New York State Energy Research and Development Authority

Biomass and Bioenergy— Framing the Debate

Final Report

November 2011

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Biomass and Bioenergy—Framing the Debate

Final Report

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NOTICE

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INTRODUCTION

Perhaps the only thing definitive that can be said about bioenergy is that it is a very complicated subject. Although there are some things about bioenergy technologies and biomass feedstocks that are generally true, nearly every aspect of bioenergy is difficult to completely classify. Similarly, outside of knowing that bioenergy includes conversion of non-fossilized carbon resources, the term bioenergy does not do justice to the universe of possible resources or conversion technologies involved. Likewise, given the broad class of products/compounds/raw materials implied by the term biomass resources a multitude of natural resource, energy, environmental and land-use policies are co-opted into the debate, often thwarting coherent discussion. Attempts to break bioenergy into sub-pieces can lead to contradictory conclusions and confuse well meaning policy development.

Recognizing that outlining an approach to changing the current landscape regarding bioenergy is outside of the scope of this report, this report focuses on identifying issues and discussions that have arisen from the complication of how the world, to this point, has dealt with bioenergy. These include debates and discussions of the following:

1. What is biomass? This is especially important in context of distinguishing biomass feedstocks from solid wastes and specifically in context of solid waste management rules and renewable energy standards.
2. What do the terms, *Renewable, Sustainable* and *Carbon Neutral* mean in the context of biomass feedstocks? Why is understanding the difference between these terms important? What are the implications of the meaning of these terms? What about indirect and direct land use changes (which stretch beyond food versus fuel)? Is *Best-Use*[1] an important metric for Biomass Feedstocks? How do perceptions about *Best-Use* play into the national policy debate?
3. What are the pros and cons of using biomass feedstocks for energy (heat, power, alternative transportation fuel, biobased chemicals)?

As this report will show, this list is deceptively short as almost all of the above topics can be expanded to reveal very complex and nuanced debates with details that stretch the boundaries of both science and policy.

A few topics will be deliberately excluded from the discussions below except possibly in an anecdotal way for illustrative purposes. These include:

- Detailed description of technologies involved in energy conversion
- Detailed description of biomass feedstock production, harvesting or processing technologies
- Exhaustive description of policies and incentives in place currently or historically for the above

Although all are important topics, the specifics of technologies are less important in this discussion than the bigger environmental and scientific issues that are driving the current discussion.

[1] Best-Use is referenced here in context of balancing sustainability factors, economic value and product conversion efficiency.

BIOMASS: A DECEPTIVELY SIMPLE DEFINITION

Defining biomass is challenging. Several functional definitions are listed below:

Biomass[2] is material of biological origin excluding material embedded in geological formations and transformed to fossil. Sources of biomass include energy crops, agricultural and forestry wastes and by-products, manure or microbial biomass.

Biomass[3] — all plant and plant-derived materials including animal manure, not just starch, sugar, oil crops already used for food and energy.

With these definitions and many others, the key definitional phrase is non-fossilized carbon. Unfortunately, this definition is so general that it encompasses nearly the entire living ecosystem. Recognizing that these definitions are simply too broad to develop policy around, law makers and regulators have attempted to define biomass in more practical terms. These efforts have included adding specificity to encourage particular solid waste, agricultural, environmental or energy policies.

As one might expect, this has introduced the potential for conflicting definitions. By way of example, the term biomass has been used in legislation enacted by Congress for more than 30 years. Biomass has been defined in legislation stretching across everything from Tax Law to Environmental Law. According to a recent report[4] to Congress, a total of 14 biomass definitions have been included in federal legislation since 2004. It is also important to note that even the definition of *wood* is different in Congressional treatments[5].

