WORKING UNDERSTANDINGS
Future Technology, Calibrating Optimism, the Possibility of Change, Decision Making, Documentation, and Maximizing Impact in the Context of the RBAEF Project

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Memo Objective. To articulate conceptual approaches and operating procedures for the Role of Biomass in America's Energy Future (RBAEF) project. By developing a shared understanding on the matters addressed herein from the outset, it is hoped that the value of our results and the efficacy of our process will be improved. It is particularly important that concepts such as "mature technology" and "allowing for the possibility of change" be applied in a consistent way across different tasks of the project.

Context. The primary focus of Tasks 1 through 5 of the project is to articulate scenarios for what could be possible in the future given a societal desire to enhance sustainability and security via expanded use of biomass and other complementary technologies, and assuming an aggressive, sustained, and efficacious effort toward this end. Task 6 addresses the transition dynamics in going from the present to the scenarios articulated in Tasks 1 through 5. Task 7 addresses formulation and evaluation of policies that would accelerate realization of benefits.

Mature Technology. The project proposal states:

> "Biomass has not received the same level of analytical scrutiny in the context of long-term energy futures as have other renewable energy technologies such as wind, solar and hydrogen. This project seeks to rectify this imbalance by analyzing bioenergy and related issues in the context of a transition over the coming decades toward meeting U.S. energy needs on a sustainable basis. In approaching this analysis, the current state of technology development (including agricultural practices as well as biomass conversion technologies) will be an important point of reference. However, the primary focus will be on technological performance that can reasonably be expected in the future given a concerted effort. A focus on mature technologies will allow us to approach more directly the question of long-term desirability that the project ultimately seeks to address. Doing our analysis based on a vision of mature biomass production and energy conversion and comparing these to mature alternatives will also enable our analysis to proceed without the complications caused by comparing technologies across different stages of development."

To make this more operational, we propose working definitions for "mature technology":

> *a. Feedstock production.* For development of cellulosic energy crops and practices related to their cultivation, mature technology for the purposes of this project will denote an expended effort and state of advancement comparable to that for production of corn today.
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> *b. Processing and downstream mobility chain technologies.* For biomass processing and mobility chain technologies (energy distribution, delivery, storage; vehicles), mature technology for the purposes of this project denotes a state of advancement such that additional R&D effort would offer only incremental improvement in either cost or benefit realization with an expended development effort comparable to today's oil refineries and gasoline/ICE-based transportation infrastructure.

These definitions are stated slightly differently because experts in processing and downstream mobility chain technologies (area b above) seem much more comfortable with the notion of approaching an asymptotic limit as compared to experts in feedstock production (area a above). It may also be noted that

the mature technologies to which these definitions draw comparisons (corn, oil refining, gasoline/ICE transportation infrastructure) should be considered relative to the objectives for which they have been optimized. In general, such objectives involve maximizing economic return rather than efficiency or environmental merit.

In many areas related to this project, the vast majority of prior work has focused on the near-term. It will take discipline on all our parts to not let this perspective creep into our future scenarios. It is also important to be clear that we seek technologies that are not only mature, but also sustainable. Thus for example while we suggest using the current state of corn development as a reference for calibrating energy crop scenarios we develop, this does not imply that the environmental impacts that accompany current corn production would be acceptable for energy crops. Similarly for processing technologies, we should where possible take sustainability to be an integral constraint to our scenarios rather than a filter to be applied later.

Calibrating Optimism. Even given a working definition of mature technology, the question still comes up: "Mature according to whom?". It is important that we conduct our analysis acknowledging that there is inherent uncertainty involved in anticipating mature technology, and that reasonable persons with comparable expertise may have disagreements in this context. Yet our analysis is predicated on the premise that we can draw meaningful and important conclusions about mature technology in spite of this reality.

