DRAFT FOR PARTICIPANT COMMENT

CENTRAL REGIONAL ROADMAP WORKSHOP SUMMARY

This document contains:

- *A summary of the discussion of the Central Regional Roadmap Workshop. Workshop participants are asked to provide comments on the document.*

- *For reference purposes, Attachment One provides a compilation of participant inputs posted during the workshop. Numbers in parentheses indicate number of votes received during prioritization process.*

Following completion of each of the three regional roadmap workshops, combined results will be used to develop a draft Roadmap. All workshop participants will be provided the opportunity to comment on the Roadmap.

I. FEEDSTOCK PRODUCTION

Biomass feedstocks include forest resources and residues, agricultural crops and residues, and animal waste. Since the development of the Committee's original Roadmap, a number of important improvements have been made in feedstock production. For example:

- The scientific community is learning more about the composition of switchgrass and the biochemistry of lignin.
- Yields are improving in crops such as miscanthus, canola, soy, wheat and other rotational crops.
- Siled storage capabilities have improved. Five years ago, the general consensus was that long-term storage needed to be dry but recent research has show that wet ensilage (45 to 50% moisture) is viable for 2+ years.
- Improvements have been made in the efficiency of cotton gin waste bailing and storage.
- Efficiencies in the pulp & paper have resulted in very low waste streams.
- Diverse feedstocks and large quantities of underutilized waste matter represent strong opportunities for future energy and products development, including land residues, high Btu content distiller grains; and hog/poultry/dairy/human manure.

Furthermore, a joint study by the U.S. Department of Energy and the U.S. Department of Agriculture found that forest and agricultural biomass resources have the potential to produce 1.3 billion tons per year of biomass. This is enough to produce biofuels to meet more than one-third of current fuel demand. [1]

Achieving Vision goals will require that biomass feedstocks are both sufficient and have the properties suitable for efficient conversion to biobased fuels, power, or products. Also it will require that those feedstocks can be produced, harvested, stored and distributed in an environmentally sound and cost-effective manner. This will require significant advances in areas such as biotechnology and plant physiology, harvesting and collection, storage, preprocessing, distribution systems, and sustainable agronomic practices.

A. TECHNICAL CHALLENGES

A number of technical challenges continue to face the biomass industries in developing, processing, and transporting biomass feedstocks for conversion to energy and products.

Some of the key challenges have to do with diversity and modularity. Realizing vision goals will require the capability to convert a diverse range of feedstocks into a wide variety of biobased energy, chemicals and materials. This will not only broaden the feedstock base but also broaden the geographic range where bioenergy and biobased products can be produced cost-effectively. There is a need for greater focus on creating cellulosic material to help supply future needs for biobased energy and products. Greater modularity in the industry overall will help to broaden the economic opportunities for biomass technologies. The capacity is needed to locally process and convert locally produced feedstocks into useful fuels and products for regional distribution.

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[1] USDA/USDOE, *Biomass as a Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-ton Annual Supply,* April 2005.

Modular, on-farm systems will help to achieve this. While the focus on diversity in feedstocks is being addressed in some research programs, the focus on modularity is not as strongly addressed.

Continued advances are needed in crop management practices and a greater understanding continues to be needed in sustainability issues and environmental impacts of agricultural production. For example, the industry still does not how much residual biomass can be removed before causing damage such as soil loss.

In the area of feedstock handling, there remain a number of concerns. For example, feedstock handling technologies have not advanced at the same rate as development in plant genetics. There is a need for new harvesting mechanisms and machinery to handle higher yields of biomass crops such as miscanthus. This has occurred on a small scale but is very expensive. Feedstock handling technologies need to be able to manage the quantity and diversity of feedstocks being developed.

Densification remains an issue for transporting feedstocks. Higher densities would reduce transportation and storage costs. Significant research is needed to overcome this gap. Feedstock handling issues may be able to be addressed economically if processing plants and quantities can be downsized. Pre-treatment closer to the field (during harvesting) may help to resolve some of these issues.

Discussion around these technical challenges led to identification of several areas for advanced research. Research in these areas could help to overcome technical challenges and enable the nation to achieve the Committee's Vision goals. These research needs are discussed in the next section.

B. RESEARCH NEEDS FOR ACHIEVING VISION GOALS

Workshop participants brainstormed R&D needs to advance feedstock production capabilities to achieve Vision goals which fell into five subcategories: decentralization; ecosystem services; crop yield; farm profitability; and feedstock diversity.

1. **Decentralization -** Decentralization addresses the need for widely distributed small-scale feedstock storage and handling operations. This would benefit nutrient recycling and sustainability, and on-farm methods which add value. Current transportation logistics and scale are not adequate for larger biorefineries. Distributed pretreatment and conversion processes would adjust the supply-chain system so conversion manufacturing is driven by feedstocks, thus removing some of the barriers to economies of scale.

   The industry must move towards a paradigm shift (laptop versus mainframe mentality) in terms of achieving economies of scale of smaller more distributed feedstock production. Smaller-sized more localized feedstock production and processing facilities will have rural development benefits but economies of scale issues must be addressed. Downsized processing plants may have a number of benefits including the ability to adopt more advanced handling technologies and to test more advanced processing methods and technologies. An added benefit will be security from having a diversified production system that will be immune to disruptions unlike our current centralized energy system. Research should be performed on modular systems to produce an intermediate that could then be economically transported to a larger processing facility for final fuels/chemicals production.

R&D pathways identified as high priority are:
- Modular, “on-farm” methods, of biomass pretreatment, processing, and fractionalization to add value.
- Development of a catalyst or enzyme as well as development of separation technologies for high value products, each suitable for small-scale applications.

Additional research needs included:
- Technologies and processes to improve economies of smaller scale production process, distributed pre-treatment, and distributed conversion.
- Develop conversion technologies and systems that can adapt to a wider range of feedstocks and which can be operated at smaller economies of scale.
- Reducing harvesting costs through one-pass systems and densification technologies.
- Testing and demonstration of advanced systems to facilitate decentralization.
- Research on optimal scale of bio-refinery from the distributed supply perspective, instead of only from the capital investment perspective and economies of scale of bio-refinery facilities
- Research on modular systems for handling and processing.
- Research on processes to account for feedstock diversity (quality)

2. **Ecosystem Services –** This centers on R&D to improve crop and soil sustainability, while addressing problems of ongoing food and feed production, and air, water, and soil quality.

   The highest priority R&D pathway is to develop and optimize production practices for an array of feedstocks. Targeting environmental and economic sustainability, these systems should include development of tools and equipment to ease partial or fractional harvest of biomass leaving a defined portion of the residue for soil sustainability.

   Research also is needed on soil sustainability. More knowledge is needed on responsiveness of soil to various types of crops. Research is needed on the effect of biomass removal on soil structure and sustainability. Also best practices and guidelines are needed such as recovering the ground with some portion of residue to ensure sustainability. Agronomic management research is needed on methods to improve biomass production, including nitrogen utilization efficiency, water quality, intercropping and perennial crops. Continued research on the development of no-till production systems is important if crop residues are to be harvested sustainably. Also the development of fertilizer application systems that minimize run-off and degradation prior to the growing plants uptake of these nutrients. This is especially important or minimizing ammonia usage.

