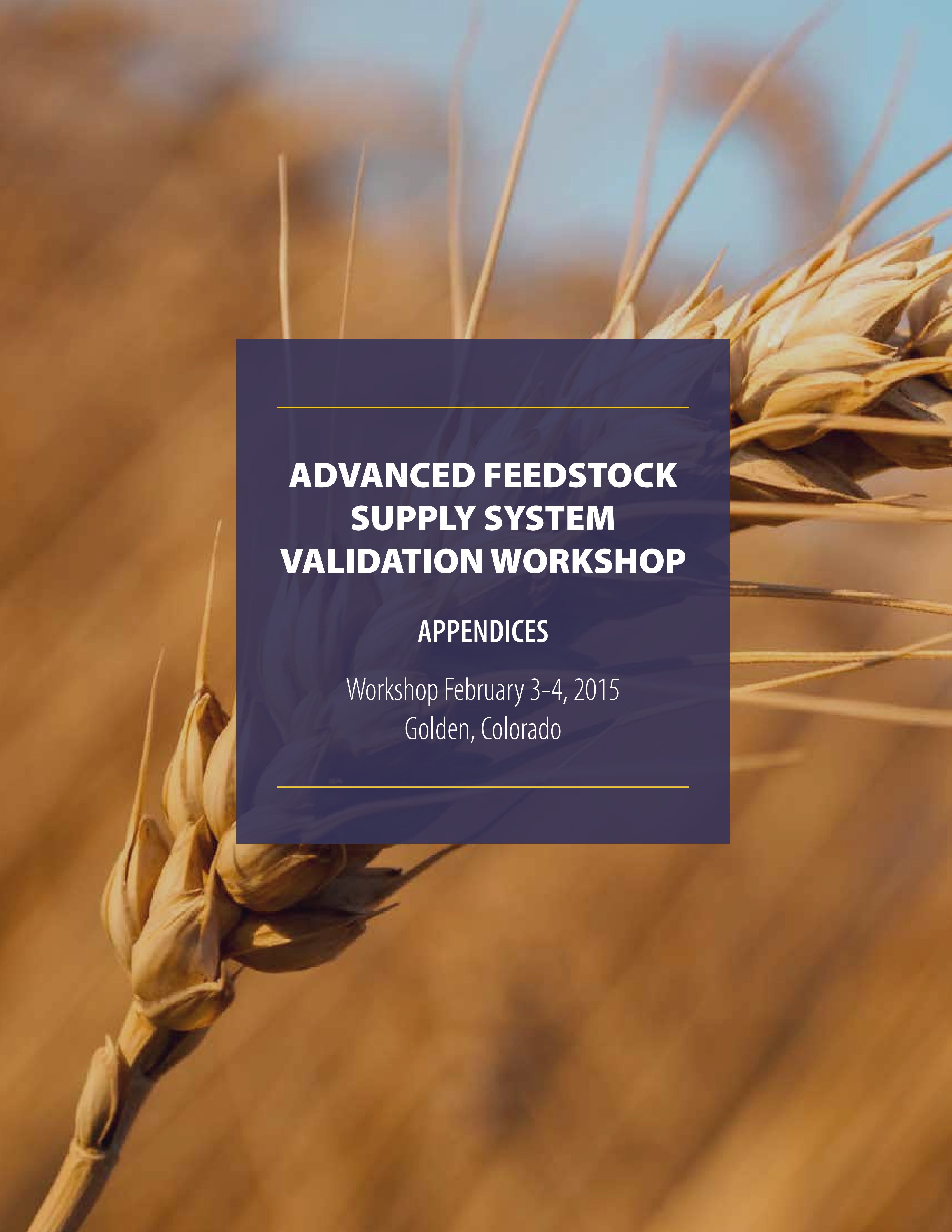

ADVANCED FEEDSTOCK SUPPLY SYSTEM VALIDATION WORKSHOP

APPENDICES

Workshop February 3-4, 2015
Golden, Colorado

APPENDIX A

Participant Comments

Comments presented in this appendix correspond to numerical references included in "Industry Perspective" sections, which are of the format "[high level topic. Sub reference]." Numbering re-starts each section. Note comments are presented as captured in the ThinkTank tool, including spelling mistakes and grammatical errors. Note that names associated with comments have been removed.

Participant Comments Received on Draft Report

D1 There is a sugar mill in South Florida that processes 5 million tons in a 140 day season. (True---the MC is 80+%.) There is a paper mill in VA that unloads 450 logging trucks/day and it is not the largest paper mill in the US. My point is that there are commercial industries in operation today that know how collect and process megatonnages of biomass---both woody and herbaceous. This report is so focused on making the case for "Advanced Feedstock Supply Systems" that the capabilities of current systems are not properly credited. Note---I am not arguing against an advanced system, but am arguing that we properly credit the successful current systems.

D2 It is true that the three current biofinery projects are located in "sweet spots". The points being made is that we need to access biomass produced in areas with a lower potential concentration of production fields. Valid point, but lets develop that point a little more. Here is the question---would you rather locate your biorefinery in a location where 15% of the surrounding land area is supplying feedstock of 5%. The answer is easy---15%. But suppose I now tell you that the yield from the 15% fields is 1 ton/ac and the yield from the 5% fields is 3 ton/ac. What is the answer now? The "feedstock density" is the same for both locations. If the farmgate contract price is the same, both locations have equal potential.

Now suppose that the land area surrounding a potential biorefinery location has 50% large farmers and 50% small- and intermediate-size farmers. We design our feedstock collection technology so that only large farmers can afford the investment to get a contract. We have now eliminated (sequestered the biomass) from 50% of the surrounding land area. The point was made in the workshop discussions that provision needs to be made for small and intermediate-sized farmers to get a farmgate contract. This point does not come through in the report. It is potentially a very strong argument for the "Advanced" concept.

D3 I believe the report should acknowledge that all agricultural industries qualify as high risk, not just the biomass industry. The same weather, disease, and pest issues apply to all. To classify the biomass industry as higher risk than any other agricultural industry is a misrepresentation, unless you are talking specifically about corn stover in the Midwest---a 5-week harvest season that has to occur after the grain is harvested. A wet fall and early snow will really define high risk.

D4 Need to point out that the depots need to be built with excess capacity to handle the excess production from a "banner" year. This might be a good time to introduce at least one of the research for an Advanced system. How much excess capacity should a depot have based on historical weather patterns?

D5 I have always been an advocate of a farmgate contract that that was tied to some industrial index. When fuel prices go up the farmagte contract goes up. Both the conversion and feedstock people get to share in the increased profits. When fuel prices go down, then both take the "hit" together. We organize to achieve a "win-win" or a "lose-lose". I do not believe the win-lose format will ever be stable.

D6 I believe there is, in general, an under appreciation of the need for short-term storage of raw feedstock. This storage is referred to as "roadside" storage by INEL and "satellite" storage by the biomass logistics team at Virginia Tech---same concept. As a research program is laid out for the depot concept, let's include varying amounts of raw biomass storage and quantify the economic impact of this storage on the cost of the depot delivered product.

D7 Amen and amen. Ten years from now in the next DOE workshop, the "conversion" people will be saying three things.

1. The feedstock is non-honogeneous---too many plant species other than the target species.
2. The feedstock has too much dirt.
3. The feedstock costs too much.

These concerns must be addressed by both the conversion and feedstock people. In every ag industry the processor has a cleaning operation as part of their receiving facility. I hope this report will firmly make this point. It is time for everyone to get real on this very, very important point.

D8 This is a key point. Can we expand it by adding two factors.

1. Any field operation requires the operation of a diesel engine. Fuel cost is set by the transportation industry. It is always (or almost always) better to use electric power for an operation---example densification.

Field operations are weather and daylight dependent. Always better to do an operation at a stationary location where there is the potential for 24/7 operation.

D9 When you pay for quality, you will get it. Farmers, like most of us, like to do a good job.

D10 This is really a key point. How can it be emphasized more in the report?

D11 This is consistent with other agricultural industries. It certainly is expected for the biomass industry.

D12 Look at the cotton industry as an example. Cotton ginning tis the most sophisticated solid-solid separation technology we have. It can separate tiny pieces of leaf from the cotton fiber. At the depot, we can take anything out of the raw biomass that the conversion people want. Are they willing to pay the cost.

D13 I recommend changing this statement. "…the cellulosic ethanol plants WILL need to adapt to this as well." . Cardinal rule---never slow down the harvesting operation. It is the most weather dependent operation in the industry. There are fewer days per year when harvesting can occur so never slow it down by adding complexity to the field operations.

D14 There is a large amount of land in the Piedmont of the Southeast that cannot grow grain competitively. This land can grow native warm-season grasses competitively. Potential for a biomass producer to change to another crop is limited. This is one of the reasons, along with high annual rainfall, that the Piedmont of the southeast will be the leading biomass production region of the U.S.I very much hope that DOE will emphasize the SE as it plans the "Advanced" program of work.

D15 I strongly support this concept. How can it be emphasized more? Local communities need to point to the facility (depot) and say'"That is OUR bioenergy plant." We are producing the liquid fuel needs for our community. Ect…

D16 I assume you will mention the risk of biomass burning up in the stackyard--a problem that every cellulosic ethanol producer has now experienced, some of them multiple times.

D17 This will drive equipment cost up and cost of harvest up. Agree we can improve in many areas but it will come with an equipment cost

D18 This is most commonly a result of storage or poor harvest management. Could improve storage area and improve quality

D19 Must include workshops for local land owners to discuss and learn about sustainable practices – not sure they will trust an analytical tool on the web.

D20 Consistent feedstock spec is needed as a target so we can improve the supply costs

D21 MUST be better implemented and consistently funded unlike BCAP

D22 Agree – and isn't that why we are supporting regional depots?

D23 Not all competitive uses will require pre-treatment or densification.

D24 But one thought was farms could use current equipment to supply the depot – so not sure I agree with this statement

Session 1 Participant Comments Corresponding to Text

1. 12,000 ton per day feddstock supply ()
2. Does this assume a centralized or distributed model? ()
3. Does include the delivered cost of feedstock? ()
4. Need to recognize that local growing conditions will require differnt types of equipment. What John Cundiff thinks will work in VA won't be viable in TX, and vice versa. ()
5. What are the opportunities for brown field sites, integration with corn ethanol plants or petroleum refineries? ()
6. B ()
7. b ()
8. c ()
9. B ()
10. The scaling equations do not incorporate disconnects in the economies of scale along the scale axis. ()
11. c ()
12. all tied back to market demand and viability of technology. this will drive investment and size ()
13. The size will be in the 500 to 1000 ton/d range. ()
14. b ()
15. A ()
16. b ()
17. c ()
18. c ()
19. b ()
20. b ()
21. So c) ()
22. A fully mature industry will be on the scale of the existing energy industry. Long term success would mean that bioenergy would just be another part of the energy infrastructure. ()
23. The local hub of end product choices and financial considerations of the grower base..Food Fuel Bioproducts ()
24. Do the 3 cases need to be exclusive of each other? ()
25. b ()
26. There may be thousands of primary converters of biomass to sugars, pyrolysis oils, etc. ()
27. b ()
28. b ()
29. multiple markets for biomass is a DECOUPLE D good idea. What do we do about that ? DECOUPLE BIOMASS MARKET FROM BIOFUELS. AND APPLY TO ALL BIOMASS MARKETS. ()
30. c) ()
31. a ()
32. 32. a ()

33. Typical oil refinery is about 30,000 tons per day...wet mill scale. Biorefineries need to get to that scale to compete on price. ()
34. B - on multiple feedstocks ()
35. b ()
36. b ()
37. can you densify material enough to offset transportation costs? (Glenn Farris)
38. B. but with a higher-value adding preprocessing step occuring in the region -- otherwise it is less than A ()
39. I don't think the market will be at scale like the corn-ethanol industry experienced. ()
40. different sizes in different locales. it will depend on specific local characteristics ()
41. If we are truly a decoupled industry, we have to look at multiple markets. Biofuels will be larger scale than biochemicals and products. Biopower could blow them all out of the water with large scales as well. ()
42. b with existing harvesting technologies. Will need creative approaches to CHST to get to c ()
43. () Not an "A B, C" answer. All of the above. Economies of scale has discontinuities that are not reflected. For example, dairy industry has operations that range from small to large. Industry will have refineries from across these scales. ()
44. Response to Dave #35. Then how will we get to the scale of the fuels our society needs? ()
45. The models to look at are the current commodity systems that integrate disparate feedstock resources into end products ()
46. a, b and c. You need all ()
47. do the cases presented on this slide consider economies gained through integration with existing plants/ refineries. ()
48. Barrier: how do you anticipate the multiple sizes of future refineries ()
49. Whats your existing harvesting and storage capabilities? Need to know before you can look at refineries () ()
50. The size of biorefinery will be a function of feedstock type and feedstock distribution availability. Co-products will also drive the size. The ultimate size will probably be from 100 DMT to 2000 DMT/day. ()
51. we have to look at all the markets we are servicing. ()

Rank	Ballot Items	Score	Avg.Rank	Std.Dev
1	BIOMASS PRICES	6.78	3.22	1.81
2	TRANSPORTATION & LOGISTICS	6.33	3.67	1.98
3	SUPPLY RISKS	5.93	4.07	2.21
4	LAND OWNER OR PRODUCER ACCEPTANCE	5.81	4.19	2.0
5	SUSTAINABILITY	5.78	4.22	2.27
6	MARKET DYNAMICS / ENTERPRISE & STRUCTURE	4.85	5.15	3.08
7	RAW MATERIAL CHARACTERISTICS	4.85	5.15	2.12
8	SEASONALITY	2.37	7.63	1.36
9	SUPPLY DIVERSITY	2.3	7.7	1.27

BARRIER	Comments
1. BIOMASS PRICES	1. Price sensitivity of the feedstock 2. Cost/benefit analysis - will/can the biorefinery accept higher cost, and how much, for conditioned/densified/fortified/etc biomass - AND, who makes the investment in the feedstock facility? Are we suggesting a new middleman between the producer/ operator and the biorefinery? 3. what is the price of petroleum... 4. Higher value end products are required to build this market 5. A detailed understanding of the price points for feedstocks and feedstock logistics as the market penetration increases not just the model mature market price. 6. capital costs of the biorefinary and its burden on feedstock cost 7. efficient feedstock supply chain and willing participants 8. Biomass markets must be competitive to other food, feed, fuel, and fiber opportunities for farmers (on a localized basis) and provide return to landowner/grower 9. Cost of current energy forms (Oil, NGas, coal) 10. Not sure there are any if the system is economical. Witness the forest products industry. 11. unpredictable production volumes - from seasonm to season 12. Biggest barrier will be the competitive position relative to fossil fuels. We can't push bioenergy up a cost competiveness hill. 13. Biomass Storage and grower incentives 14. biomass production is a regional process (climate, alternative crop enterprises, social structure0 that must integrate into a national energy market that expects a standard product 15. lower financial returns than other investment opportunities 16. the price of fossil fuels 17. ARPA-E grants are high risk. Not all winners, but opportunity to advance technology 18. Cost of biomass feedstock 19. The contract offered the feedstock producer should have a component tied to an industrial index. Fuels prices go up the producer should get their share. 20. Think more broadly about prices

2. TRANSPORTATION & LOGISTICS	21. For this size biomass must be granulated and handled like grains. 22. Equipment and storage systems that will minimize the $/DMT at the needed scale 23. Storage space, reclaim distances, weather risks in storage... 24. Load limits are there for a reason... 25. financing the supply chain 26. Overall capital costs of the system are really important. Ideally, the capital cost of the depot level processing would be borne by local investors who could then participate in the value add, and reduce capital cost at the biorefinery per annual gallon of fuel. 27. Increasing the legal wieight limit could a lot toward answering this. 28. These hard facts take us toward short distance truck transport to local depot where the biomass will be densified and stabilized against degradation 29. Transportation infrastructure 30. energy ballence, 31. Collection and storage technologies must become moisture insensitive to expand the industry beyond limited areas where climate is condusive to field drying. 32. The equipment industries can respond to the need for heavy duty balers or other collection equipment when the market is there. Just look at the mining and construction industries. 33. pounds per qubic ft transportation 34. Management of storing perishable biomass over time (months to years) 35. 1 billon ton can not move buy truck 36. Manufacturing production lines of biomass harvesting and pre-processing equipment for significant market penetration. 37. railroad infrastructure, cost, and availability if assuming regional shipping of pelletized feedstocks 38. Pulpmills already operate at the 2-3 million ton capacity per facility. 39. BETO start coming up with funding oppurtuinties that allow for ingenuity. go beyond imporving existing technologies 40. Bailers have responded to current market place. But bailers need to not just be novel, but durable. Has to handled hundreds of thousands of acres. Used for multiple markets/end uses. 41. Improving existing technology for harvesting (T Robb) 42. Energy balance may become a barrier before cost - especially when energy prices are low

