on the infrastructure needs and regulatory barriers of biopower, including the optimal locations, scale of plants, and potential densification strategies and technologies. The influence of battery energy density in the short and medium term (significantly lower than the energy density that can be achieved from liquid fuel alternatives) must be factored in the analysis.

  Factors including timing, car parc impact, carbon intensity, rural development, magnitude of capital required for infrastructure investments along different technology pathways, and the energy requirements for heating/cooling vehicles (utility aspects) must be understood.

## SUSTAINABILITY RECOMMENDATIONS

### 1) Environmental Sustainability – Land and Resource Use

- *Problem Statement:* Converting existing land to alternative uses will be considered. The complete ecological impacts may not be covered in lifecycle analysis due to incomplete data on the current ecosystem. For example, baseline data on the existing plant system would be helpful for decision making to support the maintenance of biodiversity and the increase of biofuels production.
- *Recommendation*: We recommend continuing the environmental assessment activity and those activities under development to analyze the current ecosystem as a baseline indicator for direct land use issues. The analysis should be compared to other energy systems.

### 2) Economic Sustainability

- *Problem Statement*: There are currently no good models for growth and economic analysis of a sustainable bioenergy industry
- *Recommendation*: Using best in class analysis of both a successful and unsuccessful biofuels projects funded by the DOE and/or USDA with funding in excess of $25M, do an analysis to identify the risks and potential de-risking solutions in order to create a decision tree for those projects with the highest potential for success.
- *Recommendation*: We recommend a comparative economic analysis of other countries' management of their sustainable, renewable industries by using an economic systems approach to:
  - Capital allocation
  - Capital markets
  - Systems analysis
  - Comparative economic analysis

- *Problem Statement*: Energy industry capital assets are currently under used.
- *Recommendation*: We recommend studies to examine the potential to leverage existing capital assets to advance bioenergy and bioproduct production.

- *Problem Statement*: Government and industry timelines with regards to research and commercialization are not aligned.
- *Recommendation*: We recommend that there be studies to explore how to match the timelines of program decision making with R&D timelines and commercialization timelines to determine the "best in class" (most robust and sustainable) template for bench to market implementation.

### 3) Economic, Environmental and Social Sustainability

- *Problem Statement*: To expand the industry, we have to manage multiple social issues such as job creation, training, access, and infrastructure. Growth management issues need further study.

- *Recommendation*: A comprehensive study should be conducted on the potential social and economic impacts of the emergence of a biofuels, biopower, and biobased products economy. The study should:
  - Investigate the number and kinds of jobs created, the workforce required, workforce availability in rural areas, and the likelihood and size of population shifts from urban to rural areas.
    - Estimate and project the consequential increase in demand for human infrastructure especially in rural areas- i.e. housing, education, healthcare facilities, communication, police and fire protection, etc.
    - Estimate and project the consequential need for transportation infrastructure for both the movement of biomass and the movement of the increased population- i.e. roads, bridges, rail, highway, air service, power lines, natural gas and fuel transmission, etc.
    - Develop a comprehensive plan at the federal level and communicate anticipated needs to state governments and agencies which will bear the brunt of these changes.
    - The study should include research and analysis into the appropriate size of biomass based businesses and industries for the economic, natural, and social resources in the area.
- *Recommendation*: We recommend studies to inform a plan to drive adoption of the bioeconomy (biofuels, bioproducts, and biopower). Further, the impacts, both positive and negative, of such changes on the current business community should be studied. Such a study should try to address such questions as:
  - How to maximize opportunities for rural economic development utilizing business and technology systems that encourage local ownership of biofuel, bioenergy, and bioproduct systems?
  - Will existing agricultural supply and agricultural processing be negatively impacted?
  - Will competition for labor increase wages in rural communities forcing some marginal businesses to close?

**4) <u>Cross-cutting</u>**

- *Problem Statement*: GMO regulation processes may make it too expensive to deploy some bioenergy crops.
- *Recommendation:* We recommend (as a cross-cutting issue with the feedstock subcommittee) that studies be performed to specifically address high-cost issues regarding bioenergy crop. Studies are needed to define the appropriate tests to review genetic modification and the differences in risks that exist between bacteria, yeast, algae, and higher plants including differences in cultivation methods.

- *Problem Statement:* Water quality and availability is emerging as a key issue in the growth of the bioeconomy.
- *Recommendation*: Water utilization in the production of biofuel crops and in the production of biofuels has gained additional scrutiny in recent years. Enhanced and integrated research should be conducted to better understand and compare water use

regionally at all stages of biofuels production and ways in which to conserve water, and maintain water quality, throughout this lifecycle. The analysis should be compared to other energy systems.

- *Problem Statement*: Additional data needs to be developed to expand the ability of the LCA models to analyze and compare bioenergy systems.
- *Recommendation*: We recommend that the USDA and DOE institute a program to monitor and measure relevant environmental parameters for inclusion in the model that is used, especially the current and expected feedstocks for biofuels, biopower and biobased products. These measurements should be made in different geographies and climates, and should remain in place for at least 5 years, to cover the impacts of weather and soil variability

- *Problem statement:* The DOE and USDA have made awards to large scale commercialization projects and these projects typically faced significant challenges which altered the path to success but may have provided important lessons learned for future initiatives. The administration recently has announced a new initiative for large scale production of "advanced drop in biofuels" for use by the U.S. military. This subcommittee believes that the success of this drop in biofuel project would benefit by understanding some of issues and their solutions that were part of the previous DOE large project experience.
- *Recommendation:* We recommend that the DOE institute a transparent risk analysis process that incorporates these "lessons learned" and that this process be used to develop the criteria in the Request for Proposals (RFP) under which competing projects will be selected. Based previous experience, these criteria might include; a more in depth knowledge of the feedstock biology, harvesting and storage challenges, scale of the potential feedstock, prior validation of the key technologies at an appropriate scale and an experienced management team. The statement of criteria ought to be sufficiently rigorous so that the administering agencies would be in a position to make no awards if the criteria were not satisfied.