3. **Crop Yield -** Crop yield can be addressed through long term R&D to improve crop yield per acre sustainably and to increase the yield of desirable traits (i.e., cellulosic density and high Btu content). There is a need to rethink plant physiology and to begin to consider how to grow plants for energy applications. For example, plants have been developed to require nitrogen fertilizer to make protein. This is not necessarily needed for growing plants with minimal protein. Food crops could be partitioned to more components than grain. New crops

and use of gene technologies to improve crops for energy production may provide great benefits.

The highest priority R&D pathways were identified as integrated plant breeding approaches, and multi-season, multi-location field trials of at least 10-year cycles in order to provide accurate data to farmers. Another priority is the development of crops with high cellulose content or high lignin content (transgenic - lignocellulosic). Genomics for better crops, breeders should map genome for alternative crops. Breeding should focus on overall value of the crop, Btu content, or nitrogen content, not just yield per acre.

Research also should be performed to increase photosynthetic efficiency, with a goal of increasing photosynthesis from about three percent currently to four percent. This is a 25 percent increase in efficiency.

Also better plant rotation methods and integration of seasonal crops should be conducted to increase annual biomass yield (summer and winter crops). Studies have been performed in Europe on this topic that may apply. This may also require more R&D on winter crops such as winter canola, wheat and grain sorghum in the near term.

4. **Farm Profitability -** Farm profitability must be addressed through high-value products and reduced production costs. The highest priority is to reduce harvesting costs. Similar to research needs in decentralization; this includes research and development of technologies to improve feedstock densification, enable one-pass harvesting systems, and separation technologies. Additionally analytical models such as life-cycle analysis (LCA) should be developed to help farmers assess profitability early on. Compositional analysis and research to develop rapid screening methods for feedstock analysis also should be performed.

   Farm profitability can also be gained through developing high value feedstocks and diversifying feedstocks. This will require R&D for an adaptable and commercially viable product slate (e.g., feedstock for process fuels and chemicals production). Product diversification will increase market security for U.S. farmers. However, adequate crop insurance and financing are needed to make diversity a reality.

   Additional research needs include:
   - Diverse feedstocks should be able to be blended yet provide consistent quality for biorefinery applications.
   - Processing technologies for animal waste management are needed.
   - Economic drivers must change to discourage burning and instead achieve high values outputs from residues.
   - LCA of the costs and benefits of utilizing residues for high value products in comparison to the costs and benefits of permitting forest fires should be performed.

IN THE FINAL ROADMAP, WE WILL INSERT A CHART FOR EACH SECTION ILLUSTRATING THE PATHWAY R&D AND TIMEFRAME.

II. PROCESSING AND CONVERSION

The bioeconomy needs to develop a diverse set of platform chemicals to compete in fuels power and chemicals markets. This can only be achieved through cost competitive and technically viable processing and conversion technologies. Categories of Processing and Conversion technologies addressed in this Roadmap include, thermochemical conversion, bioconversion, biorefinery integration, and anaerobic digestive biogas. Technical advances in biomass processing and conversion will improve conversion efficiencies and increase the output of useful biobased energy and products per unit of input while reducing negative environmental impacts. To facilitate commercially viable and environmentally sound biomass processing and conversion systems for a suite of biobased fuels, power and products, however, research is needed in a number of key areas. Several of these areas crosscut biobased fuels, power and products whereas others are specific to one or more end-uses.

- **Thermochemical conversion** converts biomass into intermediate products that can be used to produce fuels and chemical synthesis. The processing technologies can be categorized as gasification, pyrolysis, or hydrothermal processing. Intermediate products include clean syngas (a mixture of primarily hydrogen and carbon monoxide), bio-oil (pyrolysis or hydrothermal), and gases rich in methane or hydrogen. These intermediate products can then be upgraded to products such as gasoline, diesel, alcohols, ethers, synthetic natural gas, or high-purity hydrogen, or may be used directly for heat and electric power generation.

- **Biochemical conversion** fractionates the lignocellulosic matrix of biomass into its component parts. Until the technology to "crack biomass" as readily and economically as we can "crack crude oil" is available, the vision cannot be fully realized. This difficulty or recalcitrance of biomass to fractionation into its component parts is one of the major barriers to using biomass for fuels, products, and energy. Biochemical conversion uses molecular sugars and lignin to be used as intermediates for conversion into fuels, chemicals, materials or heat/power. Production of such commodity products falls under the Products Uses and Distribution. The intersection of the feedstock, biorefinery operations and product output are dependent upon the cost-effective fractionation of lignocellulosic biomass.

- A **biorefinery** processes biomass into value-added product streams. In theory, anything that uses biomass and makes more than one product is a biorefinery. This very simple definition captures a wide range of existing, emerging, and advanced process concepts. Examples of existing biorefineries include corn wet mill and dry mill processors and pulp and paper mills. The concept of a biorefinery is expanded to embody a facility that uses biomass to make a slate of fuels and chemicals to maximize the value of the biomass, thereby maximizing the financial return to the investor. Maximizing the value derived from biomass through an optimal slate of fuels and products is the key to understanding why the biorefinery is the central strategy for widespread biomass utilization.

- **Anaerobic digestion** is a biochemical process in which particular kinds of bacteria digest biomass in an oxygen-free environment. Several different types of bacteria work together to break down complex organic wastes in stages, resulting in the production of "biogas."

Since the development of the Committee's original Roadmap, a number of important improvements have been made in processing and conversion. For example:

- Over the last few years there has been a major increase in fuel ethanol production. However, corn starch remains the most economic source of glucose.
- Advances in enzyme production have concentrated on corn stover as a feedstock. Enzyme costs are now approximately $0.15 per gallon. Advances have been made in corn stover enzymes but they are not yet commercial.
- There are increased opportunities to leverage more chemical industrial processes, into thermochemical conversion.
- Industries are looking for alternatives to high priced natural gas.
- Major strides have been made in black liquor gasification.
- A large amount of work is being done on pretreatment of lignocellulosics to support fermentation.
- Understanding of plant molecular biology has improved over past several years
- Purification and separation issues are being addressed by processing and conversion technologies.
- Progress has been made on organisms for biobased (starch) products.
- There are an increasing number of demonstration projects in thermochemical and biochemical conversion.
- There is a growing recognition of the need to look at whole production stream including waste and other components as well as the importance of maximizing the utilization of all product streams.

Achieving Vision goals will require that processing and conversion of biomass focus on decreasing costs and improving efficiency. This will require significant advances in areas such as thermochemical conversion, bioconversion, biorefinery integration, and anaerobic digestive biogas technologies. The remainder of this section describes the challenges and research strategies for advancing the efficiency and capabilities of biomass processing and conversion systems.

A. TECHNICAL CHALLENGES

A number of technical challenges continue to face the biomass industries in processing, and conversion of biomass feedstocks to energy and products.

The cost of sugars from cellulosic feedstocks is currently higher than the cost of sugars from corn grain (starch). The cost of processing and converting cellulosic materials needs to decrease in order to achieve the Vision goals. There is an absence of process analysis tools and effective separation processes, as well as a lack of data on the physical properties of biomass feedstocks. All areas of processing and conversion should incorporate comprehensive economic modeling to address these challenges, Both thermochemical and biochemical conversion still have separation barriers to overcome and biochemistry is still not profitable. This is due in part because all unit operations are feedstock-specific in order to be cost-efficient. There is also risk associated with hedging biomass growth on petroleum prices and carbon policy which may limit investment over the long term.