Complicating matters further, most states, including New York, have adopted their own definitions. In some cases, these definitions may be tied back to federal language, but often there are nuances that reflect local values and policy objectives. For example, Renewable Portfolio Standard requirements often limit biomass sources to those resources that are considered environmentally preferred in some way. Or they may be crafted to walk a fine line between achieving a particular environmental objective without causing undue financial harm to an existing industry such as pulp and paper.

Different government policies with different objectives complicate establishing a uniform definition for biomass. That said, and especially in context of synchronizing environmental policy with energy and agriculture policies, it is important for policy makers to maintain a holistic view of the biomass industry. It is counter-productive to develop policies that encourage biomass-based markets if doing so simultaneously runs contrary to other policy objectives. Failure to coordinate policies in the case of biomass resources has caused confusion and uncertainty in some market segments, as well as unintended consequences. For example, refining and burning Kraft black liquors to recover energy and chemicals – a common practice in the pulp and paper industry – is a form of biomass fuel use. When Congress expanded a tax credit (Alternative Fuel Mixture Credit) for alternative fuels to include non-mobile uses of liquid alternative fuel derived from biomass they failed to anticipate that the existing use of Kraft black liquors[6] could qualify. According to Forbes[7], sixteen paper companies reported a windfall in 2009 as a result of the credit. In this case a poorly designed policy resulted in billions of dollars of windfall to an already mature market using black liquor, a by-product of pulp production that has been in commercial and widespread use for decades. The problem was fixed within a year by rider legislation and ended in December 31, 2009.

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[2] Bioenergy and Food Security : The BEFS Analytical Framework, FAO, Rome 2010

[3] Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Supply, USDOE, April 2005

[4] Biomass: Comparison of Definitions in Legislation Through the 111th Congress, K. Bracmort, R. Gorte, CRS, October 2010

[5] ibid

[6] A mixture of chemicals, lignin and hemicellulose that results from the chemical pulping of wood.

[7] Black Liquor Tax Credit Clouds Paper Companies' Earnings, Forbes, November, 2010.

RENEWABLE, SUSTAINABLE, CARBON NEUTRAL

The meaning and science of the terms *renewable*, *sustainable* and *carbon neutral* have again taken center stage in the international debate regarding bioenergy. The international component is important to consider, since policy treatment of bioenergy and biomass resources will depend on specific policy objectives. Such objectives not only vary within the United States, but also globally.

The issue in defining renewable, sustainability[8] and carbon neutrality for biomass resources is not a lack of clear definitions for each of these terms. Instead, it is the inter-relationship of these terms and the breadth of their scope that is often the source of confusion. A sample definition for each (there are many variations) is provided below for reference.

Renewable Resource[9] – any natural resource (as wood or solar energy) that can be replenished naturally with the passage of time.

Sustainability[10] – meeting the needs of the present without compromising the ability of future generations to meet their own needs.

Carbon Neutrality[11] – a transparent process of calculating emissions, reducing those emissions and offsetting residual emissions such that net carbon emissions equal zero.

RENEWABLE AND SUSTAINABLE

The definition of *renewable* is straight forward but it implies that resources are extracted using methods that will allow renewal to take place. For example, if one continuously clear cuts forests and then paves over the land to make way for shopping malls, then eventually no renewal is possible.

In fact, historically, unsustainable harvesting operations such as clear cutting were the key concern that plagued biomass-based energy discussions. The argument included concern that creating markets for forest-based products, or even processing residues from forest-based industries, could incentivize bad forestry practices such that resulted in the destruction of whole forests and drastic land-use changes.

In this context, it was argued by a variety of entities that *sustainability* was the key to ensuring that this would not happen. Further, bioenergy policies should naturally incorporate this concept to protect the health and renewability of the resource. As a result, more emphasis was placed on defining sustainability. There still remains some disagreement if/how social, environmental and economic impacts should be included in the definition.