3. SUPPLY RISKS	
	1. Manufacturing of supply equipment. The amount of investment can be staggering. 2. In the case of the use of woody biomass, competition with the existing wood products industry is an issue. 3. With conventional supply systems: grower adoption, feedstock risk, temporal quality, market access 4. market viability for equipment mfgrs to invest and create new (disruptive) approach 5. How do you switch from sourcing feedstocks in local supply sheds into feedstocks becoming a commodity item? 6. Lack of efficient harvest equipment to harvest large volume of biomass during short harvest season 7. too much risk, supply, policy, off-take 8. cost of borefineries 9. Weather/yield risk 10. robust, viable and cost effective feedstock supply 11. variability of biomass quality at the 500 million dry matter tons scale and higher 12. physical from of feedstock 13. R&D standpoint cant invest 30 million dollars in a new piece of equipment in an industry that doesnt exist 14. Real and perceived political risk dominates all other risks. 15. It seems to me that we need a large existing market for the biomass so that we can ADD bioenergy as a market. If the corn ethanol industry did not have a large existing corn supply system for OTHER uses. how would it have grown as it did? 16. general immaturity of the industry -- innovation requires experience 17. who comes first feedstock depot or biorefinery? How can you produce something for an industry that doesnt exist? Competing uses for the biomass. 18. How family farm that is small can cope with the large quantity 19. Establishing specifications, sampling and quality measurement techniques 20. Dealing with high moisture biomass 21. The ability of all participants in the supply chain to shoulder their own risks 22. developing financeable supply chains - not just ones that can operate 23. Variable and uncertain feedstock availability will limit biorefinery size. 24. information systems to track biomass from the source to the destination 25. Biomass-specific equipment, geared toward commercial operation 26. inconstant political support 27. Baler has important role 28. delayed market emergence

4. LAND OWNER OR PRODUCER ACCEPTANCE	1. land owner acceptance 2. Land ownership, land use control. 3. Complexity of managing relationships with the number of growers/producers/ suppliers 4. Growers have to have an incentive to participate in the supply chain. Currently those incentives are small. 5. long term leases vs. market prices to cause production of energy crops (I am biased toward crops rather than residues) 6. land owner acceptance 7. Biomass price points when competing with other land uses 8. 44%of the farm;land in the US is owned by non-farmers 9. land values 10. If the only market for the biomass is the bioenergy industry, the producers will be the captive of that industry, why will they produce or supply at the scale we need? Captive producers are not incentivized producers 11. Gaining support of environmental regulators to enable market entry of different crops and growth protocols. 12. Glenn Farris-Farmers are not well represented here at the meeting. THey are particular about what is used on their land and how it affects their soil. Farmers might not want to use the new equipment. 13. Everyone in the supply chain needs to profit. 14. We need grower education of sustainable harvest and to develop a comfort level in biomass harvest. 15. Provide more opportunity for small and inmtermediate-size farmersa. 16. how do you incentivize participation 17. Where are we going to grow the energy crops?

5. SUSTAINABILITY	1. Sustainability 2. Limits to local, economically available supplies during feasible harvest windows for the area 3. what is the price of carbon 4. substainable harvest rates 5. Energy balance - the bigger the biorefinery, the greater the need for high density feedstocks 6. short distance hauling 7. Quantity seems to be more a function of sustainable amount that can be removed (low ash), than mere cost 8. Without clear sustainability advantages, society will probably not allow us to build out the industry. We need to demonstrate environmental. economic and social sustainability advantages. 9. food vs.fuel controversy 10. viable market and projects that are financiable
6. MARKET DYNAMICS / ENTERPRISE & STRUCTURE	1. Cost of conversion 2. is this just liquid energy? 3. building permit process limitation 4. In sufficient steel and CapEx availability for this green site, standalone biorefinery in the U.S. 5. large enough market for ethanol 6. The valley of death in finance exists at all business scales, not just entrepreneurial firms. How do you make large and small industry investment risks palatable? 7. end-product value must be high enough, and demand stable enough, to support higher cost feedstock supplies and supply systems 8. market drivers and incentives far above today's circumstances are needed to grow feedstock supplies to the levels indicated. 9. Uncertain market for biofuels/bioproducts 10. Improve conversion technology to relieve biomass cost targets ($80/ton). Must be profitable for all involved in the supply chain, not just the end user 11. pricing structure development 12. cost of fossil fuels, market, cost of feedstock, demonstration of conversion technologies... 13. Uncertainty towards the growth of energy crops. What are the market drivers/market pulls to bring energy crops to be such a large portion of the market by 2030? 14. Lack of markets

7. RAW MATERIAL CHARACTERISTICS	1. low density feedstocks. limited feedstock availability. sustainability... 2. information systems to track biomass from the source to the destination 3. Unless we have material that handles a lot like corn and other grains, we will need an entirely new set of equipment in rural America. As close to the field as possible, cellulosic biomass needs to become "corn like" in its handling and storage properties.
8. SEASONALITY	1. relative profitability of growing biomass for energy compared to other crop alternatives
9. SUPPLY DIVERSITY	1. Emergence of competing uses for the resources as supply chains reduce costs and enable new quality attributes. 2. Multiple feedstocks. Technology will evolve to accept multiple feedstocks to address seasonality, etc. Proper yield monitoring and prediction will assist in mitigating low yield years. Gives you more time to identify alternatives

Solutions	Comments
1. MULTIPLE MARKETS FOR BIOMASS	1. Expand the use of biomass for heat and power production. 2. emergence of "junkyards for biomass" - bring us what you got
2. ROBUST CONVERSION PROCESSES	1. Any solution cannot operate in a vacuum. Conversion technology advancements will affect our path forward as well. We all have to work forward together to ensure efficiencies. 2. Solve issues in the supply chain that enable significant yield increases in the biorefinery. 20% increase in sugar yield reduces effective feedstock costs by almost that amount. 3. truly feedstock agnostic conversion technologies (ie, extremely robust conversion technologies)
3. PUBLIC POLICY	1. Provide incentives for supply chain development at future biorefineries which helps with startup costs to encourage growth of financiable supply chains 2. provide a market incentive to lean the supply chain. give the existing 2nd generation biorefineries a short term (<10 year) tax credit that ensures near capacity production for a number of year 3. CARBON TAX!!! 4. farm bill policy mechanisms / incentives to produce NOW. industry will innovate

4. MIDTERM MARKET DEV STRATEGY	1. Get 2nd and 3rd and 4th of a kind biorefineries built and successful (profitable production and sales of biofuels and products) so there is a clear market for the feedstock supply system to develop into. 2. an incremental strategy for scaling the industry over time is needed. too much focus on technology issues that are decades away, if that is done at the expense of helping today's (near-term) facilities to operate more profitably (including biomass suppliers), will stunt potential near term opportunities for the industry to grow and prosper. if near-term facilities are not successful, future growth of the industry will be more limited. SOLUTION: invest heavily to help solve near-term problems. 3. Number 8 () is very important
5. MULTIPRODUCT DEPOTS	1. Multi-function, multi-product depots to help cover costs. () 2. Multiple use of biomass (energy, feed, bioproducts) () 3. Multi feedstock supply chains to support emerging diverse and adaptive production systems () 4. The MSW recyclers make their business work by bringing raw feedstock from diversified sources and selling to a diversified market. (energy, gardening, mulch). () 5. Ability to provide products in addition to energy forms, multiple value chains that may be produced either at the depot or the refinery ()
6. DENSIFICATION	1. At field dencification at 20 pounds per cubic ft. at field edge () 2. Enabling biomass packaging (densificatin, value-added preprocessing...) to enable profitable recovery of biomass from stranded counties. () 3. depot would need to produce a product that allows extended storage with minimal dm/quality loss at a reasonable cost () 4. I just don't see how we get the scale we need without a commodity intermediate that can be traded and hedged. That means a depot of some kind. I just don't see how a biomass based industry at 20+ billion gallons per year can ever be based on raw unprocessed biomass going directly from the farm to the biorefinery. () 5. Need to match value improvements with price elasticity. What is the ash percentage equation to tie to willingness to pay? What is the willingness to pay for feedstock that does not need to be hammermilled or dried? () 6. Need to understand the evolution and role of liquid conversion in preprocessing - liquid and concentrated sugars, pyrolysis oils, HTL intermediates, ... () 7. () how is cost of densification justified? Moving low density product short distance, densifying, but not adding a lot of value. ()

7. COMMODITIZATION	1. An accurate, quick testing procedure for moisture and ash of biomass. () 2. I think the evaluation metric needs to be the MESP, not the delivered cost of the biomass to the biorefinery. The larger the biorefinery the lower the MESP. () 3. a realistic look at biomass/crop options within specific geographic regions () 4. Treat establishment costs of dedicated crops as a capital cost to be amortized over a significant term. () 5. If farmers are paid more to grow the biomass (for environmental services, some other reason---a policy issue). they will grow more. If they grow more, the transport and logistics costs will decrease, then a biorefinery can reach larger scales, and the MESP can decrease...may be a wash on the MESP even though the biomass costs more. () 6. The supply chain paradigms necessarily shift from one to another as the industry scales and matures. Paradigms that work well with the first plants in a region are fine. Paradigms for the nth plant are likely to be different. () 7. Planting switch grass on poor corn ground, which likely includes HEL, will drive cost of harvest much higher = higher cost per ton. We also need to be careful not to drive up cost to harvest the commodity crops by placing switch grass in/around the corn field () 8. Utilize sorted MSW ()
8. RAIL TRANSPORT	1. Better negotiate good rail freight rates for depots-otherwise cheaper by truck () 2. If I am going to produce an intermediate (specifically a liquid intermediate, I will want to locate my de[pots along a rail coorridor () 3. change bale density and size to fit centerbeam lumber rail cars. Create fast loading and unloading systems. ()

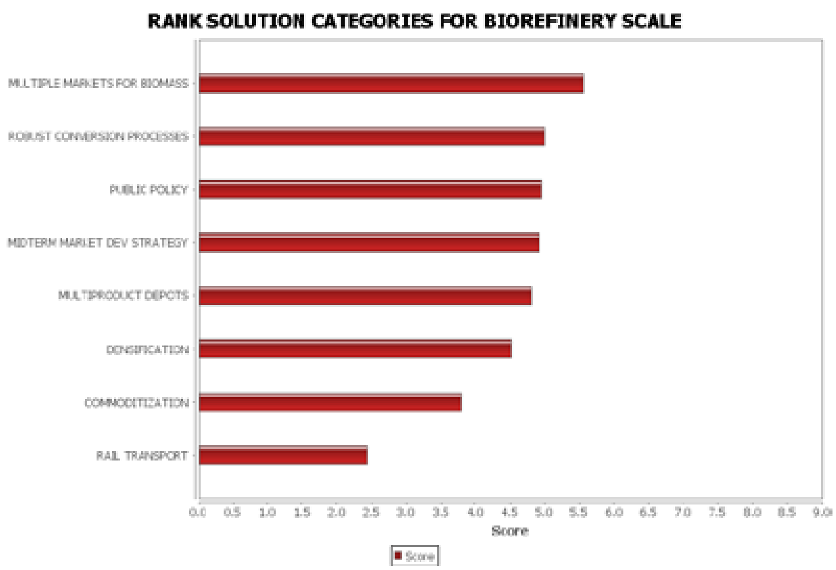

Table 8. Results of the barrier ranking

Rank	Ballot Items Breakdown	Std. Dev	1	2	3	4	5	6	7
1	COST	1.24	11	5	5	4	1	0	0
2	SUPPLY RISK (FIRE, WEATHER)	1.53	5	6	4	7	3	0	1
3	FINANCING	1.57	5	5	5	3	7	1	0
4	FEEDSTOCK COMPETITION	1.92	3	3	1	6	6	2	5
5	BUSINESS STRUCTURE	1.86	0	5	3	3	2	7	6
6	TRANSITIONING FROM CONVENTIONAL TO ADVANCED	1.81	2	2	1	3	5	8	5
7	AGRONOMIC ISSUES	1.6	0	0	7	0	2	8	9

Table 9. Table overview of what is in the text in barrier section

Ballot Items	Comments
COST	1. Over-contracting to ensure quality supplies 2. Storage loss 3. Cost of holding stocks to buffer feedstock shortages 4. Availability of adequate feedstock to biorefinery. Low intensity of biomass around 5. the biorefinery 6. Costs of developing the supply chain
FINANCING	1. Lack of History 2. Insurance costs & availability against feedstock shortfalls - self-insurance costs for 3. inventory mitigation, crop insurance costs, 4. Ability of capital providers to finance larger supply chains and the related conversion 5. facilities
TRANSITIONING FROM CONVENTION-AL TO ADVANCED	1. Captive producer risk. If the growers can only sell into the bioenergy market, they will 2. regard that as a higher risk situation and participate less (backing us off from our billion 3. ton goal) 4. and/or demand a higher price for their biomass 5. Obsolesce of conversion technology 6. Equipment availability 7. Too many bale storage sites

Ballot Items	Comments
AGRONOMIC ISSUES	1. Production risk - weather, pests. 2. Change in government regulation----especially conservation plans limiting harvest rates 3. Soil quality and loss 4. Operating within limits of sustainability, and proving/demonstrating that on an on-going 5. basis, sustainability of the industry will be challenged early and often.
FEEDSTOCK COMPETITION	1. Distance to quality feedstock 2. Feedstock Composition 3. Lack of diversity of feedstock supplies in a particular area (to extend harvest seasons and 4. mitigate weather and crop failure risks)
BUSINESS STRUCTURE	1. Risk to suppliers that refineries be there to buy biomass. 2. Look at the existing grain elevator system 3. Who pays for and builds the depots? Who compensates them for that added cost? 4. Lack of a price mechanism which limits the ability to develop insurance products. 5. Emergence of more profitable, less risk markets for producers that result in crop- 6. switching or diversion to other markets 7. Availability of operators
SUPPLY RISK (FIRE, WEATHER)	1. Unusual weather seasons/events 2. No feedstock = no operational plant 3. Inventory storability over multiple years (fire, DML, cost) 4. Grower acceptance 5. Safety risk in operations - does supply chain scaling present potential safety risks 6. feedstock security, storage costs, and quality costs 7. (R Hess) Quantifying probability and cost of risks like fire. For reference, crop insurance 8. quantifies risks based on variables, then sets premium. How do we know premium for 9. biomass risks?

Table 10. Table overview of the solutions discussion

Solutions	Any Comments
DISTRIBUTED DEPOTS	1. There is a need for depot, but the full flushed out depot concept is based on large biorefineries which haven't happened in the grain industry. a depot system that is flexible enough to de-risk the biorefinery industry. 2. Blending and densification are required for a billion tons. 3. Depots can range from simple storage to pelleting and pretreatment processes - the size and complexity of enterprise dictates the complexity of the operation. 4. Liquid intermediates need to be considered. Wet depot. 5. Distributed Depots 6. A middle ground between small biorefineries and depot.
STABLE, SOLID FORMAT REDUCES FIRE LOSS	1. A product that can be stored for extended periods of time and maintain quality. 2. Stable, solid format reduces fire loss.
POLICY	3. Innovative risk mitigation policies and programs from the DOE and other agencies in the short-term. 4. Compilation of data - to identify probabilities (frequencies and severities) on the various risk categories so insurance rates and risk financing mechanisms can be developed.
MARKETS	1. Insurance 2. Development of Multiple Markets 3. Biomass Spot Markets 4. Contracts 5. Hedging 6. A demand-pull versus supply push 7. Form a co-op. Vertical integration. 8. Being flexible to handle multiple forms of biomass (densified, not densified, etc.). 9. Art-development of co-products of off-spec feedstocks. 10. Dry depot and wet depot may offer different values.
RESEARCH & DEVELOPMENT	1. Develop longer-term storage options (multiple years) while managing quality, cost, risk 2. Help insurers understand risks. 3. Conversion systems that can shift between output products depending on profit potential.
TRANSITION	
MESSAGING & EDUCATION	4. Experience 5. Many different players with different priorities (environmental and extension people). Need to address.