B. RESEARCH NEEDS FOR ACHIEVING VISION GOALS

Workshop participants brainstormed R&D needs to advance processing and conversion capabilities to achieve Vision goals. These R&D needs fell into four subcategories: analysis of processes found in nature; increased yield; oils, sugars, and protein platforms; and new approaches to separations.

1. **Analysis of Processes Found in Nature -** There is a need to expand agriculture and animal science research to decrease the cost of processing and conversion significantly. Specifically, analysis of processes found in nature will improve the knowledge of natural processes to enable efficient deconstruction of plant material in the same environment as it was manufactured.

R&D identified as high priority:

- A major priority is the call for far reaching interagency federal research initiative which brings together the technical expertise of each agency to advance the role of biomass technologies. Roadmap participants called for a "Manhattan Project" style effort to bring together the technical resources agencies such as DOE, DOT, NSF, NIH, USDA, and others to pursue this joint effort. .
- Analyze effective biological processors, such as in ruminants, which process cellulosic biomass. By understanding how the technical world processes biomass, researchers can replicate effective biological processes in a laboratory or eventually industrial environment. Natural processes convert plant matter into coal, petroleum, and natural gas over millions of years. Research and development is needed on conversion processes found in animals such as ruminants and termites, in which nature processes cellulose into useful biological material. R&D should seek to mimic these natural processes of converting biomass but on a much shorter time scale. Research is needed to understand those processes and replicate them for industrial applications.

Additional research needs include:

- Establish a clear route to commercialization very specific to gene development.
- Create models to overcome intellectual property issues; foster information sharing.
- Combine Federal research efforts to maximize knowledge exchange and effective, targeted funding.

Comment [MSOffice1]: Policies?

2. **Increased Yield -** Increased Yield is needed across all processing and conversion technologies. In the feedstock development area there is a need to identify biological processes which will increase the efficiency of photosynthesis, creating a more

economical feedstock. This will decrease inputs such as fertilizer, water, energy, and time and decrease cost of processing.

R&D identified as high priority:

- Use the advances made in the wood industry such as biomass residue utilization and apply them for biofuels processing.
- Increase lignin utilization of feedstock as much possible
- Increase data properties on diverse feedstocks and more processing data on impact of catalysts on diverse feedstocks
- Identify more cost-effective and robust biocatalysts.

Additional research needs include:

- Demonstration projects are needed at appropriate size (scale-up) which will help reduce the cost of converting black liquor to syngas as well as minimize tar and char in clean-up in thermochemical processes.
- Evaluate and control micro organism pathways, identify superior organisms, and increase understanding of biochemistry; i.e., more thermo-tolerant biological catalysts; more tolerant to extreme heat, solvent, and pressure.

3. **Oils, Sugars, and Protein Platforms -** Oils, Sugars, and Protein Platforms need to be developed. These areas of research will enable the development of chemistries and material sciences around the basic building blocks used by nature. Such research will lead to the displacement of current petrochemical feedstocks with natural ones in the areas of plastics, composites, and other common consumer products. In many of the research areas identified, economic analysis and modeling is needed to analyze opportunities for increasing yields in these areas, including incremental yields.

R&D identified as high priority:

- There is a need for basic organic chemistry research on proteins, carbohydrates, and lignin to provide the fundamental knowledge for developing biobased carbon and hydrogen chemical platforms in order to displace petrochemicals.
- Identify commercially viable replacements for petrochemicals. As petroleum prices increase, so does the cost of petrochemicals. Biomass must develop materials which are similar to manufacture that use the existing infrastructure, and are similar in application.
- Perform economic analysis of opportunities for oil and proteins to displace petrochemicals.

Additional research needs included:

- Conduct greater R&D in the areas of bioorganic and physical of biomolecules to understand basic structures and interactions.
- Make use of macro molecules already supplied by nature in industrial applications.
- Increase yield of corn ethanol, as well as increase cellulosic fuels production.
- Use feedstocks other than energy crops (e.g. crop residues) to produce process fuel.
- Invest in biochemical research and development at much higher levels such as those found in the petroleum industry. Develop a sense of urgency in this area of research.

5. **New Approaches to Separations -** New approaches to separations addresses more effective separation technologies. New and simple approaches will help identify catalyst and syngas fermentation process improvement pathways. A continued development of expensive technologies will provide a greater understanding of technical issues which will help drive down separation costs.

R&D identified as high priority:

- Comprehensive economic modeling which includes all aspects of processing and conversion. This will enable more accurate identification of appropriate feedstocks, processing and conversion technologies, and end-products for the consumer. This was the most important R&D identified as it would determine the best approach and have the biggest impact.
- Identify syngas fermentation and catalyst separation process improvement pathways.

Additional research needs included:

- Identify enzymatic pathways for biomass conversions.
- Materials science data is inadequate. More R&D needs to be devoted to increasing our knowledge base on separations which will help maximize processing and conversion.
- Particle size reduction and fractionalization is also important to decrease costs for transportation and processing and conversion. If industry can get biomass feedstocks to act separate similarly to petroleum, processing and conversion would be more cost effective and efficient.
- In addition, research devoted to biocomposite production needs to be advanced. New materials which can utilize biomass feedstocks must be developed.

IN THE FINAL ROADMAP, WE WILL INSERT A CHART FOR EACH SECTION ILLUSTRATING THE PATHWAY R&D AND TIMEFRAME.

III. PRODUCT USES AND DISTRIBUTION

Products Uses and Distribution refers to the end-use applications for biobased power, fuels and products, as well as the distribution infrastructure needed throughout the feedstock production, processing & conversion, and end-use/consumption cycle.

A. TECHNICAL CHALLENGES

Distribution Systems

In general, distribution systems move biomass feedstock from field to plant and biobased power, fuels, or products from plant to point of sale. Distribution challenges are found throughout this cycle.

In feedstocks distribution, local rail spurs are being lost and feedstocks are increasingly transported by truck. Pipeline, rail and barge transport options should be expanded. New rail cars should be designed to be appropriate for biomass (versus other commodities).

The current infrastructure for distributing fuels has been developed around petroleum-based fuels. Alternative fuels are transported largely by rail and truck which will not be cost-effective if large volumes must be transported. Significant changes in infrastructure to accommodate biomass will require large enough volumes of those alternative fuels to justify infrastructure investment. Also, over the long term a wider range of alternative fuels may need to be transported through our nation's distribution networks (i.e. hydrogen). Research and investments related to fuels distribution networks must be cognizant of the array of fuels which may need to be transported over the long term. Future infrastructure development will require coordination with the petroleum industry to ensure distribution; storage and point-of-sale equipment needs are met.

Lack of fuels specification can also be a challenge in distribution. For example, there are concerns regarding shipping of biodiesel blends and ethanol blends via pipeline. Moreover, there are differing impurities profiles for each product with each presenting different implications for distribution and end use.

Product Uses

One of the major needs in the product uses category is continued development and greater market experience for emerging bioenergy and biobased products. Procurement requirements such as the Federal Biobased Products Procurement Program, renewable fuel standards, and renewable portfolio standards should be pursued. Models of successful past programs include federal requirements to use recycle paper. These types of programs should also be carried out at the state level. States such as California, Illinois, Iowa, Minnesota, Maine, and Washington are considering such programs.

However, as market penetration grows for biobased products and biofuels there is a growing need for product specifications to ensure product quality and performance. The biomass industries must collaborate to develop specifications, standards, testing and certification procedures to ensure biobased energy and biobased products meet consumer requirements for quality and performance. More coordination is needed with auto manufacturers to develop the number of vehicles required to meeting biofuels goals.