Trade industries and environmentalists tend to define sustainability differently. In general, trade industries relying on the use of biomass resources prefer to include some weight for economic factors in the definition of *sustainability*, while purely environmental organizations may favor less weighting for economic value and seek to include more far-reaching social and environmental measures. One example statement taken from a recent draft document[12], by the Council on the Sustainable Biomass Production is provided below. The organization includes a mix of industry, government and environmental stakeholders.

"At the outset, members of the Council agreed on a definition of sustainability to guide our process:

Adopting practices and developing products that are environmentally, socially and economically sound, and that can meet present needs without compromising the ability of future generations to meet their needs."

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[8] Read also as Sustainable Practices

[9] http://wordnetweb.princeton.edu

[10] There are many definitions, including definitions that incorporate economic, social and environmental factors. The one listed is generalized from the definition provided by SFI, "To practice *sustainable forestry* to meet the needs of the present without compromising the ability of future generations to meet their own needs," SFI 2010-2014 Standard, Section 2, January 2010.

[11] Composite definition from multiple sources but relies heavily on wording developed by the UK, Department of Energy and Climate change, "Guidance on carbon neutrality," September 30, 2009

[12] PROVISIONAL STANDARD FOR SUSTAINABLE PRODUCTION OF AGRICULTURAL BIOMASS, Council on Sustainable Biomass Production, July 2011.

The phrase, "economically sound," is included as an explicit part of sustainable practices. As noted, deciding the specifics of what constitutes "sustainable practices" is complicated. For example, deciding calculation methodologies and metrics for typical objectives (shown below) are potential subjects of debate.

Example Objectives:

- result in lower net GHG emissions than alternative energy sources
- maintain biodiversity
- improve social well being; while
- minimizing resource competition

In contrast to the above, another highly referenced definition of sustainability[13] was put forth by M. Rosenbaum, "Sustainable means using methods, systems and materials that won't deplete resources or harm natural cycles." It is clear that resource depletion and the environment are the emphasis.

Complicating the issue of sustainability somewhat is that biomass resources used for bioenergy may actually come from industrial processing or waste streams. Examples include plywood scraps or clean construction and demolition debris. In both cases, concerns regarding sustainability are more difficult to manage since the harvested wood resource was purchased and used initially by industries outside the energy sector for other markets. Sustainability must then be tracked back through a custody chain, imposing requirements on a variety of different parties. Or, stakeholders must agree on assumptions that treat this resource differently from other biomass, adding complication to rulemaking.

Especially in the case of sustainability, a holistic policy view of biomass resources is required to ensure that policies managing very diverse industries do not conflict, and over arching objectives can be met with minimal confusion. For example, there remains some debate as to whether some industrial processing residues should even be considered wastes if they have a ready market in the bioenergy industry. The difference is very important in determining the ultimate fate of a substance. This concept will be discussed further in context of greenhouse gas (GHG) Life Cycle Analysis and Carbon Neutrality.

CARBON NEUTRALITY

It is easy to see from the discussion of *renewable* and *sustainability* that *carbon neutrality* could naturally become entangled into the discussion. In order for biomass resource use to be considered carbon neutral, it must be renewed on a sustainable basis such that the uptake and release of carbon are in balance. If these conditions are not met, then a carbon imbalance eventually occurs.

In other words, if sustainably harvested biomass resources are being renewed through equivalent growth, then on a net basis, they are carbon neutral. This defacto standard has been codified in legislation and government policy stretching across a number of sectors.

Nevertheless, recently, this particular concept has come under criticism from several angles. Critics have posed (and in some cases suggested answers) to the following questions:

1. Should the timeframe over which carbon uptake occurs be taken into account if the real policy objective is lowering CO_2 atmospheric concentrations? A recent report[14] introduced the concept of a *carbon debt.* Carbon debt accrues from harvesting wood for energy, and then must be repaid over time via the complete re-absorption of carbon resulting from biomass regrowth in the ecosystem. Other reports counter this argument by saying the carbon was "banked" previous to harvest. Others[15] [16] suggest that this is not even the central issue.