For the purpose of estimating features of mature technology, we propose that we use performance parameters consistent with *a knowledgeable optimist's most likely scenario*. It may be noted that this is neither the optimist's best case scenario, nor the average most likely estimate of experts spanning the optimist-pessimist spectrum. We think the reality is often that new technologies either never make it or exceed even the most optimistic predictions (consider computers for example). It seems to us that going for the most likely estimates from optimists is a middle ground between these two extremes and is also consistent with a "can do" attitude and willingness to pursue alternatives that is probably essential in order to gracefully navigate the sustainable resource transition.

Allowing for the possibility of change. The project proposal states:

> "Current practices and trends are neither sustainable nor secure and extrapolating into the future based on these trends is thus not a fruitful way chart a course toward these ends. We take it as axiomatic that some combination of significant changes is required to arrive at a sustainable and secure energy future. Thus, when considering important factors such as land-use patterns and energy efficiency, we will allow for a range of possibilities including fairly dramatic changes relative to the status quo where plausible. By approaching the analysis in this unconstrained way, our results will provide a menu of possible changes that can be evaluated with respect to desirability and supporting policies. This forward-looking approach provides a framework for working backwards to identify key intermediate steps, evaluating the timing of these steps, and suggesting public policies that may accelerate the rate of progress."

There are several important variables having a large non-technical component that greatly impact the potential contribution of biomass to meet needs for energy services. Such "societal variables" variables include food production, land use, and vehicle efficiency to name a few. When considering such variables, a range of scenarios is desired. This range should span extrapolation of the status quo on the one hand to a scenario based on a strong motivation toward sustainability and energy security on the other hand. By considering a range of scenarios with respect to societal variables, it is anticipated that we will underscore the importance of the interplay between technical and societal variables. In addition, we will establish analytical continuity between our results and the results of analyses that assume that society is not inclined to change.

Decision-making. Consensus among project participants as well as external constuencies/experts is a desired result of our project. With this in mind, the project schedule includes two meetings to gather input from persons and organizations not directly involved. It is also hoped that the project engenders

extensive discussion and interaction among participants where relevant. Notwithstanding these priorities, obtaining broad consensus among constituencies/persons external to this project is NOT required in order for the project to be successfully completed. In early discussions, John Sheehan, Gerson Santos-Leon (of DOE), and Lee considered and rejected a project with consensus as a central goal. Our thinking in making this choice was: 1) consensus-building is very time consuming and would make the project a much larger undertaking, 2) we think that most analyses that have had a high impact have not been based on a consensus process, 3) while a group of interacting analysts can reasonably hope to go on an intellectual journey together, this is not realistic for the community at large. In the process of going on a journey, we may well change our opinions and develop new opinions - those not intimately involved with the project will have the benefit of this process to a much smaller extent. In essence, our job is to complete our journey, soliciting input from each other and others as we go, perform analysis based on our best judgement enlightened by interaction and input, and then report what we learned from this journey to the world. Hopefully the world will take notice, but it is not our job to bring the world along with us every step of the way.

Documentation. The proposal states:

> "The task leaders will author chapters on their respective tasks. The Steering Committee will combine these into an integrated project report with a supporting volume, providing documentation of analysis."

In addition to the project report, several papers resulting from the project will be submitted to the peer-reviewed literature, though their actual publication may not occur until after the project's completion."

It is desired that the supporting volume provide an account of our analysis at a level of detail exceeding that of the chapters, integrated project report, and external publications. The supporting volume should be prepared so that someone reading it can understand our rationale and could reproduce, build on, or modify our analysis with as little additional information as possible. We suggest that project participants document their work as they go, rather than when deliverables are due, and that documentation pursuant to various tasks be shared among participants in order that we evolve an effective and reasonably common format.

Maximizing impact (heading for high ground). Our analytical effort should be devoted to 1) determining which technologies and implementation options can make a large contribution toward sustainable and secure energy supplies, and 2) detailed analysis of promising options (and combinations of options) to confirm their potential and to provide a stronger basis for evaluation and inclusion in technology strategies and related policies. Although delineating shades of gray for marginal options may be rewarding in the context of exercising analytical tools designed to illuminate such subtleties, we cannot afford to have our effort diverted in such directions.