Executive Summary

Bioenergy and Greenhouse Gases (April 2008)

The greenhouse-gas implications of energy production from biomass are more complex and subtle than the greenhouse-gas implications of energy production from other energy resources. Energy production from fossil fuels removes carbon from geological storage and adds it to the atmosphere. Energy production from non-bioenergy renewables and other non-fossil sources produces energy without significant greenhouse-gas emissions. While biofuels are carbon-based fuels, the carbon in biofuels is already part of the active global carbon cycle in which carbon exchanges rapidly between the atmosphere and the biosphere. Bioenergy production does not add new carbon to the active carbon cycle, but it can affect global greenhouse-gas levels in some important ways.

Key Findings

Carbon Neutral and Beyond

The greenhouse-gas emissions produced at biomass and biogas generating facilities come from carbon that is already a part of the linked atmospheric-biospheric carbon cycle. This is in stark contrast to fossil-fuel combustion, which removes carbon from permanent geologic storage and adds it as net new carbon to the carbon already in the atmospheric-biospheric circulation system. Most people focus on this aspect of bioenergy production, and proclaim it to be "Carbon Neutral."

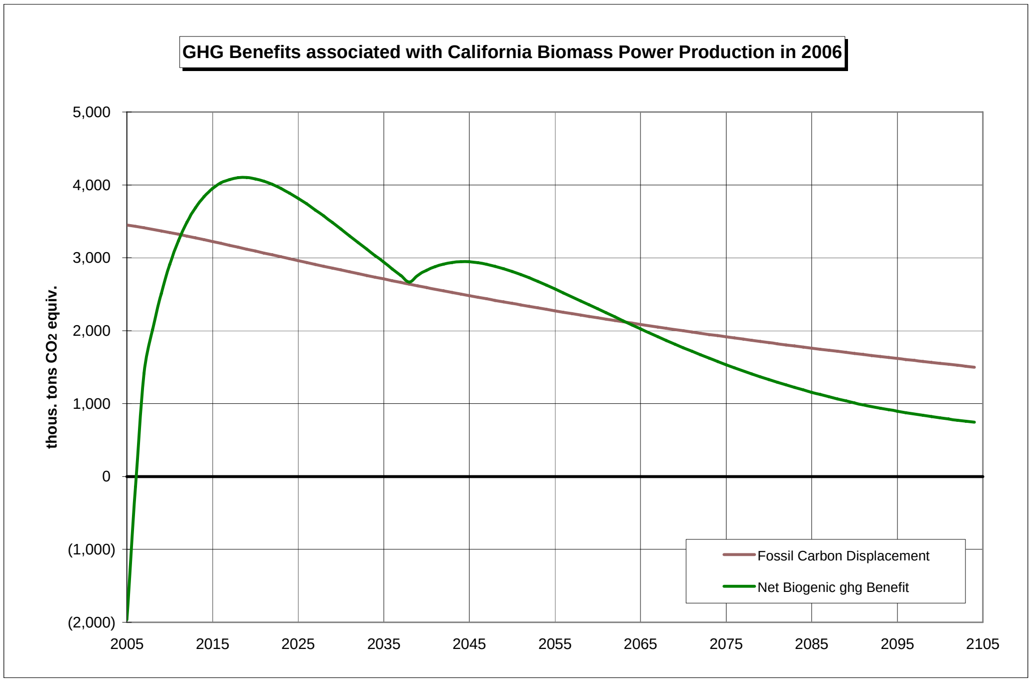
In addition to being carbon neutral, biomass energy production can affect atmospheric greenhouse-gas concentrations in two important ways. First, the total amount of carbon that is sequestered in terrestrial biomass affects the amount of carbon in the atmosphere. Energy production from forest fuels contributes to forest health and fire resiliency, thereby increasing the amount of carbon that is stored on a sustainable basis in the earth's forests. Second, biomass energy production can change the timing and relative mix (oxidized vs. reduced) of carbon forms emitted into the atmosphere associated with the disposal or disposition of the biomass resources. As a greenhouse-gas, reduced carbon (CH_4) is 25 times more potent than oxidized carbon (CO_2) on an instantaneous, per-carbon basis. Therefore the form in which carbon is transferred from the biomass stock to the atmospheric stock is critically important from the standpoint of greenhouse forcing impact.