[13] "Sustainable Design Strategies," Solar Today, Rosenbaum, March/April 1993.

[14] Biomass Sustainability and Carbon Policy Study, Manomet Center for Conservation Sciences, June 2010

[15] Accounting for Greenhouse Gas Emissions from Wood Bioenergy, Policy Analysis Group, Report No. 31, September 13, 2010

[16] Life cycle impacts of forest management and wood utilization on carbon mitigation: knowns and unknowns, Bruce Lippke, et al, Carbon Management, (2011) 2(3), 303–333

2. Should Carbon emitted by biogenic sources be treated the same as carbon emitted by fossil sources? This is a corollary to the question above.
3. Should carbon accounting occur at the stand level (very specific plots of land) or the landscape level (larger regions)? Although this topic had been addressed in past research, the release of the Manomet study[17] brought these discussions back to the forefront.
4. How do Indirect Land Use Changes (ILUC) affect carbon accounting? This is actually a two part question and part of the answer is given in the next section. This section will address carbon accounting.
5. How do all of the GHG Life Cycle Analyses conducted for bioenergy technologies compare? Do they say the same things and what do they tell us?

Answering the above questions is complicated for several reasons:

The Science: Put simply, there is still a lot of scientific research and analysis to do. This fact is complicated given that there is still ongoing debate regarding the magnitude of anthropogenic contributions to the rate of climate change and how best to ameliorate it. Since, plants and animals are of foremost importance in the Carbon Cycle[18], ferreting out issues surrounding biomass is both important and complicated. Understanding carbon sequestration provided by trees is a subject of intense and ongoing research and a critical matter in understanding carbon release and absorption.

ILUC is also a subject of debate and analysis (see the next section for a more complete treatment). Its importance is reflected in the following headlines:

- *"Europe's biodiesel industry could be wiped out by EU plans to tackle the unwanted side effects of biofuel production, after studies showed few climate benefits, four papers obtained by Reuters show[19]"*
- *"ILUC could Force a Biofuels Policy Change in EU[20]"*

A relatively recent paper analyzing ILUC states the following:[21]

"By using a worldwide agricultural model to estimate emissions from land-use change, we found that corn-based ethanol, instead of producing a 20% savings, nearly doubles greenhouse emissions over 30 years and increases greenhouse gases for 167 years. Biofuels from switchgrass, if grown on U.S. corn lands, increase emissions by 50%. This result raises concerns about large biofuel mandates and highlights the value of using waste biofuels products."

In response, other recent papers suggest a different outcome. An example from one such paper[22] is provided below.

"Using less than 30% of total U.S. cropland, pasture, and range, 400 billion liters of ethanol can be produced annually without decreasing domestic food production or agricultural exports. This approach also reduces U.S. greenhouse gas emissions by 670 Tg CO_2-equivalent per year, or over 10% of total U.S. annual emissions, while increasing soil fertility and promoting biodiversity. Thus we can replace a large fraction of U.S. petroleum consumption without indirect land use change."

For every article falling on one side of the debate, counter articles offer details of why the offending analysis is wrong. National laboratories are pitted against universities and consultants against consultants. In the opinion of the authors, part of the issue is that data is still coming in and research and analysis is still needed to reach consensus.

[17] Ibid.

[18] The cycle of carbon in the earth's ecosystems in which carbon dioxide is fixed by photosynthetic organisms to form organic nutrients and is ultimately restored to the inorganic state (as by respiration, protoplasmic decay, or combustion) – Merriam Webster Online dictionary (http://www.merriam-webster.com/dictionary/carbon%20cycle)

[19] Reuters, May 2011

[20] Biomass Hub, July 2011

[21] Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land Use Change, T. Searchinger et. al, Science, 319, 2008

[22] Biofuels Done Right: Land Efficient Animal Feeds Enable Large Environmental and Energy Benefits, Bruce E. Dale et. al, Environ. Sci. Technol., 2010, 44 (22)

It is clear that a more complete understanding of the complexity of the global ecosystem and economy will require time, and is well beyond privately funded attempts to find easy answers. Analyzing land use changes relies on modeling of behaviors, causation and responses to price signals for energy, food and other uses of available land. In this regard assumptions and algorithms will always be questionable.