Workshop References- Session 2 Discussion

What physical and/or chemical characteristics if not managed could be barriers?

1. Physical and chemical variability exists and is unavoidable

1. variability does exist, however can be managed to reduce impact
2. ash content
3. moisture level
4. Plant material grown across multiple soil types and microclimates will be variable. This variability will be difficult to address. The variability of primary concern develops at harvest and further downstream with poor practices and management. This variability can be addressed and minimized.
5. Variability in particle size
6. What are realistic and unrealstic expectations for "specs"?
7. Composition is highly impacted by growing season characteristics, active controls for key specs will have to start at first harvest steps
8. Conversion impacts of variability needs to better understood so it can guide specifications and incentives/penalties
9. It's also a source of profit for those who learn how to capture it.
10. This is true, but different end users will value differently...there will not be a single set of quality attributes
11. Step (sharp) changes in particle size or other specifications.
12. Need a quick, reliable, accurate test for moisture and ash.
13. As noted previously, real time characterization techniques for ash and moisture characterization will help with understanding variability of feed properties at the biorefinery gates.
14. variability of biomass/feedstock within harvest window (many times within same field on the same day) - conditions rapidly change, best practice to manage to allow 'best value' feedstock for the biorefinery
15. Variability will occur, but the real issue is what level of variation will be acceptable. This issue will be closely tied to one of the barriers from yesterday, the need for rapid and accurate assessment of physical and chemical properties.
16. Storability of feedstock - resistance to mold and biochemical degradation
17. Feedstock needs to be graded (rough analysis of specs), more detailed quality analysis and/or supplied based on established best practices;
18. If you can define what you want in variability, and manage to get that, this can be good for refinery.
19. Maintaining consistency in variability
20. If you can define it, variability can be good. Well established specs that are adhered to across supply chain.
21. robb-variability can also be good. if you can define the variance and target it there is an opportunity to refine your process. variability is good if you can manage it-you just have to know what it is.
22. Is all ash created equally as a challenge for a biorefinery? For instance K versus Si? There could be an opportunity for the feedstock conversion interface knowing both the species (elemental or molecular entity) and the transport of the species.

23. Are there more optimal points along the supply chain for extraction of undesirable species? What do the trade offs look like?

24. dale-refineries can adadpt over time to a different feedstocks. they dont want feedstock changing day to day year to year. they dont want to constantly tune the refinery to different feedstocks

25. Refineries can adopt to variability over time. They just dont want change on the day or year time scale.

26. Operators need to have a few years experience to know how to adjust for variability to produce consistent product.

27. Realistic and unrealistic specs. Some specs are not realistic to be met within expected cost ranges.

28. farris-any spec can be met as long as cost can be made. oil refineries take a lot of variability in their products. not everything is set to the same spec. We can work towards their models.

29. Oil refineries also have to handle feedstocks with different specs

30. we need to have a more deep understanding of the feedstock characteristics such as moisture content so that we can manage and minimize the influence of the variability, then reduce the cost at either farm gate or biorefinery gate

31. Inside the refinery handling is doable. Upstream, lack of information and education about delivering product that refinery will want.

2. Variability will be important at the scale of a single biorefinery

1. Some conversion processes will be more tolerant of variability in certain parameters than other processes

2. education of grower and harvestor before they get to the scale

3. at individual biorefinery level, compostional variability can be better managed via specifications and willingness to pay for specific sets of attributes.

4. Scheduling of feedstocks based on quality aspects may be one method to manage feedstocks that our off-spec; ex. - take high moisture feedstocks in at specific time when grinding capacity is available, or take high ash content material to secondary market

5. It's important for every load.

6. This can be extended to the depots as well.

7. Variables are throughout the process, not just harvest. Some controllable, some not - need to set achievable specs based on large scale dynamics.

8. Single biorefineries with a dedicated draw radius supply chain will face higher risk profiles from variability

9. Understanding the process capability and process control is critical to the design of the next biorefinery. The pioneer biorefineries are over designed. The sooner the process capability and control is established, the sooner the design contingencies can be relaxed.

10. Quality will be evaluated based with Cost and Delivery/Quantity - certain time periods will require more flexibility in spec depending on the biorefinery inventory, markets, etc. Risk is prevalent in each of these areas and there will be trade-offs involved. If the market is strong for end-products, quality standards may be relaxed in challenging years

3. Variability directly influence biorefinery profitability and risk (Stability in storage, handling, preprocessing, yield)

1. Dockage and premia were mentioned. Of course there is also the need to reject loads.

2. Definitely. For presprocessing, variability in moisture, incoming material packages, and other factors will significantly affect processing rates, energy usage, and other cost items.
3. Prices (base price, premia, dockage) are linked by their physical/biological impacts which will vary by process/pathway/refinery.
4. Biorefineries will need to be flexible to adopt to variations in feedstocks by considering risk mitigation approaches such a pre-processing within the refinery gates.
5. defined cause of variability is GOOD. Without it, would not know how to improve
6. Getting data on specification early in collection process to aid in managing storage variables or how quickly pulled from storage to processing.
7. What are the pros and cons of having the biorefinery own the risks versus an intermediary or even pushing the risk on the producer?
8. Don't forget about the farmers/suppliers. Monetizing specs allows this group to determine if they want to supply and how they are going to do it.
9. Biorefineries can tune themselves to utilize different feedstocks, but then these feedstocks need to be kept stable over time.
10. developing a clear and relatively simple Grading system might be a way to apply dockage or premia. suppliers should believe its a reasonable system they can then operate in
11. clearly aligning biorefinery feedstock specs to available feedstock - educate and communicate most desireable material and reward achieving those specs/characteristics
12. I see the need for specs, I'm not sure that national standards will develop.
13. See Dave above. what about farmer profitability? as Harrison mentioned yesterday, we just keep adding cost to a marginal product.
14. Specs are highly dependent on the conversion strategy. Some conversion strategies can adopt more easily to off-spec material or accept a range of specs. The conversion strategy needs to be integrated with the feedstock production and demonstration is needed to understand what the acceptable range should be on key specs.
15. if each process is sensitive to its own set of variables, then each facility needs to negotiate its own set of specs. what feedstock suppliers need to know is that there are a set of specs that are of concern to potential partners so that they can manage / determine their own value proposition.

4. Bulk density and tendency to degrade or combust are also barriers

1. Establishing fire codes and standards for feedstocks will be critical to de-risking the market. How and whom should be responsible for the insurance?
2. protection over a 365 day delivery schedual
3. Developing an understanding of insurance and helping those providers get their arms around these crops is going to be key. The BIPCS team that Erin Webb is leading is working toward UL and other standards for biomass. That activity will aid our ability to appropriately insure feedstocks after harvest. Crop insurance is a similar issue.

5. Do we know the conswquence of mold in the center of the bale?

6. Is the weathered layer on an ambient-stored rounfd bale of less value for cellulosic ethnol?

1. Yes, some of the carbohydrate has been consumed.

7. Ability to accurately measure quality is challenge.

1. And measure quickly
2. And low cost.

3. Can improve what you can't measure
4. improved techniques are needed to accurately, quickly, and economically measure quality parameters of interest to end-users both in the field and in process at the plant. If it can't be measured broadly throughout the supply chain, it can't be optimized.
5. how do we encourage development of a solid industry standard for feedstock characterization? We have NIR machines for corn grain (a couple of companies) - what is needed to get a system for biomass

8. consistency of material delivery (e.g., bale shape, dimensions, integrity, etc.)--even inches of difference can be important if handling systems aren't capable of handling variability

9. How can seed/plant breeding impact quality

1. Can we screen/clasify hybrids for total Biomass production
2. Would this need extensive trails to capture the impacts of seasons and variability in soils across the U.S. on the new hybrids?
3. I can see this developing, eg breeding for crop residue traits.

10. Monetizing the cost of quality variables is difficult and unique to each conversion pathway

1. Agreed. There will not be a one-size fits all solution. Even within the same industry sector (biochem process to ethanol), we are seeing significant differences.
2. Understanding the cost tradeoff of "improved" feedstock quality vs conversion process tolerance is not well understood

11. Equipment to process biomass to exacting spec (example grinders)

12. Lack of knowledge on material properties to control equipment that process the materials

What will drive feedstock specs (feedstock characteristics, conversion performance, other)?

1. Specs are constantly moving and evolving

1. As plants have more operating time, the spec requirement will be narrowed
2. Continuous improvement is the mantra of any young industry. As technologies, both in the field and in the facility, advance, specs will evolve.
3. specs will be adapting, the ability to manage diverse materials achieving adapting specs will put performance constraints on the supply systems

2. Composition specs are driven by model feedstocks

1. I disagree to a certain point. The conversion technology needs will drive specs. Those will evolve over time, but the feedstock must provide what the facility needs.
2. Yes to Sam's comment - each process may have variability in their process that is more favorable to certain specs. one process may work better with higher moistures, another may be more acceptable to mold,

3. Specs are different for different processes

1. Absolutely. Within cellulosic biofuels, specs vary widely. Then considering biopower and bioproducts, they range even further.
2. Having active controls in the system to respond will help balance
3. This may limit the commoditization of biomass.

4. Inherently optimal gasification particle sized particles will be different to fast pyrolysis optimal particle sizes compared to hydrothermal liquefaction optimally sized particles.
5. Biorefinery finnished thruput will dictat or change specs.
6. Absolutely, wide variation of requirement between thermochem and biochem processes.
7. The only way to control specs is by having checks in place early in the supply chain.
8. if we develop these national standards of a number two biomass. it doesnt make sense to make a number 2 biomass that cant be made outside of that region.
9. Have different grades of biomass matched for different conversion processes
10. Feedstock properties may limit the potential of some feedstocks to meet all end use markets. For example sugar platform properties will probably be different than thermochem platform properties
11. the longer these plants are running the more the definition will widen on what can and can and cant be accepted
12. Having multiple markets will improve pull for biomass, but will also increase variation in specs demanded for each product.
13. if we have different markets the specs will vary greatly between those markets.
14. In line with a petroleum refinery, a future biorefinery should be able to adopt and adjust to the feedstock variations and adopt risk mitigation strategies to overcome processing challenges associated with changes in feedstocks.
15. In biomass, the specs are different for different markets.
16. As the size and number of biorefinery increases the spec changes
17. a true commodity has multiple markets and those specs will be different between those markets
18. This is season and time in the season of harvest variable I vote ranges

4. Are specs numbers or ranges of numbers?

1. Depends on their impacts.
2. Depends on the markets - if the profit opportunity is large enough, one might relax their feedstock specification to process more material (if quantity is limiting factor)
3. Ideally identifying a max/min value for the specific conversion strategy.
4. specs need to be ranges - variability within harvest season or year to year will require a range vs a set number or value
5. Looking at existing systems it is likely to be driven by upper and/or lower bounds
6. Ranges and size of the range with different Z scores as a indicator of one dimension of quality
7. This will depend upon the property in question. Some will be a threshold and others will likely require a max and min.
8. Setting a spec for each property will be difficult because of the different conversion pathways, and a combined spec for multiple properties will be much harder.
9. Existing commodity markets have ranges
10. Need to associate the rate of change with a range
11. we need to be talking about ranges for the industry and not numbers

5. Likely to change over time (widen or narrow)?

1. They will narrow as the refinery/industry learns.
2. Filling feedstock quota - if spec to difficult/ expensive to meet, suppliers wont bother to harvest. I would assume the spec would change to ensure annual supply

6. instead of making specs for material that we can deliver, need to start specs with what the reactor needs for optimal performance

1. at what cost?
2. process optimization and economics will set the desired material spec. The entire supply chain, including harvest and pre-processing, then needs to be capable of delivering that spec (or as close as possible to it).
3. I agree, demonstrate technical feasibility of a conversion technology with an optimal feedstock and then once it shows promise then characterize how robust the the technology is. This could be used to downselect technology pathways.
4. a significant amount of improvement in certain key specs (e.g., ash) can be achieved through a combination of cost-effective techniques throughout the supply chain.

7. The diversity of conversion pathways and methods will make establishing a single feedstock spec difficult if not impossible.

1. The potential range of specs by biorefineries will make the idea of a No.2 biomass less likely to occur, but is it really needed?

8. Specs will change as processing technologies evolve and allow economic achievement.

9. Profitability

10. Rewards and discounts

11. We do not know the response curves for most of the elements that can be specified. Specifications are an economic decision.

12. Economic balance between the cost of quality improvement vs. ROI

1. The cost of drying vs. lower conversion from higher moisture material
2. The biorefinery manager may be calculating the cost point of a superior quality biomass versus the increased maintenance in the biorefinery for taking a lower cost and quality biomass.

What do we need to measure & how are we going to do it efficiently and inexpensively?

1. Ash

1. big need for rapid determination for this and ash anc CHO content
2. Not all ash is created equal. There is an opportunity at the feedstock conversion interface to understand the inorganic species and transport of the species present.
3. total ash and ash composition
4. how fast at the gate sample time and methoud exceptance by grower
5. Where do you start measuring all of these properties? Seems to me that the earlier the better to store feedstocks that will mix together.
6. Ash content is critical for themo chem processes, not so much for sugar platform
7. Grower understanding of any measurement system is important if it can affect their payment.
8. Specs vary greatly between each conversion process, even within thermochem pathways.
9. Some ash component will participate in the process chemisty, others maybe just inert

2. rapid NIR techniques are being developed and demonstrated for measuring moisture, ash, carbohydrate content, etc. much more work in this area is needed to broaden for industry-wide applicability. Increased collaboration could be significantly important in this area.

1. Understanding seasonality variations on feedstock characteristics will be key.

3. Moisture

4. Carbohydrate content

5. Handling Properties

6. Degredation

1. This is a big one, we can measure chemical changes from degradation, but the physical changes can also have a big impact onm processing
2. A understanding of how the feedstock degradation impacts processability -- challenges with conversion and feeding.
3. What is a refinery willing to pay for a bale that may not be used for two seasons? Value/risk issues.
4. Degradation will be an issue for the owner of the biomass, but the ability to measure properties will be used at points in the supply chain to determine biomass value.

7. Storability

8. physical characteristics of incoming product]

9. Ash composition

10. Particle size, power input, mass flow rate

11. Fermentable carbohydrate content...probably by near IR handheld device

12. Select ash mineral components - N, P, K, Si, S,

13. particle size distribution

14. Lower and higher heating value...on the fly. Probably by differential thermal analysis

15. Particle size distribution

16. Field location, where the corn stover bale came from? Sustainable harvest

17. How? On-baler/harvester technology. Measurement at the gates.

18. Color (spectral characteristics)

19. Flowability, bridging, etc. for mechanically preprocessed bulk feedstocks

20. collection of a consistant representative sample

21. electromagnetic properteis

22. Inhibitors - acids, molds

23. Impurities like chemicals from paint and preservatives

How will a refinery enforce specs (value proposition – reward or penalty)?

1. Dockage (penalty)

1. need carrot and stick
2. carrot stick to grower

3. biorefinery also needs to educate as to why some material is docked and some is incented
4. will depend on contract if grower has no involvement it may have to be aimed at harvestor
5. Framers are familiar with the concept of dockage
6. Many agricultural commodity markets have both premiums and discounts for quality, but they are generally larger on the discount side.

2. Rejection

1. Rejection will be challenging and potentially expensive in a dedicated supply chain

3. Incentives

1. Market should incentivize quality feedstock
2. Analyse why one supplier provided better quality. Then educate others how to supply better quality material
3. Provide data to farmer and operator to manage quality\
4. Who do you incentivize? Not just grower needs incentives, but harvester as well.