B. RESEARCH NEEDS FOR ACHIEVING VISION GOALS

The following are research needs identified in the area of Product Uses and Distribution. Research needs are in four categories:

1. Transportation and Distribution Systems
2. Expanding Product Uses and Applications
3. Certification and Product Specifications
4. Resource Sustainability

1. Transportation and Distribution Systems

Greater investment in existing transportation systems is needed to transport the quantities of biomass needed to meet Vision goals. Significantly more research is needed to develop new and advanced distribution systems that can cost-effectively move large quantities of biomass feedstocks and products in an environmentally sound manner.

High priority research needs include:

- Multi-modal Transport Study – A joint public-private study involving government, the fuels and automotive industries, as well as industries which comprise the supporting infrastructures should be conducted. It should examine the entire transportation and distribution network for multi-mode transport options and requirements for supporting those options. It should identify recommended changes to the energy distribution system to accommodate a range of alternative fuels which may be developed in coming decades. Such a study must include economic analysis to identify the volumetric "breakpoints" at which new distribution systems become economical to develop.

- Densification – Technologies and methods are needed for fast and inexpensive feedstock densification.

Additional research needs include:

- Feasibility studies for long-run pipelines (i.e. from the Midwest to West Coast) and when pipeline systems are justified over other methods of distribution.
- Develop corrosion resistant materials and corrosion protection methods. This may include development of innovative analytic sensors for corrosion protection.
- Working with industry and the Department of Transportation to test all aspects of design and manufacture of product pipelines and investigate opportunities for biofuels.
- Development and testing of an additive that will allow ethanol to be blended at the refinery site.

- Production of clean hydrogen from biomass for stationary application fuel cells (distributed energy).
- Development of pipeline systems that are also processing systems.
- Designs for truck and rail handling and hauling systems that are specific to biomass (i.e. can compact feedstocks while loading).

2. Expanding Product Uses and Applications

Opportunities exist for expanding product applications due to improved feedstock production, development of new and higher quality biobased products, biofuels, and gaseous fuels.

A large number of measures were identified to increase the range and quality of products produced from biomass. The highest priority research need in this area was a scalability study to evaluate feasibility of on-farm processes for methane production and other farm-based energy production systems. Issues including scaling, chemical process safety, and logistics will need to be considered in the analysis. The organic foods or bottled water industry may be a good model to evaluate.

Additional research needs included:

- State partnerships with the DOE Clean Cities program to expand emphasis on biomass technologies.
- Interagency research initiative for development of new biobased products.
- Incentives to build new plants for production of biobased energy and products.
- Oil and protein platform improvements to facilitate new product development.
- Design and development by the home heating or appliance sector of modular conversion technologies to facilitate on farm use in appliances.

3. Certification and Product Specification

Certification and product specifications are needed to ensure product quality and long-term consumer acceptance. These specifications also will be required for quality testing, international trade.

The highest priority identified was the need for the industries that make up the biomass industry to work together at the earliest possible stage to establish standards that are appropriate for biomass end products – the type of material or product being produced and the manner in which it is produced and to be used. Testing methods should be developed around product functionality rather than comparisons to existing products.

Additional research needs include:

- Improved purification techniques can be developed so that products meeting industry and consumer specifications.
- Sensors and controls can be developed for quality assurance.

- Studies on whole-system sustainability for purposes of certification and green labeling are needed. This will consider the entire production system from feedstock to disposal/recycling.
- Continued research on biobased solvents including classification/specifications; VOC emissions, and inert ingredient specification.

4. Resource Sustainability

Both resource availability and implementation of sustainable methods for production, consumption, disposal and recycling are important matters to address in expanding product applications for biomass. The highest priority research need was for a biomass-led study on food-versus-fuel issues to evaluate issues of availability and possible impacts on supply and costs.

Additional research needs included:

- Design recycling into biomass production and end-use systems (i.e. closed-loop systems) and ensure that recycling is economic. Design biobased products for reuse.
- Conduct life cycle analysis to evaluate environmental and security benefits.

IN THE FINAL ROADMAP, WE WILL INSERT A CHART FOR EACH SECTION ILLUSTRATING THE PATHWAY R&D AND TIMEFRAME.

IV. PUBLIC POLICY MEASURES TO SUPPORT BIOMASS DEVELOPMENT

A number of policy measures can be implemented to improve the status of biomass technologies in the marketplace. For example, consistent long-term federal policies are necessary to ensure the availability of loans and investment funding, encourage venture capital investment, and provide a sound footing for the development of new technologies. Current incentives, such as the ethanol tax incentive, have catalyzed the development of the biofuels industry. To maintain the growth of the industry, equitable financial incentives, which would include tradable credits, should continue and incentives for other bioenergy and biobased products should be investigated.

Moreover, increased integration and/or coordination is needed between the U.S. Department of Energy, the U.S. Department of Agriculture, and other federal agencies in performing bioenergy and biobased products research, working with industry to identify research priorities, and transferring research results to industry. Both the U.S. Environmental Protection Agency and the U.S. Department of the Interior, as well as states and counties, should be involved in ensuring the greatest positive results for the environment and the use of public lands.

Current important policies that promote biomass are listed in Exhibit 1.

Exhibit 1: Current Policies that Promote Biomass

Fuels	Power	Products
The Clean Air Act and Federal RFG Required Areas Ethanol and Biodiesel Tax Credit (VEETC) Alternative Fuel Infrastructure Tax Credit Small Agri-Biodiesel Producer Credit State & Alternative Fuel Provider Rule Federal Renewable Fuels Standard Small Ethanol Producer Credit Clean Fuel Tax Deduction Alternative Motor Vehicle Credit Hybrid Motor Vehicle Credit Federal Fleet Requirements	Renewable Electricity Production Tax Credit (PTC) Renewable Energy Production Incentive (REPI) Feed Laws or Advanced Renewable Tariffs (ARTs) Regional Greenhouse Gas Initiatives Renewable Energy Systems and Energy Efficiency Improvements Program Tribal Energy Program Grant	Federal Biobased Products Preferred Purchasing Program (FB4P) Federal Commodity Credit Corporation (CCC) Bioenergy Program

A. CHALLENGES

Financing training and education are major challenges which effective policies could resolve. There is a lack of financial assistance to deploy R&D technologies for development in large scale industrial production facilities. The petrochemical industry is established, with a production and distribution infrastructure in place. Biomass feedstocks and outputs can not readily use this infrastructure without major modifications. Moreover, the U.S. workforce is not trained to utilize biofuels, biopower, and bioproducts. The general public and public officials are not fully aware of the benefits of biobased products.

B. PUBLIC POLICY NEEDS FOR ACHIEVING VISION GOALS

The following are Public Policy needs identified which are necessary to promote the use of bioenergy and biobased products in the United States. Policy needs feel into six categories: Education, Public Outreach, Financing, Incentives, Environmental Measures, and Regulatory Environmental Systems Integration.

1. Education - Training and education of the industry and workforce is integral to promote the bioeconomy, especially in the long-term. However, there is a lack of curriculum in the basic sciences as they relate to biomass, biofuels, or bioproducts resulting in no investment in educational programs. Curricula development should begin with education at the K-12 level on what is biomass and how can it be used in daily life. At the college level there should be an increased emphasis on encouraging the undergraduate enrollment as well as the development of new curricula and new multidisciplinary undergraduate programs to generate degreed workers for the industry. Distributed biomass processing will require education and intellectual capital and an interdisciplinary approach to fund exploratory R&D.