Accounting Protocols/Conventions: The other issue implicit in untangling carbon neutrality is that at least part of the answer is, it depends on a variety of factors. In this case, the term *carbon accounting* is very helpful in understanding the likely endpoint. Accounting is a mixture of mathematics and convention. For example, provided that the addition and subtraction are done correctly and common convention is used in preparing the analysis, two different accountants should be able to come to reasonable agreement on a company's balance sheet.

As with sustainability, a combination of conventions and agreed upon calculation methods are needed to make decisions about carbon neutrality. An example of this issue is provided on a USDA Forest Service Website;

"Negative or positive? Atmospheric scientists have used positive carbon change numbers to mean CO_2 is increasing in the atmosphere, and negative numbers to mean CO_2 is decreasing in the atmosphere. When forests are taking more CO_2 from the atmosphere than they are releasing, these estimates would then be reported as negative. This standard is used by greenhouse gas inventories because most reported activities are emissions and are listed as positive; only a few sequester carbon. Forest scientists, however, may report increases into the forest as positive. We have adopted the standard used by the Intergovernmental Panel on Climate Change, with sequestration listed as negative. "

Clearly, conventions will be as important as the science and math in understanding carbon neutrality for bioenergy. Further, the stakes are high. Depending on the feedstock and assumptions, a number of studies (including many of those cited above (Manomet, Deluchi, Policy Analyst Group) suggest that bioenergy can be deployed in ways that range from doing better than carbon neutral, to doing far worse. Understanding the nuances is challenging.

GHG LIFE CYCLE ANALYSES (LCA)

The situation for GHG LCA for many fuels is the same. A recent report[23] from the United Nations Environment Programme states as much.

"Assessment of the net GHG effect of a bioenergy pathway[24] or project is currently done under several methodologies. To enable choices for the most GHG efficient option in a given context, a common methodology is urgently needed for different pathways over their entire life cycle, including direct and indirect changes in land use. This is particularly important for an evolving carbon market that can promote bioenergy pathways with substantial net greenhouse gas reductions."

In a recent effort to review differences in LCA models used to assess bioenergy projects, ANTARES concluded that there were key divergences in these regarding land use change, co-product crediting, and non-greenhouse gas emissions. GHG LCA also raises an important issue of comparing biomass, other renewable energy and conventional energy on comparable lifecycle terms. For example while biomass land use, fertilizer input, harvesting and transportation costs and emissions are highly visible and analyzed extensively, the fossil fuels or other renewable energy options used for comparison are often not examined on a lifecycle basis. It is not uncommon for news articles and even serious analyses to compare technologies using different lifecycle system boundaries. The land-use impacts, transportation costs, and fugitive emissions (especially of methane) of fossil fuel energy cycles are often overlooked in comparisons.

HOW TECHNOLOGY FITS IN

Many international governments have already decided at the highest level that it is appropriate to use biomass for energy. Perhaps this was done without fully realizing the broader implications. It is clear that in addition to agreeing on technologies or end-uses; even agreeing on which resources are appropriate is a matter of debate. Still, assuming that no significant course reversal occurs, at some point understanding the most efficient use of each

[23] A Growing Debate: Bioenergy in the 21st Century, UNEP

[24] Pathway means the route from raw production, conversion and end-sue.

type of biomass resource will also be scrutinized more heavily.

The efficiency of our use of biomass resources has important implications regarding sustainability and GHG life cycle emissions. Technology sets the boundary conditions for efficient use and is a critical link in the chain.