4. Premia

5. pay more

6. pay less

7. Buy feedsotck based on content- e.g. dry ash=free ton

8. contracting

9. Vertically Integrate

1. That is contract for acres. have the refinery manage harvest, possibly by a third party.
2. #1 meant for control harvest.

10. purchase based upon effective energy content (will vary with conversion pathway)

11. Control harvest.

1. have the refinery manage. have a third party harvest...

12. It is a relationship-dependent business. Coaching and advising is vital to sustainable performance.

1. I think the three cellulosic projects have done a great job with this.

13. better field and in-process quality measurement techniques will help improve enforcement of improved quality

14. Spot Market

15. tournament contracting?

Are there any other questions we should be asking?

1. competitive uses for biomass

2. Cost trade=offs -- yield per acre, for example

3. major regional supply disruptions. wildfires, hurricanes, etc

4. The structure of the biomass collection process; will it be many farmers or a custom harvest operation controlled by the biorefineries.

5. Quick screening to determine whether or not some approaches to managing different quality attributes are economically and/or environmentally sustainable.

Session 2 – Participant Comments Corresponding to Barrier Grouping

Table 11. Barrier discussion summary.

	Discussion Items			
Barrier group	**Physical and/or chemical characteristics**	**Drivers for feedstock specs (feedstock characteristics, conversion performance, etc.)**	**Quality indicators and efficient, inexpensive monitoring**	**Measures to enforce specs**
NATURAL VARIABILITY	Soil and climate, ash, moisture, seed/plant breeding, fermentable carbohydrate, heating value		Soil and climate, ash, moisture, fermentable carbohydrate, heating value	
INTRODUCED VARIABILITY	Bulk density, tendency to degrade or combust	Multiple markets	Stability in storage, handling, preprocessing, yield, bulk density, tendency to degrade or combust	
QUALITY MEASUREMENT	Measuring physical characteristics, material properties, field quality measurement techniques, ash composition, continuous evolution of specs, particle size distribution		Rapid near-infrared (NIR) for measuring physical characteristics, material properties, field quality measurement techniques, ash composition, specs evolution, particle size distribution	Educate farmers, provide data to farmer and operator, better field and in-process quality measurement technique
COST/BENEFIT		Cost of quality variables, cost of energy content	Cost of quality variables, cost of energy content	Monetizing the cost of quality variables, appropriate quality enforcement method (incentive, dockage, premia, rejection), tournament contract
QUALITY ENFORCEMENT		Appropriate quality enforcement method (incentive, dockage, premia, rejection)	Appropriate quality enforcement method (incentive, dockage, premia, rejection)	Carrot and stick approach, incentive, dockage, premia, rejection
FIELD SPECS	Color, electromagnetic properties, impurities like chemicals from paint and preservatives		Color, electromagnetic properties, impurities like chemicals from paint and preservatives, source of feedstock	
CONVERSION SPECS	Ash mineral components, flowability, bridging, etc. for mechanically preprocessed bulk feedstocks	Diversity of conversion pathways, evolution of processing technologies, starting specs for reactor's optimal performance, flowability, bridging, etc. for mechanically preprocessed bulk feedstocks, the evolution of conversion specs	Handling properties, storability, particle size, power input, mass flow rate	

NATURAL VARIABILITY

1. Physical and chemical variability exists and is unavoidable

1. variability does exist, however can be managed to reduce impact
2. ash content
3. moisture level
4. Plant material grown across multiple soil types and microclimates will be variable. This variability will be difficult to address. The variability of primary concern develops at harvest and further downstream with poor practices and management. This variability can be addressed and minimized.
5. Variability in particle size ()
6. What are realistic and unrealstic expectations for "specs"? ()
7. Composition is highly impacted by growing season characteristics, active controls for key specs will have to start at first harvest steps ()
8. Conversion impacts of variability needs to better understood so it can guide specifications and incentives/penalties ()
9. It's also a source of profit for those who learn how to capture it. ()
10. This is true, but different end users will value differently...there will not be a single set of quality attributes ()
11. Step (sharp) changes in particle size or other specifications. (
12. Need a quick, reliable, accurate test for moisture and ash. ()
13. As noted previously, real time characterization techniques for ash and moisture characterization will help with understanding variability of feed properties at the biorefinery gates. ()
14. variability of biomass/feedstock within harvest window (many times within same field on the same day) - conditions rapidly change, best practice to manage to allow 'best value' feedstock for the biorefinery ()
15. Variability will occur, but the real issue is what level of variation will be acceptable. This issue will be closely tied to one of the barriers from yesterday, the need for rapid and accurate assessment of physical and chemical properties. ()
16. Storability of feedstock - resistance to mold and biochemical degradation ()
17. Feedstock needs to be graded (rough analysis of specs), more detailed quality analysis and/or supplied based on established best practices; ()
18. () If you can define what you want in variability, and manage to get that, this can be good for refinery. ()
19. Maintaining consistency in variability ()
20. () If you can define it, variability can be good. Well established specs that are adhered to across supply chain. ()
21. robb-variability can also be good. if you can define the variance and target it there is an opportunity to refine your process. variability is good if you can manage it-you just have to know what it is. ()
22. Is all ash created equally as a challenge for a biorefinery? For instance K versus Si? There could be an opportunity for the feedstock conversion interface knowing both the species (elemental or molecular entity) and the transport of the species. ()
23. Are there more optimal points along the supply chain for extraction of undesirable species? What do the trade offs look like? ()
24. Refineries can adadpt over time to a different feedstocks. they dont want feedstock changing day to day year to year. they dont want to constantly tune the refinery to different feedstocks ()

25. () Refineries can adopt to variability over time. They just dont want change on the day or year time scale. ()

26. () Operators need to have a few years experience to know how to adjust for variability to produce consistent product. ()

27. () Realistic and unrealistic specs. Some specs are not realistic to be met within expected cost ranges. ()

28. Any spec can be met as long as cost can be made. oil refineries take a lot of variability in their products. not everything is set to the same spec. We can work towards their models. ()

29. () Oil refineries also have to handle feedstocks with different specs ()

30. we need to have a more deep understanding of the feedstock characteristics such as moisture content so that we can manage and minimize the influence of the variability, then reduce the cost at either farm gate or biorefinery gate ()

31. () Inside the refinery handling is doable. Upstream, lack of information and education about delivering product that refinery will want. ()

2. Variability will be important at the scale of a single biorefinery

1. Some conversion processes will be more tolerant of variability in certain parameters than other processes ()
2. education of grower and harvestor before they get to the scale ()
3. at individual biorefinery level, compostional variability can be better managed via specifications and willingness to pay for specific sets of attributes. ()
4. Scheduling of feedstocks based on quality aspects may be one method to manage feedstocks that our off-spec; ex. - take high moisture feedstocks in at specific time when grinding capacity is available, or take high ash content material to secondary market ()
5. It’s important for every load. ()
6. This can be extended to the depots as well. ()
7. Variables are throughout the process, not just harvest. Some controllable, some not - need to set achievable specs based on large scale dynamics. ()
8. Single biorefineries with a dedicated draw radius supply chain will face higher risk profiles from variability ()
9. Under standing the process capability and process control is critical to the design of the next biorefinery. The pioneer biorefineries are over designed. The sooner the process capability and control is established, the sooner the design contingencies can be relaxed. ()
10. Quality will be evaluated based with Cost and Delivery/Quantity - certain time periods will require more flexibility in spec depending on the biorefinery inventory, markets, etc. Risk is prevalent in each of these areas and there will be trade-offs involved. If the market is strong for end-products, quality standards may be relaxed in challenging years ()

3. How can seed/plant breeding impact quality ()

1. Can we screen/clasify hybrids for total Biomass production ()
2. Would this need extensive trails to capture the impacts of seasons and variability in soils across the U.S. on the new hybrids?
3. I can see this developing, eg breeding for crop residue traits. ()

4. Do we know the conswquence of mold in the center of the bale? ()

5. Is the weathered layer on an ambient-stored rounfd bale of less value for cellulosic ethnol? ()

1. Yes, some of the carbohydrate has been consumed. ()

6. Fermentable carbohydrate content...probably by near IR handheld device ()

7. Lower and higher heating value...on the fly. Probably by differential thermal analysis ()

INTRODUCED VARIABILITY

1. Variability directly influence biorefinery profitability and risk (Stability in storage, handling, preprocessing, yield)

1. Dockage and premia were mentioned. Of course there is also the need to reject loads. ()
2. Definitely. For presprocessing, variability in moisture, incoming material packages, and other factors will significantly affect processing rates, energy usage, and other cost items. ()
3. Prices (base price, premia, dockage) are linked by their physical/biological impacts which will vary by process/pathway/refinery. ()
4. Biorefineries will need to be flexible to adopt to variations in feedstocks by considering risk mitigation approaches such a pre-processing within the refinery gates. ()
5. defined cause of variability is GOOD. Without it, would not know how to improve ()
6. Getting data on specification early in collection process to aid in managing storage variables or how quickly pulled from storage to processing. ()
7. What are the pros and cons of having the biorefinery own the risks versus an intermediary or even pushing the risk on the producer? ()
8. Don't forget about the farmers/suppliers. Monetizing specs allows this group to determine if they want to supply and how they are going to do it. ()
9. Biorefineries can tune themselves to utilize different feedstocks, but then these feedstocks need to be kept stable over time. ()
10. developing a clear and relatively simple Grading system might be a way to apply dockage or premia. suppliers should believe its a reasonable system they can then operate in ()
11. clearly aligning biorefinery feedstock specs to available feedstock - educate and communicate most desireable material and reward achieving those specs/characteristics ()
12. I see the need for specs, I'm not sure that national standards will develop. ()
13. See Dave above. what about farmer profitability? as X mentioned yesterday, we just keep adding cost to a marginal product. (
14. Specs are highly dependent on the conversion strategy. Some conversion strategies can adopt more easily to off-spec material or accept a range of specs. The conversion strategy needs to be integrated with the feedstock production and demonstration is needed to understand what the acceptable range should be on key specs. ()
15. if each process is sensitive to its own set of variables, then each facility needs to negotiate its own set of specs. what feedstock suppliers need to know is that there are a set of specs that are of concern to potential partners so that they can manage / determine their own value proposition. (

2. Bulk density and tendency to degrade or combust are also barriers (Bruce Dale)

1. Establishing fire codes and standards for feedstocks will be critical to de-risking the market. How and whom should be responsible for the insurance? ()
2. protection over a 365 day delivery schedual ()
3. Developing an understanding of insurance and helping those providers get their arms around these crops is going to be key. The BIPCS team that Erin Webb is leading is working toward UL and other standards for biomass. That activity will aid our ability to appropriately insure feedstocks after harvest. Crop insurance is a similar issue. ()

3. Are specs numbers or ranges of numbers?

1. Depends on their impacts. ()
2. Depends on the markets - if the profit opportunity is large enough, one might relax their feedstock specification to process more material (if quantity is limiting factor) ()
3. Ideally identifying a max/min value for the specific conversion strategy. ()

1. specs need to be ranges - variability within harvest season or year to year will require a range vs a set number or value ()

2. Looking at existing systems it is likely to be driven by upper and/or lower bounds ()

3. Ranges and size of the range with different Z scores as a indicator of one dimension of quality ()

4. This will depend upon the property in question. Some will be a threshold and others will likely require a max and min. ()

5. Setting a spec for each property will be difficult because of the different conversion pathways, and a combined spec for multiple properties will be much harder. ()

6. () Existing commodity markets have ranges ()

7. Need to associate the rate of change with a range ()

8. we need to be talking about ranges for the industry and not numbers ()

4. Ash

1. big need for rapid determination for this and ash anc CHO content ()

2. Not all ash is created equal. There is an opportunity at the feedstock conversion interface to understand the inorganic species and transport of the species present. ()

3. total ash and ash composition ()

4. how fast at the gate sample time and methoud exceptance by grower ()

5. Where do you start measuring all of these properties? Seems to me that the earlier the better to store feedstocks that will mix together. ()

6. Ash content is critical for themo chem processes, not so much for sugar platform ()

7. Grower understanding of any measurement system is important if it can affect their payment. ()

8. () Specs vary greatly between each conversion process, even within thermochem pathways. ()

9. Some ash component will participate in the process chemisty, others maybe just inert ()

5. Moisture

QUALITY MEASUREMENT

1. rapid NIR techniques are being developed and demonstrated for measuring moisture, ash, carbohydrate content, etc. much more work in this area is needed to broaden for industry-wide applicability. Increased collaboration could be significantly important in this area. ()

1. Understanding seasonality variations on feedstock characteristics will be key. ()

2. How? On-baler/harvester technology. Measurement at the gates. ()

3. Lack of knowledge on material properties to control equipment that process the materials ()

4. better field and in-process quality measurement techniques will help improve enforcement of improved quality ()

5. Ability to accurately measure quality is challenge. ()

1. And measure quickly ()

2. And low cost. ()

3. Can improve what you can't measure ()

4. improved techniques are needed to accurately, quickly, and economically measure quality parameters of interest to end-users both in the field and in process at the plant. If it can't be measured broadly throughout the supply chain, it can't be optimized. ()

5. how do we encourage development of a solid industry standard for feedstock characterization? We have NIR machines for corn grain (a couple of companies) - what is needed to get a system for biomass ()

6. Inhibitors - acids, molds ()

7. collection of a consistant representative sample ---- ()

8. Ash composition ()

9. Specs are constantly moving and evolving

1. As plants have more operating time, the spec requirement will be narrowed ()
2. Continuous improvement is the mantra of any young industry. As technologies, both in the field and in the facility, advance, specs will evolve. ()
3. specs will be adapting, the ability to manage diverse materials achieving adapting specs will put performance constraints on the supply systems ()

10. particle size distribution ()

11. Composition specs are driven by model feedstocks

1. I disagree to a certain point. The conversion technology needs will drive specs. Those will evolve over time, but the feedstock must provide what the facility needs. ()
2. Yes to Sam's comment - each process may have variability in their process that is more favorable to certain specs. one process may work better with higher moistures, another may be more acceptable to mold, ()

12. Degredation ()

1. This is a big one, we can measure chemical changes from degradation, but the physical changes can also have a big impact onm processing ()
2. A understanding of how the feedstock degradation impacts processability -- challenges with conversion and feeding. ()
3. What is a refinery willing to pay for a bale that may not be used for two seasons? Value/risk issues. ()
4. Degradation will be an issue for the owner of the biomass, but the ability to measure properties will be used at points in the supply chain to determine biomass value. ()

13. Particle size, power input, mass flow rate ()

14. Equipment to process biomass to exacting spec (example grinders) ()

15. What is the role of process equipment (forage harvesters, shredders, balers, grinders) have in managing quality ()

COST/BENEFIT ()

1. Monetizing the cost of quality variables is difficult and unique to each conversion pathway ()

1. Agreed. There will not be a one-size fits all solution. Even within the same industry sector (biochem process to ethanol), we are seeing significant differences. ()
2. Understanding the cost tradeoff of "improved" feedstock quality vs conversion process tolerance is not well understood ()

2. Storability ()

1. purchase based upon effective energy content (will vary with conversion pathway) ()
2. Profitability ()
3. Particle size distribution ()

QUALITY ENFORCEMENT

1. Incentives ()

1. () Market should incentivize quality feedstock ()
2. Analyse why one supplier provided better quality. Then educate others how to supply better quality material ()
3. Provide data to farmer and operator to manage quality\ ()
4. Who do you incentivize? Not just grower needs incentives, but harvester as well. ()

2. Control harvest. ()

1. have the refinery manage. have a third party harvest... ()

3. Premia ()

4. contracting ()

5. Rejection ()

1. Rejection will be challenging and potentially expensive in a dedicated supply chain ()

6. Economic balance between the cost of quality improvement vs. ROI ()

1. The cost of drying vs. lower conversion from higher moisture material ()
2. The biorefinery manager may be calculating the cost point of a superior quality biomass versus the increased maintenance in the biorefinery for taking a lower cost and quality biomass. ()

7. Vertically Integrate ()

1. That is contract for acres. have the refinery manage harvest, possibly by a third party. ()
2. #1 meant for control harvest. ()