Alternative Fates

Most of the biomass and biogas resources that are converted to energy would otherwise be open burned, buried, or allowed to accumulate in forests as overgrowth material. Compared to combustion in a controlled boiler, open burning entails poor combustion conditions and gives rise to significant emissions of carbon in reduced form (methane and hydrocarbons). This elevates the greenhouse-gas potency of the emissions. Biomass burial in a landfill or agricultural field leads to even greater emissions of reduced carbon than open burning. Although the emissions from landfills are delayed, the greenhouse-gas potency of the emissions over the long term is much greater. Overgrown forests tend to be unhealthy and have heightened sensitivity to fire losses, disease, and pest attacks. Biomass power production can offset some of the costs of forest treatments by paying for the residue removals, in the process promoting better and more extensive forestry management. Although the immediate consequence of forest treatment is to reduce the amount of standing biomass in the treated forest, in the long term the sustainable biomass stocking on the land is enhanced.

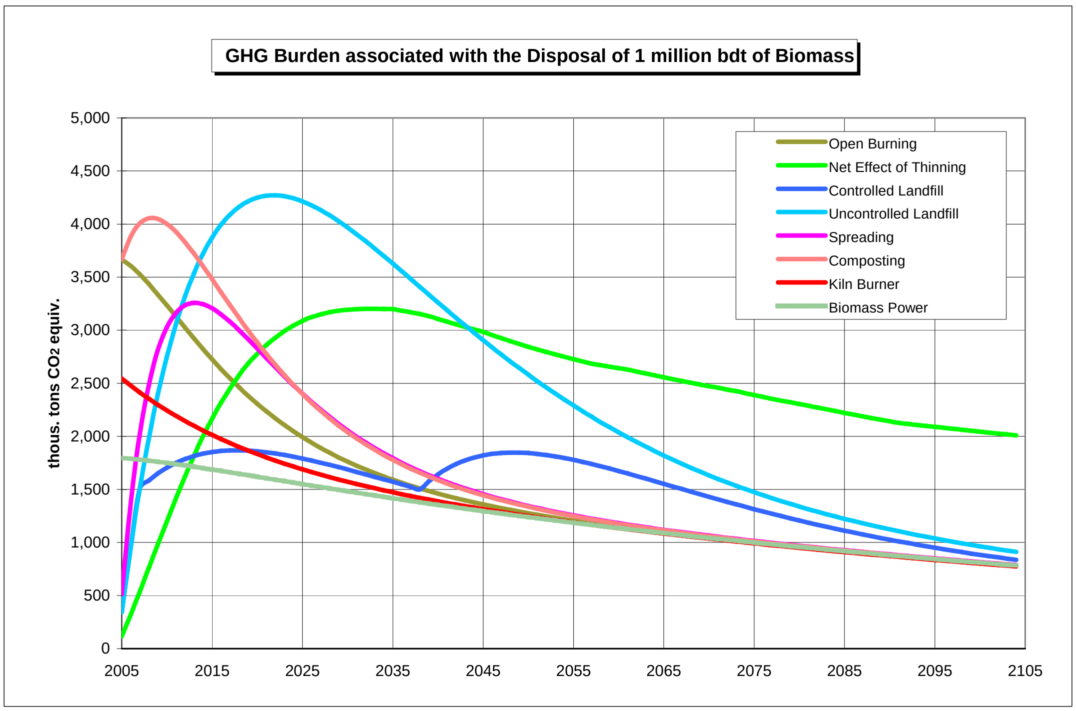
Energy Production from Biomass and Biogas Resources

Bioenergy production provides two kinds of greenhouse-gas benefits. Like all renewable energy generation, bioenergy production avoids the production of an equivalent amount of energy from fossil fuels. In addition, bioenergy production avoids the biogenic greenhouse-gas emissions of the various alternative disposal fates for the residue and waste biomass, replacing them with the lower potency greenhouse-gas emissions of energy production. The figure below shows the long-term atmospheric greenhouse-gas benefits with respect to both the avoided fossil and reduced biogenic greenhouse-gas emissions provided by the operations of the California biomass energy industry during calendar year 2006. The figure shows the benefits, in terms of long-term atmospheric greenhouse-gas burdens, resulting from the industry's 2006 operations. The avoided fossil-carbon emissions, about 3.5 million tons, all occur during 2006. The atmospheric burden of this carbon gradually diminishes over time. All of the emissions of biomass



energy production, and some of the avoided emissions of the avoided alternative disposal of the biomass, also occur during 2006, but some of the emissions of alternative disposal are delayed. Although the shapes of the curves are different, the reduction of the concentration of atmospheric greenhouse-gases due to avoided fossil-fuel use and reduced biogenic emissions is approximately the same over the long term. It should be noted that the curves do not account for the qualitative difference between fossil and biogenic emissions, which is that fossil carbon emissions increase the amount of carbon in the active carbon cycle, while biogenic carbon emissions are already part of the cycle.