Education-related measures identified as high priority:

- White Paper on educational and R&D needs and the specific funding in the three platform areas (biopower, biofuel, and bioproducts). In addition, papers in scientific journals that address biofuels benefits and the educational needs.
- Training at all levels to avoid gaps in technical knowledge of biomass, which will address the gaps for full scale production.
- An increase in National Science Foundation grant opportunities related to biomass R&D. Also increase National Academy of Science studies on biomass.
- Publication of biomass technical papers which make the linkage between energy, environment, and social issues.
- Life long learning at graduate schools and graduate programs to encourage biomass research.

Additional needs include:

- There is a need for four-year degree programs with interdisciplinary focus. USDA/DOE/NSF R&D programs need to expand and develop higher education challenge grant programs.
- Clearly define R&D needs e.g., funding in chemicals and genetics.
- University extensions programs; related curricula and availability of jobs.
- NSF should explore biomass related opportunities at a level similar to that applied for nanotechnologies.

2. **Public Outreach –** Existing biomass initiatives (i.e., 25x25), the biomass related industries, and the environmental community should form a coalition to promote benefits which are specific to biomass and which no other resource can provide. There needs to be an increase in consumer education and an organized approach to convince the public on the benefits of biomass. Moreover, the industry needs to speak with one voice.

Public outreach measures identified as high priority:

- The importance of conservation and sustainability needs to be communicated to the public to encourage wide spread support for technologies such as biomass.
- Coalitions should be established with a mix of industry, consumer, and environmental groups, to promote the economic, social, and environmental benefits of biomass.

Additional needs include:

- There needs to be an effort in the biomass industry to work with media for more widespread outreach activities. A public outreach activity could be to develop slogans, promote energy related aspects, decrease fear of genetically modified organisms, and increase knowledge of the benefits derived from biomass reducing U.S. dependency on oil.
- Partnerships with pharmaceutical and other biotech industries which already have an established industry and strong outreach mechanisms.

3. **Financing –** Financial incentives such as loan guarantees, increased venture capital, and reduction of risk through risk management are high priorities for the biomass industry. Risk sharing or insurance for demonstration projects will create incentives for biomass markets. This can be accomplished through community "buy down" of risk enabling technical breakthroughs in biomass R&D and deployment.

Finance-related measures identified as high priority:

- A "Manhattan Project" scale investment for development of biorefinery and the bioeconomy e.g., one "Billion" dollars for biomass R&D. (see Processing and Conversion)

Additional needs include:

- Risk management tools such as income insurance and established futures markets (commodities exchange market) for energy crops will reduce risk and lure financing from large scale investors.
- Increased demonstration funding for unproven technologies is important for new emerging technology development.
- There is a need to lower matching funds requirements in Requests for Proposals (RFPs) for the federal government.
- Currently there is too high a return on investment (ROI) requirement, requires >30%, on new technologies or post-demonstration production.

4. **Incentives -** Current incentives are only related to gasoline or diesel displacement, rather than petroleum displacement (used to make chemicals). A paradigm shift in policy from gasoline displacement to energy security will encourage a reduction in demand for petroleum and all fossil fuels as well as improve domestic energy security by encouraging consumption of domestically produced biomass for fuels, power and products. Biomass incentives need to reduce uncertainty so that the private sector can move technology forward for the public good. There needs to be a measurement and valuation of externalities using life cycle assessment to quantify impacts.

Incentive-related measures identified as high priority:

- Long term policies will provide a stable investment environment. Policies also need to apply to the whole supply-chain in biomass industry. An analysis should be completed to identify those barriers.
- Petroleum displacement credits should be developed to encourage biomass products use. Identify successful incentives that apply specifically to biofuels and adapt them for bioproducts.
- Conservation Reserve Program (CRP) payments should incorporate widespread energy crop production.

Additional needs include:

- Incentives for agricultural residues which will help increase feedstocks for the biomass industry.
- CO_2 credits should be established through regional programs or agreements creating a disincentive to use fossil fuels for power, fuels, and products.

5. **Environmental Measures -** Environmental benefits of biomass include reduction in net CO_2 emissions, the largest contributor to global warming. Biobased fuels and products also reduce harmful air emissions such as carbon monoxide, particulate matter, nitrogen oxides, and hydrocarbons. In general biofuels and biobased products are essentially nontoxic and biodegrade readily. Their use displaces fossil fuel use, in turn reducing damage to the environment from energy extraction processes such as petroleum spills and leaks, oil drilling and coal mining. However, there is a land use debate, ranging from converting food to fuel and products, petrochemical fertilizer use, to water management and movement. There is a need for metrics for environmental impacts of biomass in relation to fossil fuels.

Environmental measures identified as high priority:

- Life-cycle analysis (LCA) is needed for biobased products and fuels as well as fossil fuels to accurately quantify the cost-benefits of these products. This should include identification ecosystem services such as reduction in erosion, reduction in CO_2 levels, increased water quality, and quantify values for biomass crops as well as metrics for public benefits. The data generated from these life cycle analysis can then be used to create policies which will “level the playing field” through taxes on products which have large negative environmental impacts or rebates for products which have less negative environmental impacts.

Additional research needs include:

- A sensitivity analysis associated with LCA to identify high risk environmental impacts which can be addressed immediately through increased biobased fuels and products use.
- If a transition from fossil fuels to biomass takes place, increased pressure on arable land will occur. A carbon soil study is needed to analyze the affects of taking carbon from soils.

6. **Regulatory Environmental Systems Integration -** To help develop the biomass industry, regulatory environmental permitting must be streamlined to encourage increased production of biobased products as well and more industrial facilities that process biomass for products. The whole supply chain for biomass from growth to end use must be integrated in research and development efforts, policy implementations, and infrastructure development.

IN THE FINAL ROADMAP, WE WILL INSERT A CHART FOR EACH SECTION ILLUSTRATING THE PATHWAY R&D AND TIMEFRAME.

ATTACHMENT ONE

DOCUMENTATION OF CARDS POSTED DURING CENTRAL REGIONAL ROADMAP WORKSHOP SESSIONS

Key:
Blue card – category header
Yellow card – current status by category
Green card – R&D categories
Purple and Red cards – R&D and policy needs

Feedstocks

1. Biotechnology and Plant Physiology (blue)
    a. Learning more on biochemistry of lignin (switch grass) (yellow)
    b. Miscanthus my produce 2x as much biomass (yellow)
    c. Work in commercialized conola, soy, wheat (rotational crop) (yellow)
    d. Feedstock handling technology not on same path as gene R&D (yellow)
    e. Feedstock availability has to make sense across value chain (yellow)
    f. Focus is not on creating cellulosic material (yellow)
    g. More efficient plants using nitrogen (yellow)
2. Agronomic Practices (blue)
    a. Crop Development: Most testing programs are state-based - barriers to regulation and deployment (yellow)
    b. Not enough diversity and modularity (yellow)
    c. Still don’t know if limits of residual removal of biomass will ensure sustainability (yellow)
    d. Crop management practices (cotton) biomass output (yellow)
    e. Not enough diversity in crops (yellow)
    f. Pulp & paper have only 2% waste streams; Land residues constitute a high opportunity; Distiller grain constitute high Btu content; Hog/poultry/dairy/human manure (yellow)
    g. Ned to downscale more localized opportunities needed and economies of scale - social value and rural development (yellow)
    h. Large quantities of underutilized waste matter (yellow)
    i. Remain different yardsticks (yellow)
3. Feedstock Handling (blue)
    a. Siled storage capabilities have improved 2+ years ~ 50% moisture of stover (yellow)
    b. Some improvements in cotton gin waste bailing and storage (yellow)
    c. Some properties concerns (potential) w/ wet properties (yellow)
    d. Bulk is still issue in storage and handling. Need to achieve smaller economies of scale (yellow)
    e. Not close to achieving densification needed for transportation (yellow)
    f. Lime pretreatment can be explored. Some work already occurring (yellow)
    g. John Deere, residue cog. Mechanism e.g., marriage between production and feedstock handling (yellow)
    h. Advances: storage and genetics/production; limits: disconnect between production and handling, production for food & energy; economies of scale/modularity; unused waste streams of high value (yellow)