8. Spot Market

9. Buy feedsotck based on content- e.g. dry ash=free ton

10. Rewards and discounts ()

11. tournament contracting? ()

12. pay more ()

13. pay less ()

14. physical characteristics of incoming product] ()

15. Field location, where the corn stover bale came from? Sustainable harvest ()

16. Specs are different for different processes

1. Absolutely. Within cellulosic biofuels, specs vary widely. Then considering biopower and bioproducts, they range even further. ()
2. Having active controls in the system to respond will help balance ()
3. This may limit the commoditization of biomass. ()
4. Inherently optimal gasification particle sized particles will be different to fast pyrolysis optimal particle sizes compared to hydrothermal liquefaction optimally sized particles. ()
5. Biorefinery finnished thruput will dictat or change specs. ()
6. Absolutely, wide variation of requirement between thermochem and biochem processes. ()
7. () The only way to control specs is by having checks in place early in the supply chain ()
8. if we develop these national standards of a number two biomass. it doesnt make sense to make a number 2 biomass that cant be made outside of that region. ()
9. () Have different grades of biomass matched for different conversion processes ()
10. Feedstock properties may limit the potential of some feedstocks to meet all end use markets. For example sugar platform properties will probably be different than thermochem platform properties ()
11. the longer these plants are running the more the definition will widen on what can and can and cant be accepted ()
12. Having multiple markets will improve pull for biomass, but will also increase variation in specs demanded for each product. ()
13. if we have different markets the specs will vary greatly between those markets. ()
14. In line with a petroleum refinery, a future biorefinery should be able to adopt and adjust to the feedstock variations and adopt risk mitigation strategies to overcome processing challenges associated with changes in feedstocks. ()
15. In biomass, the specs are different for different markets. ()

16. As the size and number of biorefinery increases the spec changes ()

17. a true commodity has multiple markets and those specs will be different between those markets ()

18. This is season and time in the season of harvest variable I vote ranges ()

17. Dockage (penalty)

1. need carrot and stick ()

2. carrot stick to grower ()

3. biorefinery also needs to educate as to why some material is docked and some is incented ()

4. will depend on contract if grower has no involvement it may have to be aimed at harvestor ()

5. Framers are familiar with the concept of dockage ()

6. Many agricultural commodity markets have both premiums and discounts for quality, but they are generally larger on the discount side. ()

18. () educating custom harvesters is different than educating farmers ()

FIELD SPECS ()

1. Color (spectral characteristics) ()

2. electromagnetic properteis ()

3. Impurities like chemicals from paint and preservatives ()

4. It is a relationship-dependent business. Coaching and advising is vital to sustainable performance. ()

1. I think the three cellulosic projects have done a great job with this. ()

CONVERSION SPECS ()

1. Handling Properties ()

2. Carbohydrate content ()

3. Specs will change as processing technologies evolve and allow economic achievement. ()

4. We do not know the response curves for most of the elements that can be specified. Specifications are an economic decision. ()

5. Select ash mineral components - N, P, K, Si, S, ()

6. Flowability, bridging, etc. for mechanically preprocessed bulk feedstocks ()

7. instead of making specs for material that we can deliver, need to start specs with what the reactor needs for optimal performance ()

1. at what cost? ()

2. process optimization and economics will set the desired material spec. The entire supply chain, including harvest and pre-processing, then needs to be capable of delivering that spec (or as close as possible to it). ()

3. I agree, demonstrate technical feasibility of a conversion technology with an optimal feedstock and then once it shows promise then characterize how robust the the technology is. This could be used to downselect technology pathways. ()

4. a significant amount of improvement in certain key specs (e.g., ash) can be achieved through a combination of cost-effective techniques throughout the supply chain. ()

8. Likely to change over time (widen or narrow)?

1. They will narrow as the refinery/industry learns. ()

2. Filling feedstock quota - if spec to difficult/expensive to meet, suppliers wont bother to harvest. I would assume the spec would change to ensure annual supply ()

9. The diversity of conversion pathways and methods will make establishing a single feedstock spec difficult if not impossible. ()

1. The potential range of specs by biorefineries will make the idea of a No.2 biomass less likely to occur, but is it really needed? ()

Rank	Ballot Items	Score	Avg. Rank	Std.Dev
1	QUALITY MEASUREMENT	5.58	2.42	1.55
2	COST/BENEFIT	4.38	3.62	1.98
3	QUALITY ENFORCEMENT	3.88	4.12	1.85
4	INTRODUCED VARIABILITY	3.77	4.23	1.83
5	CONVERSION SPECS	3.69	4.31	2.35
6	FIELD SPECS	3.38	4.62	1.64
7	NATURAL VARIABILITY	3.31	4.69	1.75

Rank	Ballot ItemsBreakdown	Std.Dev	1	2	3	4	5	6	7
1	QUALITY MEASUREMENT	1.55	11	4	5	2	3	1	0
2	COST/BENEFIT	1.98	6	3	3	4	6	1	3
3	QUALITY ENFORCEMENT	1.85	1	6	3	7	1	4	4
4	INTRODUCED VARIABILITY	1.83	3	1	5	6	4	3	4
5	CONVERSION SPECS	2.35	5	3	4	0	2	5	7
6	FIELD SPECS	1.64	0	5	2	3	7	6	3
7	NATURAL VARIABILITY	1.75	0	4	4	4	3	6	5

Session 2 – Participant Comments Corresponding to Solution Discussion

To what extent are Best Management Practices sufficient? ()

1. Harvest, collection & storage methods & technologies for ash avoidance, moisture mitigation, etc.

1. Control of ash and moisture begins from managing harvest ()
2. () Are BMPs in the field enough to manage quality? ()
3. best management practices are a good start. Often there is "art" associated with the modification of BMP's that need to be implemented on the go ()
4. When coupled with dockage/incentive type programs, training, and other aspects of the overall operation, this will be extremely beneficial. Continuous monitoring of these specs and the best management practices will be required to provide a robust system that has credibility. ()
5. They will have to be if this is a field exercise. ()
6. () To what extent are BMPs needed? ()
7. communication and education for the farmer/producer/contractor must be the starting point - quality product starts in the field... carrot and stick in place to encourage ongoing desired practices ()
8. we can't guarantee specs with BMP's alone ()
9. () What BMPs are needed? To what extent should biorefinery enforce or implement BMPs? ()
10. BMP are about the only tool available with existing harvest and storage tools ()
11. material schould be choped to spec in the field ()
12. its about the incentive structure and the role of the different players in the supply chain. the incentive structure needs to be more structured. (harrison pettit) ()
13. The equipment operator must have guidance on the impact of their actions on the quality parameters. ()
14. BMPs are a start but we need to look at harvesting systems that increase quality/lower ash but are also cost effective ()
15. How to set equipment for least ash yet for most yield ()
16. () 2012 harvest - growing season dictated significantly extra corn stover. BMPs could do nothing against other constraints. ()
17. Equipment development can overcome some poor operator/management choices ()
18. Data on best practices is not available ()
19. without new equipment the only option we have are best management practices ()
20. In today's environment, BMPs are the only option for management. Envrionmental variability cant be controled. ()
21. we need to look at the technology associated with harvesting the biomass more and not ash content, etc. ()
22. () Focus on moisture on ash is not whole picture. Also look at technology that harvests. Biomass bailer may be different from current bailers that optimize for grain harvest. ()
23. Field drying rate of biomass ()
24. () Do everything across supply chain, including education, passive techniques in bailers (inexpensive plates can be installed in bailers to improve feedstock quality). and increasing resilience of equipment. ()

25. comer- process eqipument has to be capable of dealing with dirty material so that if something gets through it wont get all the way through to your process. ()

26. farris-agco makes a corn stover head, also offer best practices training program for our operators, improved desnity by 25%. Learned a lot while going through these exercises. ()

27. () Improve best practices and R&D for next generation.. ()

2. Depends on the cost of implementing quality measurement - if the industry cannot afford quality measurement, then best management practices may be the most viable option. ()

3. best management techniques, passive techniques, and active management techniques all need to be used ()

4. Processing/sizing also impacts quality ()

5. No, field level quality control will help but probably not provide sufficient control at the biorefinery inlet. ()

6. Active solutions are needed that can be economically deployed in a distributed model across local producers ()

1. For example bale breaking, screening and ash separation then fixed location rebaling to high density. May include blending across multiple source bales to homogenize moisture content. Akin to export rebaling facilities in the hay industry. ()
2. () For 2030 vision, move toward community scale distributed equipment ()

7. The economics of best management must be demonstrated ()

8. BMPs should include collection and storage operations that can maintain biomass quality under variable moisture conditions. The need to field dry to a safe storage moisture will cause DM losses and will be difficulty to consistently achieve. ()

1. The conversation is too focused on the bale based systems. Lessons can be learned from the silage system, as well as other bulk collection and handling systems. ()

Q2. What are physical and chemical preprocessing approaches to consider and are any approaches out-of-bounds?

1. Densification

1. cost vs benefits ()
2. 20 pounds per qubic ft. dose not add cost to the total process ()
3. Increased density will contribute to bale stability and lowering cost but increases the cost of making bales (increased power input) ()
4. Unit cost of densification must more than pay for itself compared to the standard operation. Some of that cost/benefit may be difficult to calculate due to the value of densification to supply risk reduction. ()
5. 20 lbs/cu ft can be acheived without increasing entire cost by mitigating other costs ()
6. () mobile unit designed to process at field edge, uses less energy than bailer. ()
7. As Paul points out, we have to look at the impacts on the entire chain, not just at that point in the chain. Need to be better systems thinkers. ()
8. what other characteristics are changed by densification? ()
9. Densification is an investment of energy. The level of densification must be justified by energy savings at other parts of the supply chain. ()

2. Ash mitigation

1. mechanical screening ()
2. pneumatic separation ()
3. Cost effective leaching technologies are needed and a detailed understanding of the treatment of the liquid stream that extracted species from the biomass.

4. Anything that slows corn harvest will be out of bounds for growers. ()

5. We have solid-solid separationj technology to take out as much dirt as desired , if someone will pay for it.

6. () Who absorbs cost for leaching? Different quality characteristics have unevenly distributed risks, need to determine who pays for them ()

3. Moisture management

1. To some degree this is out of our control. This has a lot to do with farming practices in the area you are, weather, etc. ()

2. Active moisture management is expensive, but a critical component of current commodity systems ()

3. will always, to an extent, need to learn to deal with off-spec moisture. nature gives us high moisture biomass. ()

4. Similar approaches to managing field drying of hay may be exercised ()

5. Understanding of the non-linear curves of moisture content and which process or grinder to use for optimal costs and quallity control. This would be a rich dialogue at the feedstock/ conversion interface in marching towards collective optimal solutions ()

6. How does the biorefinery utilize information about moisture at harvest to schedule and plan their feedstock into the conversion process or to market for other uses - secondary markets ()

4. Blending: Mixed feedstocks

1. depots can handle this process ()

2. Low cost way to manage some key specs, can create conflicts with other specs ()

3. Enable the reduction of risk due to seasonal quality variability of feedstock availability in a region ()

5. Cost/Benefit Ratios of Preprocessing ()

1. The integrated understanding of where preprocessing is the most economical -- within the feedstock logistics or within the biorefinery gate ()

2. Detailed understanding of all the cost benefits across the entire supply chain. ()

6. A preliminary life cycle assessment should probably be done to see if a given approach should be discarded. Too much water to dispose of, too much ash to dispose of, too much energy...any of these might be enough to make us say "forget it, try something else." ()

1. This needs to be considered jointly with the financial implications. ()

2. To clarify, I am talking about a preprocessing approach. ()

7. sizing in context of sieve, aspect ratio, etc. ()

1. and ash content ()

8. Appropriate storage techniques that allow for passive chemical modification during storage ()

9. who takes the risk for processing the feedstocks? ()

1. Different quality characteristics-where is the risk going to fall? ()

2. will it happen at the depot or will they happen at a conversion facility? ()

10. Additives that might stabilize and/or improve quality during storage/transport. ()

1. Expanding the harvest window needs work. By stabilizing higher moisture material would have a large impact to supply/cost ()

11. Anatomical fractionation and pure stream intermediates. ()

12. Operational management of feedstocks by quality - sell off spec to secondary market ()

13. Collection systems that can perform some of the preprocessing during the harvest ()

1. ....and/or preprocessing or pretreatment during transport and/or storage ()

What steps will conversion technologies take to address variability?

1. Successful conversion technologies will be more robust

1. but there are limits ()
2. winning technologies will be robust ()
3. () 1% ash spec for thermochem, but gasifiers can handle more. Depends on what conversion process can tolerate economically. ()
4. Understanding the process variability and process control in order to move towards reduction of over engineered processes in current pioneer IBRs ()
5. () Some preprocessing options should be taken off the table bc bad environmental impacts (i.e. too much water or too much acid). ()
6. dale-take off some of these preprocssing options off the table due to environmental issues. screening these options. ()

2. Price paid for feedstock will vary with the quality and the additional processing costs incurred ()

3. Develop risk mitigation strategies through process flexibility to improve overall performance independent of feedstock variability ()

4. Improved incoming feedstock monitoring technologies/data collection ()

1. Real time online monitoring and feedback systems to provide real time data to the IBR of the biomass quality as it enters the gate and both eneters and leaves preprocessing on site. ()
2. similar techniques can be developed for use in a mobile manner to assess quality in the field (at in-field storage). this could be used fr material grading, blend planning, etc. ()

5. Directly and through intermediaries -- engage in education and training ()

6. Blending will have to be part of addressing variability. ()

1. I'd like to know more about how this would be handled at commercial scale ()
2. Dave: it would be limited to liquids or pelleted solids...both easy to blend. Bales of biomass cannot be blended. ()
3. Ok. ()
4. depots can blend high moisture and low moisture ()
5. Blending becomes extremely difficult when material to blend is variable (example chlorine content) ()

7. Allow a wider range of variability ()

8. Material screening and drying ()

9. Most industries have a cleaning unit operation---the cellosic ethanol plants will need to do this as well.

10. In-plant preprocessing operations will use the blending or fractional processing approaches. ()

11. Utilize secondary markets for low quality / higher cost feedstocks ()

12. Focus on feedstocks which present lower risks for quality - avoid high variability feedstocks ()

13. An alternative value use of ash by products to offset cost of handling ()

14. expand the scope of the landscape to include other uses of biomass. Some grades for bioreifnery, others for other uses - competitive uses

What costs and value can we attribute to quality?