1. The more efficiently we use a resource, the less we need to use. This results in lower impacts for producing, collecting and converting the resource. Maximizing efficiency also minimizes land-use.
2. Similarly, the magnitude of unintended impacts is reduced. Even the most careful analyses will not be able to account for every potential impact. Maximizing efficient use of biomass resources is the best hedge against unforeseen events.

Technology choices for bioenergy present their own set of challenges.

- The bioenergy industry is crowded with technology vendors with offerings that include biopower, heat and biofuels. Many of these technologies continue to struggle to live up to the hype generated by their developers. It is a challenge for many to discern which technologies offer real prospects of advancing the state-of-the-art in conversion and which are merely wishful thinking.
- The pathway from raw material to energy end-use can be very convoluted. For example, biomass resources can be pelletized, gasified, and then converted to steam before producing electricity for end-use applications. Biofuels are produced from feedstocks, then transported to delivery stations, and then consumed in vehicles for transportation. Analyzing these long pathways (from source to end-use) with such a diverse set of feedstocks, collection methods and conversion technologies makes deciding what is the most "efficient[25]" use for biomass resources a challenge. Further, the advent of electric powered vehicles is now allowing policy makers to consider the potential for the bioenergy heat/power markets to compete directly with traditional transportation energy options.

That said, energy policy makers set the rules for the markets, and technology and project developers take their cues accordingly. Although it is beyond the scope of this report, the world has seen how differences in energy policy (namely between the U.S. and Europe) can affect development and deployment of bioenergy technologies. There is no doubt that policy decisions about "best-use" or most "efficient-use" of biomass resources will be expressed through technology choices by the energy sector.

[25] The term, "efficient" is emphasized given that efficiency has many definitions. Still, regardless of the specific definition used by policy makers, technology development will mature accordingly.

THE BEST USE OF THE REAL RESOURCE; LAND

As noted several times above, biomass resources are entangled in several pillars of the global economy; agriculture, forestry and energy. At the heart of the debate is something more fundamental. In all cases, the real resource, the fundamental natural resource that is in play is land.

Most biomass currently used or planned for use in bioenergy applications (possibly excepting algae and some waste streams) will require substantial amounts of land. Whether forest- or farm-based, the choice on what is the best use of earth's finite land-base underlies many of the critical issues surrounding bioenergy.

This fact was brought to the forefront in the "Food vs. Fuel" debate. In 2007, global concern regarding grain supplies sparked debate regarding the use of corn for ethanol production. The lead paragraph from a January 2007 New York Times article[26] is just one of many from the period.

"Renewing concerns about whether there will be enough corn to support the demand for fuel and food, a new study has found that ethanol plants could use as much as half of America's corn crop next year."

Although at a high level the question considered above was whether we should be using a food crop for fuel, fundamentally the debate centered on the question on how best to use our farm land, whether for food, energy, other uses, or some combination. Economists, scientists and policy makers lined up on both sides of the issue, attracting considerable media attention, at least for short period. At the time, many bioenergy advocates asserted that they did not believe using corn for ethanol was responsible for food price increases. Further, they argued that in the future, ethanol would be made from non-food crops, relieving any concern over potential price impacts.

With respect to the first point, it appears the industry was at least partly right. A World Bank study[27] released July, 2010 and quoted in a Reuters article[28] this year, states the following:

"The effect of biofuels on food prices has not been as large as originally thought, but that the use of commodities by financial investors ...may have been partly responsible for the 2007-08 spike."

Other studies suggest that while it is likely that increased demand for corn used for ethanol had an impact on prices, such impacts were relatively modest. The following excerpt was taken from a 2011 report[29] also focused on the issue.

"The results developed in the previous two sections show that US ethanol policies modestly increased maize prices from 2006 to 2009 and that under tighter market conditions, such as we have seen in 2010 and so far in 2011, market impacts of the policies will be larger."