1. Ecosystem services (green) 3
    a. Make soil systems more sustainable (red) 2
    b. What is the model for feedstock diversity to address monoculture issues (red) 3
    c. Learn more on soil responsiveness to management opportunities of alternative crops (red) 1
    d. Low cost methods to diversify feedstocks i.e., to move away from monoculture (red)
    e. Recover ground with some potion of the residue for sustainability (red)
2. Sustainable increase in yields per acre (green) 1
    Genetics to improve crop efficiency (green)
    Increase photosynthesis from ~ 3% to 4% (25% increase) (green) 1
    a. Demonstrate that $$ can be made on biomass to fuels
    b. Develop crops with high cellulose content or high lignin content (transgenetic - lignocellulosic) (red) 3
    c. Integrated plant breeding approach (red) 4

   d. Partition food crops to more components than grain (red) 1
   e. More R&D in winter canola (near term) winter wheat and grain sorghum (red) 2
   f. Multi season, location field trials (10 years) (red) 4
   g. Rationale product design, structure-function, gasification-energy dense, fermentation-cellulosic (red) 1
   h. Identify crops based on yield and maturity time (red) 1

3. High value products for farmers to support production (green)
   Change economic drivers to discourage burning (green)
   Farm profitability (green) 4
   Achieve high values from residues (green)
   a. Reduce harvest costs. Densification, one pass systems (red) 9
   b. analytical models for farmer to assess profitability (red) 4
   c. Conduct LCA of biomass in comparison to forest fires (FF?)
4. Feedstocks for chemical production (green)
   Feedstock for process fuels (green)
   Additional crops for crop land (green)
   Feedstocks to enable more diverse products (green)
   Diverse feedstocks (diversity of outputs) (green)
   a. Crop insurance and financing has to happen prior to producing energy crops and diversifying (red) 8 [policy]
   b. Understand composition of feedstocks analysis (red) 2
   c. Animal waste management needs new process technology (red) 1
   d. Product definition is needed (red)
5. Decentralization (green)
   Smaller scale production process (green)
   Benefit of nutrient recycling (green)
   Distribution pretreatment (green)
   Logistics and scale not there for large biorefineries (green)
   Distributed conversion (green)
   Re-orient system so that conversion manufacturing is feedstock driven. Remove economies of scale issue (green)
   a. Modular pretreatment and processing, fractionalization “on farm methods to add value” (red) 13
   b. Separation technologies for high value products at small scale (red) 4
   c. Transform infrastructure needs to be in place (red) 1
   d. Testing and Demo (red) 1
   e. Reduce harvesting costs: densification; one-pass systems

Need a catalyst or enzyme/ develop technology appropriate from smaller scale (red) 6

Processing and Conversion

1. Thermochemical Conversion (blue)
    a. Changes in fuel/alcohol businesses to look for alternative to natural gas (yellow)
    b. Opportunities to leverage more chemical industrial processes in use now, into thermochemical area. Original roadmap was too narrow (yellow)
    c. Major strides in black liquor gasification (agenda 2020) (yellow)
2. Bioconversion (blue)
    a. Advances in corn stover enzymes but not commercial yet (yellow)
    b. Enzyme development by Novozymes/Genencorp reduced cost of ethanol to $0.15/gal (yellow)
    c. Pretreatment of lignocellulosics to support fermentation work being done (corn stover) (yellow)
    d. Understanding of plant molecular biology has improved over past several years (yellow)
    e. Biochemistry still largely not profitable (yellow)
    f. Hardwoods - addressed purification and separation issues but not yet commercial (yellow)
    g. Process on organisms to make biobased products in xylotol (yellow)
    h. Separation technologies to separate protein and oil fractions - thermochemical to biochemical (yellow)
    i. More demonstration projects - thermochemical and biochemical: Iogen, Seaalaska, Canadaeast (yellow)
    j. Need to realize biochemical conversion opportunities to produce products such as methane. (yellow)
3. Biorefinery Integration (blue)
    a. Need to recognize opportunities for high value products (yellow)
    b. Still absence of process analysis tools to analyze product slate of a biorefinery, internal (international) properties looking at feedstock and refining to multiple components (yellow)
    c. Lack of physical properties data (yellow)
    d. Technology is not there regarding self generation (yellow)
    e. Lack of effective separation processes (yellow)
    f. Growing recognition to look at whole production stream, waste, etc. (yellow)
    g. Feedstock purity is not sufficient - can be solved through crop production techniques or separation (yellow)
    h. Broin: says they've included fiber conversion. (yellow)
4. Anaerobic Digestive Biogas (blue)

1. Analyze processes found in nature (green)
2. Deconstruct plant material in same environment as it was manufactured (green)
3. Utilize agriculture/animal science research community (green)
    a. A joint solicitation from NSF/NIH/DOE/USDA in "billions" of dollars (red) (8)
    b. Ruminants process and breakdown in phases. Should learn from evolution (red) (6)
    c. Understanding fundamentals of biochemistry in nature (red) (6)

d. Establish a clear route to commercialization very specific to gene development (red) (2)
e. Systems research combined with focused R&D (red) (2)
f. Research on synergistic effects of cellulosic micro organisms and mechanical processes (red) (1)
g. Leverage biogenetics work at NIH, NASA. Involve/create a research consortia (red)
h. Identify teams of industry/academia to establish a research plan for large-scale fundamental R&D (red)
i. What are the biometrics? Understand fundamentals (red)
j. Look at semiconductor model - industry/university/government - systems based, requires drive R&D, internal policy
k. Create models to overcome intellectual property issues; foster information sharing.
l. intellectual property issues are a potential barrier (driver in this subcategory)
m. Make biochemistry a research priority. Leverage capital of NSF/OS/NIH (red)
n. Quantify and breakdown key "digestion" needs for biomass. Ask that each step be demonstrated and then combine. (red)
o. Interagency effort on how to address initiative and focus on key R&D needs (red)

1. Economically and environmentally viable biorefineries (green)
2. Risk management cross-cuts roadmap (green)
3. Explore a variety of usable products from biomass "initiative" (green)
4. Communication loop to breeders; work with universities (green)