1. Ash: $2.25/ton/% ash

1. This value will vary based on conversion technology/biomass use ()
2. I don't think we have enough information to make these assessments. ()
3. () Depends on whether ash is inert or chemically active in process. ()
4. I am skeptical of this number being applied broadly ()
5. Ash composition matters to thermal conversion...but not much to biochemical conversion. ()
6. Agree with 5 ()
7. () Big cost is variation. Individual spec alone may not be as large of a cost as large variability. ()
8. The actual dollar cost will be determine with plants getting more run time, but is definitely more then just the purchase cost ()
9. () Docking--how much to incentivize to get what you want? ()
10. Ash content will impact catalytic processes ()
11. () Dockage could be used as carrot or stick. Pay more for high quality, or penalize for poor quality ()
12. () Quantity is bigger priority than quality. ()
13. No value if there's no transaction. Negotiation needed between buyer and seller to determine value to each party. ()
14. More risk may need to be shouldered by biorefinery ()

2. Carbohydrate content at the equivalent value of fermentable dextrose...with some discount ()

3. Lower ash can directly affect yield per acre - corn stover ()

4. Moisture, $ per point moisture - similar to grain shrinkage cost ()

5. determine point where you pay 2.25 for lower ash contents

6. Disposal and backhauling costs of ash so,ids, sludge, broken bales, wet bales..... ()

7. If quality is variable in a dedicated supply chain then contracting dynamics (and costs) will be impacted to ensure sufficient high quality supply ()

8. Jackson-big costs of variation itself. having an increased amount of variability into your conversion process equals a huge cost. ()

1. Not only costs - but the variability will also impact financeability of the supply chain and the resulting project - high variability feedstock may not be able to even get financed...so we do not realize the Billion ton goals. Low variabiliity feedstocks may be higher cost, but more financeable ()

9. this is a coordination issue - no value to either side if the deal doesn't happen. the two parties need to evaluate the value added from the transaction to each of them and this needs to be shared ()

10. Biorefineries will vary the price paid for feedstock depending on how the quality parameters cause added costs through additional processing. ()

11. Heating value of the biomass for all applications. ()

12. () forseeable future challenge for biorefineries is getting enough feedstock, not just the quality. second goal is getting enough of quality ()

13. Harrison is right. We need biomass, lots of it, first and then we can worry more about quality. ()

Session 2 – Participant Comments Corresponding to Solution Grouping

Equipment Solutions ()

1. Processing/sizing also impacts quality ()

2. Active solutions are needed that can be economically deployed in a distributed model across local producers ()

1. For example bale breaking, screening and ash separation then fixed location rebaling to high density. May include blending across multiple source bales to homogenize moisture content. Akin to export rebaling facilities in the hay industry. ()

2. () For 2030 vision, move toward community scale distributed equipment ()

3. Material screening and drying ()

4. BMPs should include collection and storage operations that can maintain biomass quality under variable moisture conditions. The need to field dry to a safe storage moisture will cause DM losses and will be difficulty to consistently achieve. ()

1. The conversation is too focused on the bale based systems. Lessons can be learned from the silage system, as well as other bulk collection and handling systems. ()

5. Appropriate storage techniques that allow for passive chemical modification during storage ()

6. Collection systems that can perform some of the preprocessing during the harvest ()

1. ....and/or preprocessing or pretreatment during transport and/or storage ()

7. Harvest, collection & storage methods & technologies for ash avoidance, moisture mitigation, etc.

1. Control of ash and moisture begins from managing harvest ()

2. () Are BMPs in the field enough to manage quality? ()

3. best management practices are a good start. Often there is "art" associated with the modification of BMP's that need to be implemented on the go ()

4. When coupled with dockage/incentive type programs, training, and other aspects of the overall operation, this will be extremely beneficial. Continuous monitoring of these specs and the best management practices will be required to provide a robust system that has credibility. ()

5. They will have to be if this is a field exercise. ()

6. () To what extent are BMPs needed? ()

7. communication and education for the farmer/producer/contractor must be the starting point - quality product starts in the field... carrot and stick in place to encourage ongoing desired practices ()

8. we can't guarantee specs with BMP's alone ()

9. () What BMPs are needed? To what extent should biorefinery enforce or implement BMPs? ()

10. BMP are about the only tool available with existing harvest and storage tools ()

11. material schould be choped to spec in the field ()

12. its about the incentive structure and the role of the different players in the supply chain. the incentive structure needs to be more structured. (harrison pettit) ()

13. The equipment operator must have guidance on the impact of their actions on the quality parameters. ()

14. BMPs are a start but we need to look at harvesting systems that increase quality/lower ash but are also cost effective ()

15. How to set equipment for least ash yet for most yield ()

16. () 2012 harvest - growing season dictated significantly extra corn stover. BMPs could do nothing against other constraints. ()

17. Equipment development can overcome some poor operator/management choices ()

18. Data on best practices is not available ()

19. without new equipment the only option we have are best management practices ()

20. In today's environment, BMPs are the only option for management. Envrionmental variability cant be controled. ()

21. robb-we need to look at the technology associated with harvesting the biomass more and not ash content, etc. ()

22. () Focus on moisture on ash is not whole picture. Also look at technology that harvests. Biomass bailer may be different from current bailers that optimize for grain harvest. ()

23. Field drying rate of biomass ()

24. () Do everything across supply chain, including education, passive techniques in bailers (inexpensive plates can be installed in bailers to improve feedstock quality). and increasing resilience of equipment. ()

25. comer- process eqipument has to be capable of dealing with dirty material so that if something gets through it wont get all the way through to your process. ()

26. farris-agco makes a corn stover head, also offer best practices training program for our operators, improved desnity by 25%. Learned a lot while going through these exercises. ()

27. () Improve best practices and R&D for next generation.. ()

8. best management techniques, passive techniques, and active management techniques all need to be used ()

9. Most industries have a cleaning unit operation---the cellosic ethanol plants will need to do this as well.

"Passive" Management

1. Heating value of the biomass for all applications. ()

"Active" Management

1. determine point where you pay 2.25 for lower ash contents ()

2. Improved incoming feedstock monitoring technologies/data collection ()

1. Real time online monitoring and feedback systems to provide real time data to the IBR of the biomass quality as it enters the gate and both eneters and leaves preprocessing on site. ()

2. similar techniques can be developed for use in a mobile manner to assess quality in the field (at in-field storage). this could be used fr material grading, blend planning, etc. ()

3. No, field level quality control will help but probably not provide sufficient control at the biorefinery inlet. ()

4. sizing in context of sieve, aspect ratio, etc. ()

1. and ash content ()

5. Anatomical fractionation and pure stream intermediates. ()

6. Additives that might stabilize and/or improve quality during storage/transport. ()

1. Expanding the harvest window needs work. By stabilizing higher moisture material would have a large impact to supply/cost ()

7. Carbohydrate content at the equivalent value of fermentable dextrose...with some discount ()

8. Directly and through intermediaries -- engage in education and training ()

9. In-plant preprocessing operations will use the blending or fractional processing approaches. ()

Conversion Solutions

1. Develop risk mitigation strategies through process flexibility to improve overall performance independent of feedstock variability ()

2. An alternative value use of ash by products to offset cost of handling ()

3. Blending will have to be part of addressing variability. ()

1. I'd like to know more about how this would be handled at commercial scale ()

2. it would be limited to liquids or pelleted solids... both easy to blend. Bales of biomass cannot be blended. ()
3. Ok. ()
4. depots can blend high moisture and low moisture ()
5. Blending becomes extremely difficult when material to blend is variable (example chlorine content) ()

4. Disposal and backhauling costs of ash so,ids, sludge, broken bales, wet bales..... ()

5. Densification

1. cost vs benefits ()
2. 20 pounds per qubic ft. dose not add cost to the total process ()
3. Increased density will contribute to bale stability and lowering cost but increases the cost of making bales (increased power input) ()
4. Unit cost of densification must more than pay for itself compared to the standard operation. Some of that cost/benefit may be difficult to calculate due to the value of densification to supply risk reduction. ()
5. 20 lbs/cu ft can be acheived without increasing entire cost by mitigating other costs ()
6. () mobile unit designed to process at field edge, uses less energy than bailer. ()
7. As Paul points out, we have to look at the impacts on the entire chain, not just at that point in the chain. Need to be better systems thinkers. ()
8. what other characteristics are changed by densification? ()
9. Densification is an investment of energy. The level of densification must be justified by energy savings at other parts of the supply chain. ()

6. Ash mitigation

1. mechanical screening ()
2. pneumatic separation ()
3. Cost effective leaching technologies are needed and a detailed understanding of the treatment of the liquid stream that extracted species from the biomass. ()
4. Anything that slows corn harvest will be out of bounds for growers. ()
5. We have solid-solid separationj technology to take out as much dirt as desired , if someone will pay for it. ()
6. () Who absorbs cost for leaching? Different quality characteristics have unevenly distributed risks, need to determine who pays for them ()

7. Moisture management

1. To some degree this is out of our control. This has a lot to do with farming practices in the area you are, weather, etc. ()
2. Active moisture management is expensive, but a critical component of current commodity systems ()
3. will always, to an extent, need to learn to deal with off-spec moisture. nature gives us high moisture biomass. ()
4. Similar approaches to managing field drying of hay may be exercised ()
5. Understanding of the non-linear curves of moisture content and which process or grinder to use for optimal costs and quallity control. This would be a rich dialogue at the feedstock/ conversion interface in marching towards collective optimal solutions ()
6. How does the biorefinery utilize information about moisture at harvest to schedule and plan their feedstock into the conversion process or to market for other uses - secondary markets ()

8. Blending: Mixed feedstocks

1. depots can handle this process ()
2. Low cost way to manage some key specs, can create conflicts with other specs ()
3. Enable the reduction of risk due to seasonal quality variability of feedstock availability in a region ()

9. Successful conversion technologies will be more robust

1. but there are limits ()
2. winning technologies will be robust ()
3. () 1% ash spec for thermochem, but gasifiers can handle more. Depends on what conversion process can tolerate economically. ()
4. Understanding the process variability and process control in order to move towards reduction of over engineered processes in current pioneer IBRs ()
5. () Some preprocessing options should be taken off the table bc bad environmental impacts (i.e. too much water or too much acid). ()
6. dale-take off some of these preprocssing options off the table due to environmental issues. screening these options. ()

10. Allow a wider range of variability ()

Cost vs. Value Added

1. expand the scope of the landscape to include other uses of biomass. Some grades for bioreifnery, others for other uses - competitive uses ()

2. If quality is variable in a dedicated supply chain then contracting dynamics (and costs) will be impacted to ensure sufficient high quality supply ()

3. Cost/Benefit Ratios of Preprocessing ()

1. The integrated understanding of where preprocessing is the most economical -- within the feedstock logistics or within the biorefinery gate ()
2. Detailed understanding of all the cost benefits across the entire supply chain. ()

4. Depends on the cost of implementing quality measurement - if the industry cannot afford quality measurement, then best management practices may be the most viable option. ()

5. A preliminary life cycle assessment should probably be done to see if a given approach should be discarded. Too much water to dispose of, too much ash to dispose of, too much energy...any of these might be enough to make us say "forget it, try something else." ()

1. This needs to be considered jointly with the financial implications. ()
2. To clarify, I am talking about a preprocessing approach. ()

6. Jackson-big costs of variation itself. having an increased amount of variability into your conversion process equals a huge cost. ()

7. Utilize secondary markets for low quality / higher cost feedstocks ()

8. this is a coordination issue - no value to either side if the deal doesn't happen. the two parties need to evaluate the value added from the transaction to each of them and this needs to be shared

9. art-who takes the risk for processing the feedstocks? ()

1. Different quality characteristics-where is the risk going to fall? ()
2. will it happen at the depot or will they happen at a conversion facility? ()

10. Focus on feedstocks which present lower risks for quality - avoid high variability feedstocks ()

11. Lower ash can directly affect yield per acre - corn stover ()

12. Price paid for feedstock will vary with the quality and the additional processing costs incurred ()

13. Operational management of feedstocks by quality - sell off spec to secondary market ()

14. Biorefineries will vary the price paid for feedstock depending on how the quality parameters cause added costs through additional processing. ()

15. The economics of best management must be demonstrated ()

16. Ash: $2.25/ton/% ash

1. This value will vary based on conversion technology/biomass use ()
2. I don't think we have enough information to make these assessments. ()
3. () Depends on whether ash is inert or chemically active in process. ()
4. I am skeptical of this number being applied broadly ()
5. Ash composition matters to thermal conversion...but not much to biochemical conversion. ()
6. Agree with 5 ()
7. () Big cost is variation. Individual spec alone may not be as large of a cost as large variability. ()
8. The actual dollar cost will be determine with plants getting more run time, but is definitely more then just the purchase cost ()
9. () Docking--how much to incentivize to get what you want? ()
10. Ash content will impact catalytic processes ()
11. () Dockage could be used as carrot or stick. Pay more for high quality, or penalize for poor quality ()
12. () Quantity is bigger priority than quality. ()

17. Moisture, $ per point moisture - similar to grain shrinkage cost

	Impact	Avg.Score	+/-	Std Dev	1	2	3	4	5
1	"PASSIVE" MANAGEMENT	3.00	23.0%	0.92	2	3	16	3	2
2	"ACTIVE" MANAGEMENT	3.96	27.3%	1.09	1	2	4	9	10
3	CONVERSION SOLUTIONS	4.04	29.9%	0.90	0	2	4	11	9
4	COST VS. VALUE ADDED	4.27	28.2%	1.13	2	0	2	7	15
5	EQUIPMENT SOLUTIONS	4.12	26.7%	0.80	0	1	4	12	9

	Likelihood	Avg.Score	+/-	Std Dev	1	2	3	4	5
1	"PASSIVE" MANAGEMENT	3.38	30.3%	1.21	2	4	8	6	6
2	"ACTIVE" MANAGEMENT	3.81	34.6%	1.04	0	4	5	9	8
3	CONVERSION SOLUTIONS	3.65	29.2%	0.87	0	3	7	12	4
4	COST VS. VALUE ADDED	4.23	29.7%	1.19	2	0	4	4	16
5	EQUIPMENT SOLUTIONS	4.12	29.7%	0.89	0	1	6	8	11

	Impact Likelihood Map	Impact	Likelihood	Product
1	"PASSIVE" MANAGEMENT	3.00	3.38	10.15
2	"ACTIVE" MANAGEMENT	3.96	3.81	15.08
3	CONVERSION SOLUTIONS	4.04	3.65	14.76
4	COST VS. VALUE ADDED	4.27	4.23	18.06
5	EQUIPMENT SOLUTIONS	4.12	4.12	16.94

Session 3 – Participant Comments Corresponding to Barrier Discussion

Q. What are the operational/financial-related risks to scaling feedstock supply systems?

1. COST

1. Over-contracting to ensure quality supplies

1. This is probably the only way to ensure adequate supply. Have we given adequate attention to storage, managing supply risk across time (instead of spatially with a regional system).
2. And this will have real cost impacts across the board. The question becomes what is the lowest cost risk mitigation tool.

2. Storage loss

1. both for quality loss and quantity - loss of carbohydrate or the entire pile (eg fire)
2. Look back to grain elevators systems as model. Must be adjusted for biomass, and could be co-op style.

3. cost of holding stocks to buffer feedstock shortages

4. Availability of adequate feedstock to biorefinery. Low intensity of biomass around the biorefinery

5. Costs of developing the supply chain

1. its all about the scale! We are in the infancy stage, building stepping stones to create our path to the billion ton objective. Need demand pull from biorefineries and other biomass consumers to entice producer/contractors to get involved and build critical mass to fully commercialize the activity. Starting with current equipment (in-field and at-plant) and evolve into purpose-built, more effective/efficient solutions.
2. art-financial institutions may not be willing to take the risk to develop a density of conversion facilities that will create supply issues.
3. If you have a depot model, the depots can probably be financed at the local level, Main Street, and not Wall Street. An existing depot system will then reduce the risks for Wall Street.

6. Understanding where risks lie across supply chain and distributing evenly

1. Current structure has biorefinery assuming most of risks
2. Oil industry doesnt have landowner assuming risk
3. It's not about distributing it evenly, it's about understanding how risk gets transferred/balanced across the system - so that a risk amelioration strategy from one player (e.g. biorefinery) doesn't increase the risk to another player (e.g. farmer or aggregator) to a point that they leave the supply chain.
4. Farmers will face counter-party risk.
5. I think the farmer/land owner has most of risk today. Harvest choices, weather issues, storage, bale integrity, full-filling contracted quantity. the end user only takes the risk once delivered.

7. Unacceptably slow rate of adoption of new methods and transactional schemes at the local and national level.

1. Must have robust extension, demonstration, and outreach delivery to coach and support rapid adoption at local and regional levels.

8. Who are the investors and what are their priorities?

1. Capture risks that face the industry, and leverage to understand priorities for investors.

9. Competitive agricultural markets

2. FINANCING

1. Lack of History

1. Price volatility in biomass to biopower, composite products, and energy pellets is extreme and increases perceived investor risk

2. Insurance costs & availability against feedstock shortfalls - self insurance costs for inventory mitigation, crop insurance costs,

3. Ability of capital providers to finance larger supply chains and the related conversion facilities

3. TRANSITIONING FROM CONVENTIONAL TO ADVANCED

1. Captive producer risk.If the growers can only sell into the bioenergy market, they will regard that as a higher risk situation and participate less (backing us off from our billion ton goal) and/or demand a higher price for their biomass

1. fIt would really help if the farmers had an existing market to sell their biomass into, that would help the emergence of the bioenergy demand for that biomass.

2. Obsolence of conversion technology

1. Building first-generation technologies exposes risk of being outdated by second and third generation facilities

3. Equipment availability

4. Too many bale storage sites

4. AGRONOMIC ISSUES

1. Production risk - weather, pests,...

2. change in government regulation----exp conservation plans limiting harvest rates

3. Soil quality and loss

1. must understand sustainability and harvest model must align with the individual farmer at the field level

4. operating within limits of sustainability, and proving/demonstrating that on an on-going basis. sustainability of the industry will be challenged early and often.

