CRITICAL NATIONAL NEED IDEA

Avoiding Unintended Consequences: Sustainable Biomass Management Frameworks in the New Energy Economy

A White Paper submitted to the

Technology Innovation Program (TIP)
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RE: Critical National and Societal Needs in Emerging Alternative Energy Technologies

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Our national focus on alternative energy development has gained tremendous momentum in response to several critical national and societal needs: energy and national security, greenhouse gas (GHG) emissions mitigation, foreign and fossil fuel dependency, long-term green-collar job establishment and maintenance, and rural economic development, to name the most critical (and those identified as high-priority national objectives). The nascent *advanced* biofuels/biorefining industry is uniquely positioned in its ability to simultaneously address all of these critical needs. However, while these critical needs are rapidly gaining in relevance and urgency among national policy priorities, it is imperative that we strengthen and deepen our strategic frameworks for growing and maintaining the bioenergy/biorefining industry in a sustainable manner. In other words, while so many of us in industry and government are intensely focused on developing advanced biorefining *technologies*, we must also develop the biomass *resource management frameworks* that will not only underpin a robust and enduring alternative energy industry but that will also help in maintaining, restoring and regenerating the biomass and ecological resources with which these industries – not to mention society as a whole – are inextricably connected and upon which they, of course, depend.

In a systems-based approach to analyzing and understanding biomass/biorefining supply chains, it is instructive to consider the whole supply chain in three major categories: feedstock production/harvesting/logistics; feedstock processing (bio-refining); and energy/bio-product distribution/consumption. The first category, biomass feedstock production/harvesting/logistics, by definition, requires certain inputs. In very basic terms, water, soil, nutrients, sunlight and carbon dioxide are among the primary inputs required for primary biomass production. When processed for bio-energy purposes, the biomass resources will also yield certain outputs. Chief among these outputs are energy, carbon, ash, and other organic and inorganic by-products. A sustainable[1] biomass resource management framework – an economic and ecologic necessity[2] – will establish sufficient balance between the water, nutrient, gaseous vegetative inputs and the water, nutrient and gaseous (ie: GGE) outputs resulting from biorefining processes. Additionally, sustainable biomass resource management frameworks will, per se, ensure that the long-term productivity of our agriculture and ecosystems is not impaired or diminished by biomass resource demand and utilization in the shorter-term. Put simply, although increasingly possible from a technical standpoint, we must not liquidate our bio-resource/natural capital base if we are to establish and maintain a sustainable bioenergy framework.

It is nearly certain that geometrically increasing biorefining production capacity will substantially increase demand for a variety of biomass resources and the ecosystem services those resources provide[3]. Whether forests of

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[1] U.S. Code, Title 7, Section 3101 defines "Sustainability" to mean an integrated system of plant and animal production practices having a site-specific application that will over the long term: satisfy human food and fiber needs; enhance environmental quality and the natural resource base upon which the agricultural economy depends; make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls; sustain the economic viability of farm operations; enhance the quality of life for farmers and society as a whole.

[2] The classics student will be quick to point out the etymological fraternity shared by the words economy and ecology – both pertaining to and deriving from the Greek *oikos* – "home".

[3] The Millennium Ecosystem Assessment group organizes the earth's natural capital – or ecosystem services – into four distinct categories: Provisioning (ie: food, freshwater, wood, fiber, fuel); Regulating (climate regulation, flood regulation, disease regulation, water purification); Cultural (aesthetic, spiritual, education, recreational); and Supporting (nutrient cycling, soil formation, primary production) – see: www.millenniumassessment.org for more information.

cellulose, prairies of switchgrass, or any other number of imaginable sources of abundant biomass, these are also the ecosystems that form the fabric of life on earth as we know it. It is imperative that we develop the frameworks to manage these systems responsibly and sustainably, particularly as we expect to sustain ongoing biomass yields from them. This natural bio-productivity will be complemented and augmented via industrial biomass production systems such as aquacultures producing algae (and likely other fiber, energy and food resources) and industrial food waste and agricultural residue recovery and biorefining facilities. The former "natural" biomass producing ecologies will need to be maintained in a robust and sophisticated ecological stewardship framework. The latter "artificial" biomass producing ecologies will be a critical source of many supplemental nutrient inputs into both the natural and artificial ecologies.

Overlaying these biomass resource productivity and sustained yield issues (and the associated natural capital/ecosystem services issues) are closely related issues of fresh water consumption/recovery/re-use, greenhouse gas emissions cycles (the "carbon" cycle), land-use and habitat patterns and enhanced vegetative metabolism vis-à-vis these water, carbon and habitat issues. Of course, while all of these issues converge in ecological and industrial systems, they do so in an emerging industry that is simultaneously a crossroads and nexus of otherwise divergent energy, agricultural, water and GHG markets and commodities. A sustainable bioenergy future will have a robust, sophisticated and carefully applied biomass and ecosystem management framework as a primary and necessary attribute.

To this end, it is imperative that our federal government prioritize, foster and finance the development of these frameworks. As we know, the Department of Energy, Department of Agriculture and Environmental Protection Agency, to name a few of the most prominent federal agencies charged with certain aspects of the biomass and biorefining federal policy directives, are well under way in their efforts. However, it would seem that the National Institute of Science and Technology, with its general focus on commerce standards, information systems, advanced data development and analysis and technology advancement capabilities, and the NIST Technology Innovation Program (TIP) in particular, with its focus on societal challenges of large magnitude that are unmet by others, opportunities to stimulate the Nation's capabilities, and transformational impacts, would add substantially (and on a matter of great significance and criticality) to the development of a sustainable biomass and biorefining future. As this is a societal challenge area of critical national need, and will yield a transformational result, NIST's TIP seems to be an ideal conduit and mechanism for harmonizing and enhancing the ongoing efforts of DOE, USDA, EPA and others. As industry, policy-makers and technocrats make it an increasing priority to balance water, energy, climate and agriculture in our biomass and biorefining supply chain development efforts, we will succeed in establishing a sustainable, new energy economy that not only meets the food, fiber and energy needs of current generations, but does so while enhancing the biosphere resources and services upon which future generations will depend.

The high-risk, high-reward science and technology that could achieve the transformational results by the end of the TIP funded research efforts would likely include comprehensive techno-economic-ecologic modeling of a myriad of biomass resources and their associated inputs, outputs and environmental and market economy impacts. This will

further advance and stimulate certain complex systems modeling capabilities, such as those utilized by the National Oceanic and Atmospheric Administration (NOAA) for climate change modeling. This science and technology area will also further advance the appropriate technologies, supply chain management, resource management and other information technology and biorefining technology development. The magnitude of this societal challenge is not being met adequately (or to a large degree, even identified) by others, and the requisite research and technology needed in this area must be comprehensive and robust in scope and analytical capabilities. Without the leadership and prioritization from TIP, this critical national need idea will not likely receive the technology leverage, the cross-discipline integration, and the expeditious development of a critical biomass resource management framework. Total and/or partial success will be tantamount to truly sustaining our natural ecosystems while developing and maintaining a robust biorefining industry.