5. Increase Yields (green)
6. Thermochemical Conversion - minimize tar, char; man syngas, pyrolysis oils. (green)
7. Categorize approaches or enzymes - facilitate research to increase yields (green)
8. Increase fuel production to decrease cost per gallon (green)
    a. A lot learned in wood industry to translate to biomass to biofuels processes (red) (3)
    b. Increase lignin utilization as much of feedstock as possible (red) (2)
    c. More properties data on diverse feedstocks and more processing data on impact of catalysts on diverse feedstocks (red) (2)
    d. Develop robust enzymatic catalysts and develop robust chemical catalysts (red) (2)
    e. Evaluate catalysts and PERF. Over multiple cycles (red) (1)
    f. Develop chemical catalysts to work in these systems, don't foul (red)
    g. Need to understand biochemistry of micro organisms (red) (1)
    h. Evaluate and control micro organism pathways (red)
    i. Control understand reactors (red) (1)
    j. More thermo-tolerant biological catalysts; more extreme tolerant (red) (1)
    k. Evaluate organisms and identify superior ones (red)
    l. Simplify media requirements - will simplify downstream separation (red)
    m. More runs, more tools to assess final PERF. (red)

   n. Demos are needed at appropriate size; needed for scale-up (red)
   o. More selective chemical catalysts (red)

9. Look at oil, sugars and protein platform and cross-integration (green)
10. Synthetic fibers out of soy protein (green)
11. Major breakthrough to demonstrate that you can move from carbon/oils to platform chemicals (green)
    a. Economic analysis of opportunities for oil and proteins to displace petrochemicals and use that to focus R&D (red) (8)
    b. Organic chemistry R&D on: protein, carbo, oil, c-1 photosynthesis (red) (7)
    c. Understanding platform chemistry; chemistry design. (3)
    d. Physical chemistry to understand basic structures (red) (1)
    e. Make use of macro molecules already there (red)
    f. Gradually increase yield of corn ethanol, increase cellulosic fuels production. Use crop residue to produce process fuel.
    g. Invest in biochemical R&D at levels found in oil industry
    h. Money into R&D to attract plant breeders
    i. Chemical modification of proteins. Can you go from globular (cellular?) to structural?
    j. Design models to run reactions, economic analysis, and incremental yields.
12. Understanding risks and trade offs of diversification (green)
13. Need a new approach to separation processes (green)
    a. Comprehensive economic modeling; iterative??? process (red) (13)
    b. Fermentation of syngas (red) (4)
    c. Processes, catalysts separations, multifunctional reactions - catalysts manufacturing; enzymatic mobilization (3)
    d. Identify what unit operations need to be invested in - e.g., membrane reactions (red) (2)
    e. Include protein, carb, oil, food uses. Global economic model (red) (2)
    f. Materials science R&D. RE: mill???? and equip (red) (1)
    g. Particle size reduction and fractionalization (red) (1)
    h. Biocomposites production (red) (1)
    i. Gather property data (red)
    j. Demonstrate sites to develop the data for the model (red)
    k. Molecular weight distribution (red)
    l. Scenario under alternative oil prices (red) (1)
    m. Better estimates of cost of hydrocarbons 5+ years, hedge (red) (1)
    n. Analytical methods development create sensors to control process on-line (red)
    o. Absorption and de-absorption in a highly stable way, dilute (red)
    p. Clear direction on GHG regulations (red)
    q. Nature: harvest high energy content micro organisms. Molecular biology to better understand micro organisms (red)
    r. Estimate analytical framework for separation processes and needed materials (red)
    s. Evaluate strategic implications of $100 Bbl oil on chemical security (involve DOD) (red)

t. Materials w/ particulates. Shape or properties to only accept the desired components (red)
u. Create one-pass systems benefits of nutrient recycle (red)
v. Address acids issues (bioproducts) (red)
w. Emphasis technology that produces concentrated end products (red)
x. Optimize ability to produce “top ten” chemicals. Enzymatic inhibitors, process design (red)
y. More dilute ethanol due to diverse feedstocks (red)

Product Uses and Distribution

STATUS OF ORIGINAL SUBCATEGORIES

1. Distribution systems (blue)
    a. What are the fuel options over long term? What timeframe are we looking at? (yellow)
    b. Long-term fuel options will change (e.g., hydrogen) (yellow)
    c. Need enforcement to meet specifications for fuel (yellow)
    d. MN (Montana) mandate created issues with off quality fuels (yellow)
    e. Issues with transporting biodiesel by pipeline (yellow)
    f. Volumes today don't justify ethanol pipeline (need 25,000 BBCS/day) (yellow)
    g. Losing rail spurs to local elevators switching to less EE trucks. (yellow)
    h. Lack of training for people entering biofuels/BBP (yellow)
    i. Summer oxygenate requirements area a driver. Need to identify more alternatives MTBE (yellow)
2. End products (blue)
    a. Pipeline corrosion issues force train or truck (yellow)
    b. Scandanavia more reuse of wood products (yellow)
    c. Analogy between this program and federal paper recycling (yellow)
    d. States (IL, CA, MN, ME, IA, WA) looking into (passing) biobased procurement and RFS (yellow)
    e. FB4P **-** limited biobased products; some fuel additives will have a rule changed (yellow)
    f. Tremendous growth in fuels and products. recent to future (yellow)
    g. Increasing role of biomass as H2 energy carrier (yellow)

NEW SUBCATEGORIES

1. On farm process for production of methane (green)
    a. do a study on scalability to see if there are opportunities (purple) (9)
    b. evaluate scaling issues; logistics issues; chemical process safety (purple) (2)
    c. look at organic foods or bottled water industry as a model (purple) (2)
    d. need local markets for electricity??; alternative ways to store energy (purple) (1)
    e. when farms over produce there is resistance from utilities to "buy back" (purple)
    f. carbon neutral benefits; ethanol doesn't "need a Navy" (purple) (1)
    g. stimulate demand based on least cost attributes: i.e., environment (purple)

2. Increase product uses or applications (green) {Additional degrees of freedom that didn't exist previously i.e., fatty acids (green); Gaseous fuels; H_2 (green)} Alternative to MTBE (green); Need the infrastructure to support distribution and demand i.e., E85 autos (green); Coordinate with auto industry (green)

    a. Since 2000 soy grown: < 400 million pounds to > 750 million pounds; polyeurathanes; polyoils; biodiesel (yellow)???

b. Need to address issue of differing impurities profiles of each product and implications for distribution and end use (yellow)??
c. State partnerships with clean cities, expand to bio (purple) (4)
d. Initiative for new product development (purple) (2)
e. Incentives to build new plants (purple) (2)
f. Oil and protein platform improvements can facilitate new product development (purple) (2)
g. Home heating or appliance sector develop a modular conversion product to facilitate on farm use in appliances (purple) (1)
h. Deconstruction plant to produce gaseous fuels (purple)
i. Step wise process what builds off platform thread in P&C (purple)
j. Design platform in plant: conversion and separation process; modification; formulation to new products; certification (purple)
k. Need appliances that can use bioheat. Home heating oil market is in place (purple)
l. Need to overcome valley of death (purple)
m. Make sure localized use can address health and safety issues (purple)
n. Need user friendly appliances; have to address emissions (purple)
o. Central region has model for distribution of fuel and ash removal (purple)
p. Develop producers for use on farm (more incentive to buy) (purple)
q. Agriculture industry E3 example in NE closed loop industrial park (purple)
r. Involve end users - appliances (purple)
s. Evaluate byproducts: innovative uses; new markets for protein; etc. (purple)
t. High exposure to involve biomass and identify new approaches (purple)