5. FEEDSTOCK COMPETITION

1. distance to quality feedstock

1. biomass consumption facilities will be located in areas of high concentration of target biomass for the near/foreseen future - follow the path of corn ethanol plants - built in high concentration of corn producers

2. Feedstock Compotion

3. lack of diversity of feedstock supplies in a particular area (to extend harvest seasons and mitigate weather and crop failure risks)

6. BUSINESS STRUCTURE

1. counter-party risk. will refineries be there to buy biomass.

2. look at the existing grain elevator system

3. who pays for and builds the depots. who compensates them for that added cost?

4. lack of a price mechanism which limits the ability to develop insurance products.

5. Emergence of more profitable, less risk markets for producers that result in crop-switching or diversion to other markets

1. This a major issue -- the resource exists and it will go to it highest best use
2. Need long-term supply commitments.
3. The same technologies and depot operations that make better biofuel feedstocks make that material more valuable to other uses and markets. Eg. AFEX, fiber panel furnish, erosion control materials, chemical industry feedstocks...

6. Availability of operators

7. SUPPLY RISK (FIRE, WEATHER)

1. unusual weather seasons/events

2. no feedstock = no operational plant

3. Inventory storability over multiple years (fire, DML, cost)

4. grower acceptance

5. Safety risk in operations - does supply chain scaling present potential safety risks

6. feedstock security, styorage costs, and quality costs

1. distributed, in-field storage mitigates risk of large feedstock loss (ie fire)

7. Quantifying probability and cost of risks like fire. For reference, crop insurance quantifies risks based on variables, then sets premium. How do we know premium for biomass risks?

1. Ag economists do this all the time for new crop insurance products. Same for commercial insurance.

Session 3 – Participant Comments Corresponding to Solution Discussion

Q. What are the operational/financial-related risks to scaling feedstock supply systems?

1. DISTRIBUTED DEPOTS

1. There is a need for depot, but the full flushed out depot concept is based on large biorefineries which havent happened in the grain industry. a depot system that is flexible enough to derisk the biorefinery industry.

2. Blending and densification are required for a billion tons

3. Depots can range from simple storage to pelletization and pretreatment processes - the size and complexity of enterprise dictates the complexity of the operation.

4. Liquid intermediates need to be considered. Wet depot.

5. Distributed Depots

1. Distributed feedstock supply
2. Diverse feedstocks – enables integrated landscape management
3. Distributed/Reduced business risk
4. Reduces capital at biorefinery (distributes to depots)
5. Does this include distributed conversion?
6. could overcome the chicken/egg issue through shared risk and mutual hostages

7. At what cost? Who funds the capital required here? Multiple offtake customers will be required to make this economical. A depot will not work for one customer. Who will utilize excess material in good years when the customer does not need it.

8. Depots need to be associated with cheap transportation means like rail and barge - similar to the inland and port grain elevators.

9. Could cost be reduced by integrating the biomass depot with existing depots? (grain, wood, etc.)? These existing 'depots may want the additional product stream

10. Agree strongly, especially if the depots are locally financed. That way the local owners of the depots participate in the value added. Also benefits the biorefinery by reducing the capital they have at risk. So both Main Street and Wall Street benefit.

11. DEPOT owners and cooperatives will redeploy assets to produce variations on the products (e.g. pellets) to sell into highest margin markets. Biomass pellets may displace wood pellets for residential stoves. Other markets will establish price floors for biomass supply to biorefineries.

12. diversity in outputs - biomaterials not always a threat and co-located to reduce risk and increase diversity of feedstocks

13. need to be more clear that the cost added are overcome by the value added -- not at all clear today

14. we need to make sure we understand the cost of the depot. in the short term, the depots will be very difficult to finance unless you have multiple customers.

15. Understand cost of depot for users. In short term, depots will be more difficult to finance and operate unless you have multiple users. Depot should be able to supply multiple biorefineries/markets.

16. DOE could help fund demonstration depots to provide operating examples. Depot sizes could be minimized initially to match local markets, but still provide commercially relevant example operations for review/observation by financiers, customers, etc.

17. We are considering market that we are in. But we have to consider full landscape and competing markets

18. if you are going to service biomass you have to account for the entire landscape

19. Multiple markets increase supply risk, particularly in years with biomass shortages

20. Depot needs flexibility to compete in markets, not just supply one user.

21. Value has to exceed cost. Can depot provide intermediate product?

22. Will this become more of an intermediate product instead of a stable product?

23. In short term, different way depot operates than long term. Have to configure path from 0 depots to 2030 format.

24. Flexibility decreases financial risk

25. A depot that is flexible will be less risky. don't tie it to one output. feed, biomass, etc

26. Depots can bridge gap from present to future. Share risk.

27. MSW recyclers are perfect examples of successful depots for biomass. A recycler receives feedstock from a variety of sources, fractionates, grinds, blends and ship the material to a variety of users (greenhouses, energy producers, gardeners, etc.)

28. Designing depot around flexibility. Cannot commit to one market.

29. Depot is very much part of rural economy.

30. Bear was invented as a way of keeping grain for long time

31. Feels like depots serving multiple markets will have same issue as a single plant faces - large quantity of material in one place. One major event like fire would wipe out major supply. Then that pushes it out to the farm again so why add a middle man (depot)?

6. A middle ground between small biorefineries and depot

32. range of biorefinery sizes are being pursued.

33. POET/refineries need to know feedstocks are in place before building new refinery

34. If biomass is readily present, what are the barriers? Are we ready to roll out refineries?

2. STABLE, SOLID FORMAT REDUCES FIRE LOSS

1. A product that can be stored for extended periods of time and maintain quality

1. for example, preprocessing that improves storage qualities.

2. Stable, solid format reduces fire loss

1. Intrinsically dry biomass has a faster rate of combustion than coal. Coal storage yards currently turn over coal mechanically and/or water coal in the summer to reduce fire risk. What would be the analogous strategies for biomass fire risk reduction?

3. POLICY

1. Innovative risk mitigation policies and programs from the DOE and other agencies in the short-term

1. Depots will be viable in the future, but in the short-term we need to develop risk mitigation tools to get to the next stages of industry development.

2. Compilation of data - to identify probabilities (frequencies and severities) on the various risk categories so insurance rates and risk financing mechanisms can be developed.

3. Coherent energy policy that encourages co-firing of biomass and fossil fuels

4. MARKETS

1. Insurance

2. Development of Multiple Markets

1. need to be a market maker in an area for the feedstock selling to multiple markets
2. I believe that multiple markets already exist. It’s the competitive uses and we all need to be thinking of the entire landscape for biomass
3. Could drive down initial cost of feedstock supply development - additional demand pull could spur grower acceptance
4. depots would ideally be able to sell into energy, feed, and other markets, and manage their profitability accordingly.
5. crucial to avoiding holdup issues
6. Agree strongly. Helps reduce the chicken and egg problem.
7. fuel. power. feed.

3. Biomass Spot Markets

1. This would complement existing forage markets, but how active would these markets be?

4. Contracts

5. Hedging

6. A demand-pull versus supply push

1. if don't have this, how do you incentivize / create a feedstock industry?

7. Form a co-op. Vertical integration.

8. being flexible to handle multiple forms of biomass (densified, not densified, etc)

9. art-development of co-products of off-spec feedstocks

10. Dry depot and wet depot may offer different values.

1. Wet depot offers stable, flowable, value-add
2. Wet and dry refers to the intermediate coming out of the depot
3. wet depots enable pipeline and other "gathering systems" as alternatives to trucks.
4. does trucking dictate scale and location...

11. conversion systems that can shift between output products depending on profit potential

5. RESEARCH & DEVELOPMENT

1. Develop longer-term storage options (multiple years) while managing quality, cost, risk

2. Help insurers understand risks.

1. Fed agencies can help identify risks, share word, then mitigate

6. TRANSITION

7. MESSAGING & EDUCATION

1. Experience

2. Many different players with different priorities (environmental and extension people). Need to address.

1. Understand sociological drivers

Session 3- Participant Comments Corresponding to write up

Note that comments contain all typos and original wording.

Table 12. List of barriers and main comments.

Barriers	Comments (first tier only)
1. COST	1. Over-contracting to ensure quality supplies 2. Storage loss 3. cost of holding stocks to buffer feedstock shortages 4. Availability of adequate feedstock to biorefinery. Low intensity of biomass around the biorefinery 5. Costs of developing the supply chain 6. Understanding where risks lie across supply chain and distributing evenly 7. Unacceptably slow rate of adoption of new methods and transactional schemes at the local and national level 8. Who are the investors and what are their priorities? 9. Competitive agricultural markets
2. FINANCING	1. Lack of History 2. Insurance costs & availability against feedstock shortfalls - self insurance costs for inventory mitigation, crop insurance costs, 3. Ability of capital providers to finance larger supply chains and the related conversion facilities
3. TRANSITIONING FROM CONVENTIONAL TO ADVANCED	1. Captive producer risk. If the growers can only sell into the bioenergy market, they will regard that as a higher risk situation and participate less (backing us off from our billion ton goal) and/or demand a higher price for their biomass 2. Obsolence of conversion technology 3. Equipment availability 4. Too many bale storage sites
4. AGRONOMIC ISSUES	1. Production risk - weather, pests,... 2. change in government regulation-exp. conservation plans limiting harvest rates 3. Soil quality and loss 4. operating within limits of sustainability, and proving/demonstrating that on an on-going basis. sustainability of the industry will be challenged early and often.

5. FEEDSTOCK COMPETITION	1. distance to quality feedstock 2. Feedstock Compotion 3. lack of diversity of feedstock supplies in a particular area (to extend harvest seasons and mitigate weather and crop failure risks)
6. BUSINESS STRUCTURE	1. counter-party risk. will refineries be there to buy biomass. 2. look at the existing grain elevator system 3. who pays for and builds the depots. who compensates them for that added cost? 4. lack of a price mechanism which limits the ability to develop insurance products. 5. Emergence of more profitable, less risk markets for producers that result in crop-switching or diversion to other markets 6. Availability of operators
7. SUPPLY RISK (FIRE, WEATHER)	1. unusual weather seasons/events 2. no feedstock = no operational plant 3. Inventory storability over multiple years (fire, DML, cost) 4. grower acceptance 5. Safety risk in operations - does supply chain scaling present potential safety risks 6. feedstock security, styorage costs, and quality costs 7. Quantifying probability and cost of risks like fire. For reference, crop insurance quantifies risks based on variables, then sets premium. How do we know premium for biomass risks?

Table 13. List of solutions and main comments.

Solutions	Comments (first tier only)
1. DISTRIBUTED DEPOTS	1. There is a need for depot, but the full flushed out depot concept is based on large biorefineries which havent happened in the grain industry. a depot system that is flexible enough to derisk the biorefinery industry. 2. Blending and densification are required for a billion tons 3. Depots can range from simple storage to pelletization and pretreatment processes - the size and complexity of enterprise dictates the complexity of the operation. 4. Liquid intermediates need to be considered. Wet depot. 5. Distributed Depots 6. A middle ground between small biorefineries and depot
2. STABLE, SOLID FORMAT REDUCES FIRE LOSS	1. A product that can be stored for extended periods of time and maintain quality 2. Stable, solid format reduces fire loss
3. POLICY	1. Innovative risk mitigation policies and programs from the DOE and other agencies in the short-term 2. Compilation of data - to identify probabilities (frequencies and severities) on the various risk categories so insurance rates and risk financing mechanisms can be developed.
4. MARKETS	1. Insurance 2. Development of Multiple Markets 3. Biomass Spot Markets 4. Contracts 5. Hedging 6. A demand-pull versus supply push 7. Form a co-op. Vertical integration. 8. being flexible to handle multiple forms of biomass (densified, not densified, etc) 9. art-development of co-products of off-spec feedstocks 10. Dry depot and wet depot may offer different values.

5. RESEARCH & DEVELOPMENT	1. Develop longer-term storage options (multiple years) while managing quality, cost, risk. 2. Help insurers understand risks. 3. Conversion systems that can shift between output products depending on profit potential.
6. TRANSITION	
7. MESSAGING & EDUCATION	1. Experience 2. 101971DPO Many different players with different priorities (environmental and extension people). Need to address.

APPENDIX B

Participant List

Althoff, Kyle	President, Equinox LLC, Fargo North Dakota
Belden, Bill	Consultant for Antares, Fayetteville, New York
Carolan, Joe	Oakland University, Rochester, Michigan
Comer, Kevin	Associate Principal, Antares, Fayetteville, New York
Cundiff, John	Virginia Tech, Blacksburg, Virginia
Dale, Bruce	Associate Director, Michigan State University
Dang, Qi	Research Associate, Iowa State University, Des Moines, Iowa
Dooley, Jim	Chief Tech. Officer, Forest Concepts, Federal Way, Washington
Farris, Glenn	Marketing Manager, AGCO Corp., Greater Atlanta
Henson, Mark	Tech Lead, Monsanto, Glencoem Missouri
Jackson, Sam	Vice President, Genera Energy, Vonore, Tennessee
Keller, Alan	Regional Biomass Manager, POET, Algona, Iowa
Muth, Dave	Senior Vice President, AgSolver, Des Moines, Iowa
Nguyen, Quang	Program Manager, Abengoa, Greater St. Louis
Petersen, Steve	Market Manager, Monsanto, Waterloo, Iowa
Pettit, Harrison	Partner and Vice Pres., PacificAg, Hermiston, Oregon
Ripplinger, Dave	Agribusiness and Economics, North Dakota
Robb, Tom	Manager of institutional relations, Abengoa, Kansas
Van Roekel, Jay	Biomass Business Manager, Vermeer, Pella, Iowa
Searcy, Steve	Dept. Head, Bio & Agi, Eng., Texas A&M University
Schroeder, Richard M.,	President, BioResource Management, Inc. Gainesville, Florida
Weishaar, Scott	Biomass Product Manager, Vermeer, Pella Iowa
Wever, Paul	President, Paul Wever Construction Equip, Goodfield, Illinois

Attendees from BETO: Alison Goss Eng, Sam Tagore, Steve Thomas, Mark Elless, and Alicia Lindauer

Attendees from the National Renewable Energy Laboratory: Mary Biddy

Attendees from INL: Richard Hess, Kevin Kenney, Erin Searcy, Jason Hansen, Jake Jacobson, and Patrick Lamers

Attendees from ORNL: Tim Theiss, Erin Webb, Shahb Sokhansanj (called in), and Laurence Eaton

Attendees from Corporate Navarro Joint Venture: Bryce Stokes and Art Wiselogel

APPENDIX C

ThinkTank Software

This workshop used ThinkTank© software, which enabled participants to record comments, suggestions, and ideas throughout the workshop. This tool helps to categorize and theme large amounts of feedback and engage in assessment activities to identify the best ideas. A typical ThinkTank user's interface to communicate with the workshop participants is shown Figures E-1 and E-2. These figures show the brainstorming process for the assumption "Feedstock supply systems limit biorefinery economies of scale." At the end of the workshop, the fundamental assumptions of Advanced Feedstock Supply Systems are validated, modified, or refuted based on workshop participants' expert opinion.