None-the-less, land-use practices are far from settled with respect to bioenergy. Competing uses for land are both important and compelling. On one hand the world is in agreement that the use of renewable resources are critical to the long-term survival of our way of life and the planet. On the other, growing global populations need better food supplies, and clear cutting for pasture and farm land is already a global problem.

These competing pressures are highlighted in current debates surrounding ILUC. Quoting a recent article[30] in Reuters,

[26] Rise in Ethanol Raises Concerns About Corn as a Food, New York Times, A Barrionuevo, January 2007

[27] Placing the 2006/08 Commodity Price Boom into Perspective, The World Bank Development Prospects Group, July 2010

[28] Analysis: In food vs. fuel debate, U.S. resolute on ethanol, Reuters, T. Gardner, February 2011

[29] The Impact of US Biofuel Policies on Agricultural Price Levels and volatility, ICTSD Programme on Agricultural Trade and Sustainable Development, June 2011

[30] A divisive European debate over the credentials of Biofuels has stalled investment, but the stalemate may soon be over for advanced Biofuels and some types of Bioethanol, Reuters, P. Harrison, M. Roberts, May 2011.

"In essence it [ILUC] means that if you take a field of grain and switch the crop to biofuel, somebody, somewhere, will go hungry unless those missing tonnes of grain are grown elsewhere."

Even though it has been argued that cellulosic-based sources of biomass (energy crops of grasses and wood) will not be grown on prime cropland for economic reasons, clearly there is concern that current land-use situations could change and result in a different paradigm. According to a 2011 report by the UN Food and Agriculture Organization, "Roughly one third of the food produced in the world for human consumption every year – approximately 1.3 billion tones – gets lost or wasted…" Apparently reduced wastage alone could offset much of the current and future impact of energy crops on our ability to produce food. In addition, improved agricultural practices in developing countries could help alleviate pressure on global food supplies and prices.

As the headline in a recent trade publication[31] suggests, the problem of competing use is not limited to food versus fuel; *"Bioenergy Investments Rattle the Forest Products Industry."* Related concerns have been raised with respect to wood-chips that may have multiple markets. It has been feared by some pulp and paper industry observers that increased use of wood chips for energy (heat, power, wood pellets for export, etc.) will increase demand on pulp wood chips, driving up feedstock prices for the pulp and paper industry. Although, in general, the existing biopower industry seeks lower quality, lower cost feedstocks than pulpwood, experts appear to agree that competition for pulp quality biomass could increase if large numbers of bioenergy plants come on-line. The magnitude of the effect will depend on a lot of factors, many of which are extremely difficult to quantify, and are feedstock dependent. Still, it is clear that increases in feedstock prices are likely to impact the pulp and paper industry; an industry that has already experienced economic difficulties.

[31] Bioenergy Investments Rattle the Forest Products Industry, Forest Landowner, P. Stewart May/June 2007

SUMMARY / CONCLUSIONS

Properly understanding the issues surrounding bioenergy and biomass resources requires embracing both a broad and complex view of the world, while simultaneously embracing the very local nature of key pillars of the economy, including agriculture, forestry, waste management and energy. At the highest level, the key issues include:

- Full and complete definition of the resource base, while understanding that "biomass" feedstocks may be as different as algae and wood pallets
- A need for a holistic view across feedstocks and across industry sectors
- Appreciating the importance of land-use in context of food, fiber and energy production
- The complexity of sustainability, carbon accounting, and life cycle green house gas emissions in context of biomass production and conversion chains that include very different technologies and pathways.

Wrestling with the complexities documented in this report will require considerable research, analysis and consensus building before many of these issues can be satisfactorily resolved. Fortunately, a global effort is underway to accomplish this task. Although it remains disjointed and often focused on regional issues, frameworks and tools are being developed that should provide clarity and models for future policy makers. In many ways, bioenergy and biomass resources offer a concrete opportunity to *"think globally, and act locally."*

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