3. Certification and product specification to ensure quality (green) {Coordinate production capacity with use targets (green); Specifications needed for international trade, reduce negative public perception; testing and establish requirements (green)}

a. Bioindustry needs to set standards not another industry (purple) (11)
b. certification for sustainability ties back to feedstock (purple) (4)
c. study on issue of whole system sustainability and role of certification (purple) (3)
d. Biobased solvents - classification/specifications; VOC emissions, inert ingredient specification (purple) (1)
e. Get involved in ASTM community asap; industry has to be involved in standards development (purple)
f. Certification can constrain production opportunities - look at function vs. form (purple)
g. “don’t make biomass perform like petroleum”; relate standards to the function of the material (purple)
h. put a biobased motor fuel equivalent through certification process - will educate he community (purple)
i. have biobased products be part of original equipment (brake fluids, hydraulics, etc) (purple)
j. American Oil and Chemists’ Society (AOCS) methods may work better in certification - may look to use or develop other methods than ASTM (purple)
k. Biodiesel industry needs to go through standards development process

4. Transportation/Distribution systems (green). Need more investment in rails barge - oceans/rivers (fuels, products, and biomass) (green)

l. Multi-modal transport study involving industry (purple) (13)
m. Quick and cheap densification (purple) (9)
n. Study feasibility of larger pipelines (purple) (2)
o. Test loop - to test all aspects of design, manufacturing of pipeline; opportunities for biofuels; work with dept. of transportation (purple). (2)
p. Study on optimum lowest cost distribution system at what point do volumes make it economic (purple) (1)
q. Stimulate innovation on corrosion protection on-line analytical sensors (purple) (1)
r. R&D objective to identify an additive that will allow EtOH to be blended at the refinery site (purple) (1)
s. Clean H2 production from biomass for fuel cells - stationary applications (purple) (distributed energy) - needs biomass feed transport network (purple) (1)
t. Study on transportation requirements to meet goals (purple)
u. How do you design a distribution network that fits a model of decentralized product/end-use? (purple)
v. Compatibility between mechanical properties of carried material and carrier/handlers may require retrofits or redistribution of carrier (purple)
w. Pipeline system that is a reactor/processing system. (purple)
x. New decent facilities need to address railroad economies of scale, e.g. 100 trains (purple)
y. Containship model for biomass. Transfer costs back to origin not transporter. (purple)
z. Allow competition with conv. Freight rail on a contract basis (purple)
aa. Largest pipeline network is in the region. Opportunities to use it in test loop (purple)
bb. Pipelines from Midwest to coast
cc. Maximize river use in central region: channel depth requirements; new locks facilitate barge transport; river management (purple)
dd. Customer is responsible for take-off. Reduces responsibility of pipelines opportunities (purple)
ee. More incentive and investment in shorter hauling, shorter SPLIR??? (purple)
ff. Transfer highway subsidies to rail (purple)
gg. Offset retrofit costs (purple)

5. Procurement Requirements (green); Design for recycling; closed-loop systems (green) (1)

hh. Food vs. fuel issue is a significant need. Biomass industry needs to lead (purple) (5)
ii. Cost of recycling needs to be economic (purple) (1)
jj. Government procurement program needs to continue (purple)
kk. PLA needs to be recycled (purple)
ll. Biobased materials are different than petroleum-based materials - design for reuse (purple)
mm. Important to commercial LCA - security benefits (purple)

nn. Look at Europeans for packaging materials models; look at standards that work (purple)
oo. commercial/public benefit; incentives (purple)
pp. create seed market; foster distribution; build cash flow (purple)

Public Policy

1. Education (blue)
    a. training and education of the industry and workforce (green)
        i. distributed processing will require education and intellectual capital (pink)
        ii. students and university based R&D (pink)
        iii. communicate positive benefits of biomass to public (pink)
    b. education at all levels (primary, secondary, ETC)
    c. Increase undergrad enrollment
    d. Fund exploratory R&D
    e. Interdisciplinary approach
    f. Cost-efficient and modern farming methods
2. Public outreach (blue)
    a. Coalition of environmental and biomass groups (green)
    b. Increase consumer education
    c. What are the additional benefits of biomass?
    d. Convince public of biomass benefits
    e. Education nuances of ethanol
    f. Environmental organizations should participate
3. Finance (blue)
    a. Risk sharing/insurance for demonstration projects. Loan guarantees (green)
    b. Incentives for creating markets
    c. Community to "buy down" risk
    d. Barriers of high capital
    e. Enabling technical breakthroughs that make biomass viable
4. Incentives (blue)
5. Environment (blue)

1. Education (blue)
    a. White paper on funding in platform areas (purple) (4)
    b. Training at all levels; avoid gaps or "Death Valley" (green) (3)
    c. Write NSF grants to include biomass R&D (purple) (3)
    d. Publish pro-biomass papers/ fight Pimentel (purple) (2)
    e. Papers (pro-bio) to make linkage between energy, environment, social issues (purple) (2)
    f. National academy of science (green) (2)
    g. Life long learning at graduate schools and graduate programs (purple) (1)
    h. NSF/USDA etc higher education challenge grant programs (purple)
    i. Need 4-yr degree programs but need general well-rounded training: need funding of chemicals and genetics (purple)
    j. Clearly define R&D needs (purple)
    k. USDA/DOE/NSF programs need to expand/develop (education) (purple)
    l. Lack of interest of basic science; no money (green)
    m. University extensions programs; related curricula and availability of jobs (purple)
    n. Similar nanotechnologies from NSF (purple)
6. Public outreach (blue)

   a. Conservation and sustainability message (purple) (3)
   b. Establish Trade Associations (2)
   c. Create Biomass Association/ Lobby (green) (2)
   d. Coalition with selected environmental groups (purple) (1)
   e. 2525 Coalition
   f. industry to work with media (Discovery Channel) (purple)
   g. Public outreach slogans (purple)
   h. Partnerships with pharmaceutical and other biotech industries (green)
   i. Energy related aspects - decrease fear (purple)
   j. "Scare" campaign - dependency on oil is bad (purple)
   k. Don't preclude "food" crops in RFPs (purple)
7. Finance
   a. Reducing investor uncertainty is important federal agency mission (purple) (5)
   b. Manhattan project for development of biorefinery (purple) (3)
   c. "Billion" dollars for biomass R&D (green)
   d. lower matching funds requirements for RFPs (pink)
   e. Risk management tools (pink)
   f. Lure financing from tycoons (Bill Gates) (purple)
   g. Lack of funding for unproven technologies (purple)
   h. Income insurance (purple)
   i. Establish futures contracts (commodities exchange market) for energy (purple) crops
8. Incentives (blue)
   a. Long term policies (purple) (5)
   b. Supply-chain analysis - incentives/barriers (purple) (3)
   c. Petroleum displacement credits (green) (5)
   d. Draft similar incentives that apply to biofuels for bioproducts (2)
   e. CRP payments for energy crops (green) (1)
   f. Analyze incentives for barriers (green) (1)
   g. Look at new demonstrations; supply-chain; create incentives (purple)
   h. Keep incentives for agricultural residues (purple)
   i. Target prices and deficiency payments (purple)
   j. CO2 credits; establish programs or agreements (purple)
   k. Growers in regions need to commit to growing; long term contract - guaranteed prices (purple)
9. Environment
   a. LCA (green) (5)
   b. Identify ecosystem services and quantify values for biomass crops (purple) (1)
   c. metrics for public benefits (green) (1)
   d. Coalition with environmental groups (purple) (1)
   e. sensitivity analysis - associate with LCA (purple)
   f. Carbon Soil Study- taking carbon from soils is an issue (purple)
10. Regulatory Environmental Systems Integration (blue)