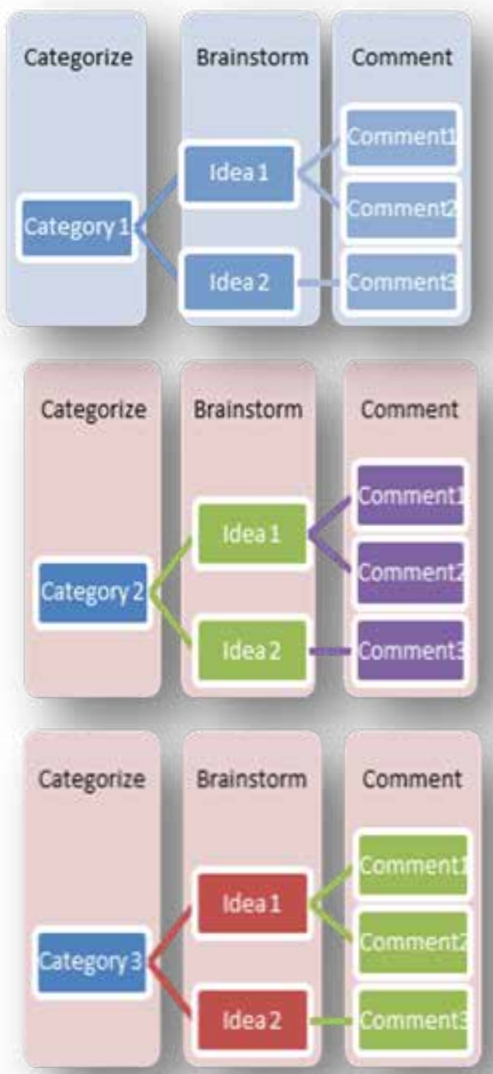

Figure C-1. Brainstorming and generating ideas for each assumption.

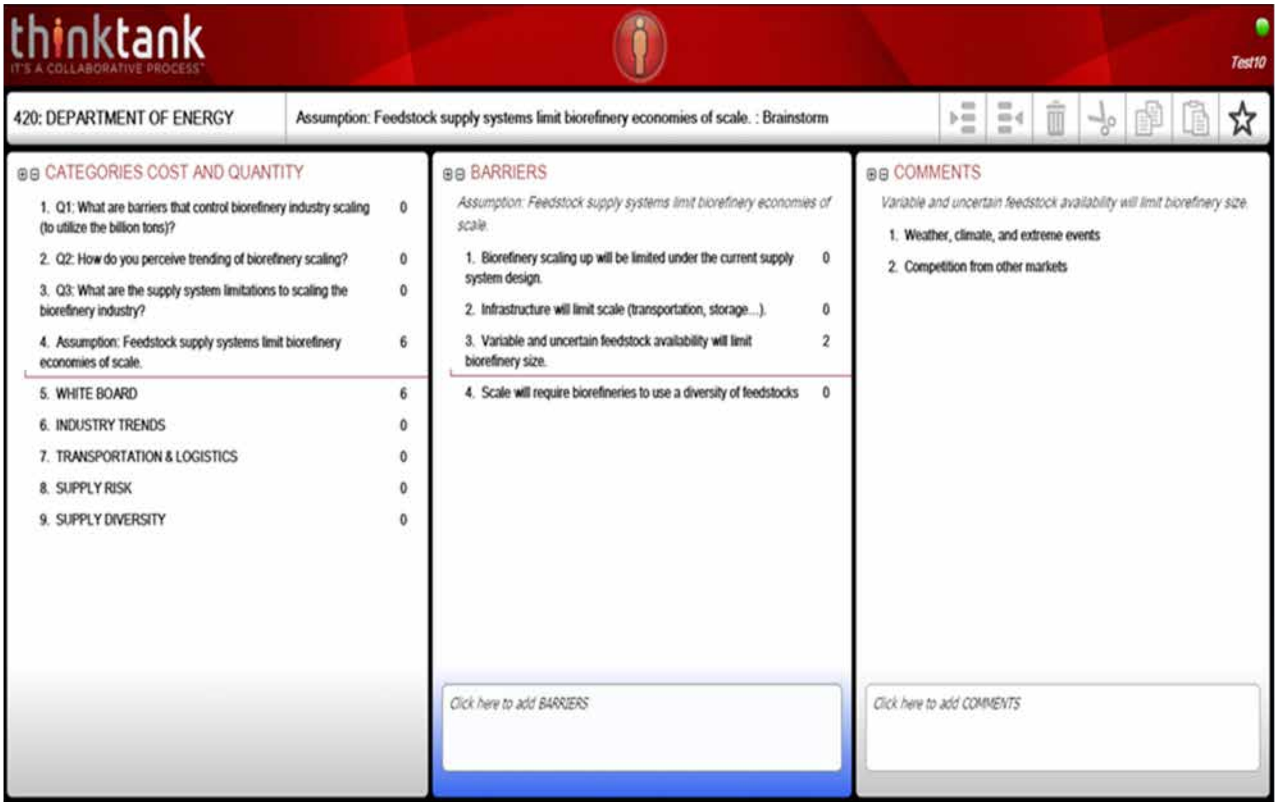

Figure C-2. ThinkTank user interface to communicate with workshop participants.

APPENDIX D

Feedstock R&D Tools

This section includes some of the tools funded by DOE that were selected based on relevance to the workshop.

Biomass Feedstock National User Facility

The DOE Office of Energy Efficiency and Renewable Energy is working with collaborators from across industry to develop the science and technologies needed to transform diverse forms of biomass into consistent, quality-controlled commodity products that can be efficiently handled, stored, and transported to biorefineries for processing.

INL has developed the capabilities to perform these investigations through the Biomass Feedstock PDU, a group of pilot to full-scale preprocessing equipment that can be operated onsite or deployed to the customer. The PDU is a preprocessing research system for demonstrating production of advanced biomass feedstocks at pilot scale. PDU capabilities include grinding and milling, drying, fractionation of plant components, formulation of feedstock blends from multiple biomass types or from various fractions, and feedstock densification. Onsite operations are supported by laboratory-scale units for initial development, including thermal and chemical preprocessing systems, full characterization, and analytical capabilities.

To support the DOE Office of Energy Efficiency and Renewable Energy's needs, INL has established this set of capabilities as the INL Biomass Feedstock National User Facility. The National User Facility will advance U.S. energy security by meeting the needs of researchers for an easily accessible, state-of-the-art, and affordable capability. The INL Biomass Feedstock National User Facility is be the premier facility in the United States for scientific, technical, and engineering investigation for transforming biomass feedstocks into consistent, quality-controlled commodity products that can be efficiently handled, stored, and transported to biorefineries in support of biomass-based energy security applications. The facility does the following:

- Supports academic, industrial, and federal researchers working at the forefront of scientific and technical understanding
- Provides the full range of equipment, facilities, personnel, and services needed to advance the science and technology for biomass feedstock preprocessing for energy applications
- Provides accessible, affordable, reliable, and leading-edge capabilities to the scientific and industry community.

The INL Biomass Feedstock National User Facility contributes to major developments in energy applications with high value for the nation, including the following:

- Developing the scientific, technical, and engineering understanding of biomass feedstock materials for the advancement of U.S. energy security
- Improving regulatory understanding of new technologies
- Improving the industrial performance of current and future energy supply systems, including hybrid energy systems.

The term "National User Facility" describes scientific and engineering facilities in the DOE complex that are both unique and too expensive for industry or universities to build. User facilities are made available to a wide variety of outside researchers; provide a base funded

Figure D-1. PDU housed at INL.

from major sponsors; operate as scientific, technical, and specialized engineering resources; and have governing bodies that approve the experiments and recommend facility improvements.

The National User Facility complements other Office of Energy Efficiency and Renewable Energy and national user facilities. The INL Biomass Feedstock National User Facility is fully integrated with the capabilities at the National Renewable Energy Laboratory, Lawrence Berkeley National Laboratory, and Pacific Northwest National Laboratory. All four national laboratories seamlessly provide their combined unique capabilities to users, acting as a single agent on behalf of Office of Energy Efficiency and Renewable Energy.

The PDU is an integral part of INL's new 91,000-ft^2 Energy Systems Laboratory (Figure D-1).This is a state-of-the-art research facility used to support key DOE advanced energy programs and projects. The Energy Systems Laboratory is a core capability for integrating Office of Energy Efficiency and Renewable Energy's key bioenergy and renewable energy strategic objectives.

The PDU was designed in modules to allow for operation of each unit individually or in any combination and for easy replacement of a particular piece of equipment. Each of the four modules (i.e., grinding, drying, milling, and densifying) includes all equipment (i.e., primary unit, input and output conveyances, and necessary support equipment), power, instrumentation, and controls for independent operation.

A variety of conveyors are available for moving the material into and out of the system and between modules that can be reconfigured to allow for maximum flexibility in the PDU. The primary units include a horizontal grinder, rotary drum dryer, hammer mill, and pellet mill. Throughput of the system is nominally 5 T/hour, though the inlet grinder design capacity is 15 T/hour. (Note that actual throughput is highly dependent on the input material characteristics and the desired final product.) A pneumatic transfer system can be attached to the grinder for increased throughput. Screen sizes range from 6-in. to 3/16-in. for a wide range of particle sizes. Ring dies for the pellet mill are available for herbaceous and soft-to medium hard wood. The system is also sealed except at the inlet and outlet to minimize fugitive dust and capture as much material as possible.

Data collection can be performed at each module or conveyed via Ethernet to a central control trailer for storage or immediate review. A user can enter process run-specific information (i.e., user name, material type, and purpose) and an automated report will be generated at the end of the run that includes typical data summaries (e.g., material mass, operating time, kilowatt hours by motor, and total power usage). Each module instrumentation/control box is expandable to allow additional instrumentation to be easily added as necessary. The resulting data can be added to the automated report if desired or saved for later interpretation.

Products from the PDU include the material generated to meet a particular specification and the data collected. Source material types essentially can be any biomass (herbaceous or woody) in a variety of conditions (e.g., freshly harvested, pristine stored, or degraded). Modifications can include size reduction, drying, some separation and fractionation, and densification in any combination or order. Multiple materials can be combined in any ratio. Portions of a material (i.e., a particular size or density fraction) can also be separated as a product or combined with other components. Individual materials or fractions—or combinations of materials or fractions—can be produced as a ground, dried, and/or densified product. If preprocessing is performed at INL, additional options are available. Laboratory-scale grinding, separating, and pelletizing equipment allow for initial testing before operating the larger PDU.

Thermal treatment (in addition to the PDU rotary drum dryer) includes a small-scale batch torrefaction unit, a variable residence time dryer to simulate reuse of other process heat, and a variable temperature thermal treatment system that can modify the material structure or destroy some unwanted components in order to improve specific material properties (from deep drying to torrefaction).Off gas analysis is available through online monitoring and sample collection. A chemical preconversion system began operations in Fiscal Year 2013 to evaluate material modifications using water, steam, and mild acid or base solutions.

Extensive analytical equipment is also available at INL for detailed characterization of the material at any stage (e.g., fresh, ground, pelletized, thermally treated, or chemical treated). Typical analyses include moisture, density, ash content, chemical composition, mechanical characteristics, and more. This equipment is part of the Bioenergy Feedstock Library.

Bioenergy Feedstock Library

The Bioenergy Feedstock Library, within INL's Biomass Feedstock Program, provides a robust mechanism for storing, recording, tracking, retrieving, accessing, and analyzing critical information regarding biomass feedstock resources. It hosts thousands of physical samples and data from over 80,000 historical and current samples. The Bioenergy Feedstock Library allows data from multiple organizations and experimental objectives across the research teams to be housed and assimilated in a single location, enhancing opportunities to analyze data and results together, to answer specific performance questions, and to integrate project results. The meta data establish the foundation of information and are linked to various feedstocks and respective physical, chemical, and conversion performance data.
The Bioenergy Feedstock Library comprised two primary components: the physical storage of feedstock materials (tracked through global unique identifiers) and the archive database system. Extensive analytical and characterization capabilities at INL are a key part for determining the quality and performance characteristics of feedstock materials. The Library allows subsequent quality analyses to be tracked back to the original sample, such that one could relate the impact of initial biomass quality on various conversion processes. Therefore, the Bioenergy Feedstock Library plays a key role in the interface between conversion and feedstocks. The Library also gives researchers broad datasets to compare and contrast specific feedstock resources and the tradeoffs between feedstocks. Although measured

Figure D-2. Examples of labeled storage containers in the Bioenergy Feedstock Library.

parameters vary and are often project driven, typical parameters measured include feedstock moisture, ash, compositional (i.e., extractables, ash, lignin, glucan, and xylan), proximate/ultimate analysis (i.e., carbon, hydrogen, nitrogen, sulfur, oxygen, lower and higher heating value, and calorimetric data), elemental speciation, particle size, reactivity and density.

The Bioenergy Feedstock Library was developed to maintain and archive all samples (now exceeding 60,000 samples) submitted by the DOE Regional Feedstock Partnership Institutions, Cooperative Research and Development Agreements partners, and core BETO research programs and their respective quality attribute data. The Knowledge Discovery Framework developed at ORNL provides a repository of land management practices and production data with a geographic information services interface in addition to numerous biomass feedstock models. The Library and Knowledge Discovery Framework systems provide different but complementary capabilities that are key to meeting the cost targets established by BETO. With continued development and enhancement of the Bioenergy Feedstock Library, efforts have been renewed to look at opportunities to for analyzing the datasets within the Library to create a comprehensive spatial and temporal report of feedstock quality in the United States.

Because of the significant number of biomass samples within the Bioenergy Feedstock Library (Figure D-2), complete quality attribute data could not be generated for all sample sets. Theses samples and supporting data cover a broad range of biomass feedstocks and agronomic conditions over several years. Compiling this data into a single, comprehensive feedstock characterization repository provides an opportunity to perform in-depth retrospective analysis of the spatial and temporal impacts of climatic conditions, production practices, tillage management, harvest methods, and best management practices on biomass feedstock quality and variability throughout the United States.

The PDU is operated in concert with the Bioenergy Feedstock Library, which provides a robust mechanism for storing, tracking, and retrieving various feedstocks for research and demonstration purposes. The Library comprised the physical storage of feedstock materials and the archive database system and leveraged the extensive analytical capabilities at INL. The Bioenergy Feedstock Library allows subsequent quality analyses to be tracked back to the original sample, such that one could relate the impact of initial biomass quality on various conversion processes and give researchers a broader dataset for their data.

Bioenergy Knowledge Discovery Framework

Decision Support Challenges for Bioenergy Assurance

Successful assimilation of the national bioenergy infrastructure not only relies on efficient operation of its components, but more so on effective harmonization with enabling critical infrastructure, including energy, transportation, water, agriculture, and commerce. These complex interdependencies of infrastructure across multiple space and time scales cannot be addressed by a single model or tool. Consequently, an integrated decision support environment must be developed where data, modeling, and visualization tools can be shared by multiple stakeholders to understand, design, and develop efficient local and regional practices for bioenergy infrastructure that can be guided with strategic policy decisions to ensure national bioenergy assurance.

A Standards-Based Dynamic and Scalable Architecture (https://bioenergykdf.net)

Utilizing world- class computing and information technology capabilities, ORNL is designing and developing a standards-based dynamic and scalable architecture that integrates, from distributed archives, bioenergy infrastructure-related data, models, and tools developed by government, academic, and private sector partners. A robust geospatial technology framework provides efficient data collection, integration, management, and analysis through geographic information systems; visualization through geographic information and exploration systems; and dissemination through geographic information services. Webenabled and role-based interactive access will ensure wide accessibility and usability of the Bioenergy Knowledge Discovery Framework.

Benefits to Stakeholders

- Easy information access to the current status of bioenergy
- Common operating data, models, and tools for the entire bioenergy supply chain
- Incorporation of models and tools for environmental, economic, and social impact analysis
- Support policymaking by visualizing the outcomes of proposed policies
- Definition of candidate areas for demonstration
- Improvement of public awareness, education, and outreach.

Relevant Capabilities and Ongoing Activities

- Integration of proprietary (i.e., ArcGIS Server, ArcIMS, and custom database) and standards-based (i.e., web mapping service and web feature services) data into a customizable, browser-based viewer
- Integration of dynamic sensor and weather data collected in the field, including moving object tracking capabilities made available to consumers via web feature services
- Provision of access to server-side geoprocessing tasks that allow the user to simultaneously utilize multiple disparate data sources

Desktop spatial analysis capabilities such as interactive feature buffering and complex spatial and textual querying into a browser-based framework.

  

Advanced Feedstock Supply System Validation Workshop Summary Report

Available at **www.inl.gov/bioenergy**

For more information, contact:

Bioenergy Technologies Office
Energy Efficiency and Renewable Energy
U.S. Department of Energy
1000 Independence Ave., SW
Washington, DC 20585

Idaho National Laboratory
Biofuels and Renewable Energy Technologies
PO Box 1625
Idaho Falls, ID 83415
www.inl.gov/bioenergy

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

15-GA50315