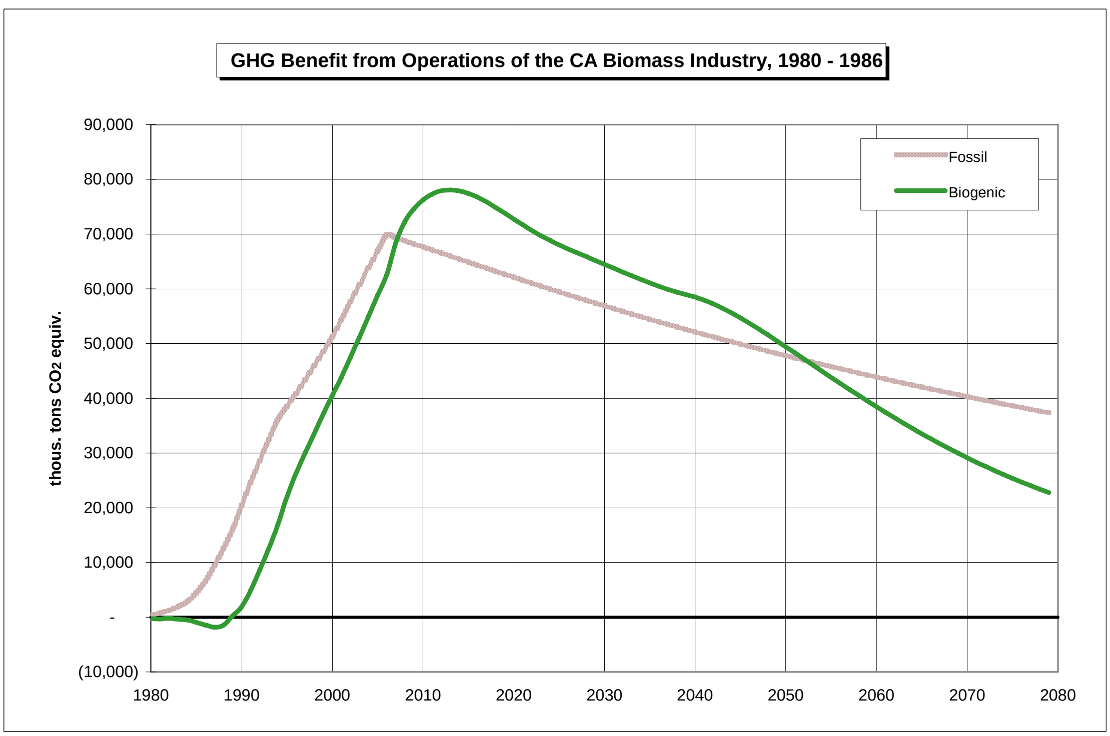
The figure below shows the profiles over time of the greenhouse-gas burdens associated with biomass energy production, and the various alternative disposal options for the biomass fuels that are included in the analysis, with all curves scaled to the disposal of one million bdt of biomass residues in 2005. As illustrated by the figure, the atmospheric greenhouse-gas profile over time is very different for the energy production alternative, and for the alternative disposal activities.



The curve for stack emissions from the biomass energy alternative is based on the immediate release of virtually all of the fuel-bound carbon as CO_2, followed by its gradual clearance from the atmosphere. The conversion of one million bdt of biomass leads to emissions of 1.75 million tons of biogenic CO_2 equivalents. Open burning and low-efficiency combustors (kiln boilers and fireplaces) also produce their emissions immediately, but their greenhouse-gas emissions are higher, in terms of tons of biogenic CO_2 equivalents, than those of the power alternative.

Biomass that is landfilled, spread, or composted has both immediate and delayed emissions of carbon gases. Biomass left in the forest as overgrowth material has a longer lag time in emissions than any of the other alternative fates, but in the long term the greenhouse-gas potency of the emissions stabilizes at a higher level than that for any other alternative. All of the alternative disposal options for the biomass residues produce higher levels of biogenic greenhouse-gas levels than use of the biomass for electricity production.

The modern California biomass power industry has operated for almost 30 years. The figure below shows the cumulative greenhouse-gas benefits that have already been provided by the California biomass power industry since its inception through 2006. The chart does not show 2007 or later operations of the industry, which are additive to the curves in the figure. Atmospheric greenhouse-gas levels in 2006 were lower by 70 million tons of CO_2 equiv. of fossil greenhouse gases and by 62.5 million tons of CO_2 equiv. of biogenic greenhouse gases as a result of solid-fuel biomass power production in California during 1980-2006. The greenhouse-gas reductions already in the books will continue to provide benefits well into the future.



Bioenergy and Greenhouse-gas Reduction Programs

Existing greenhouse-gas reduction programs are geared toward reducing fossil carbon emissions to the atmosphere. Continuing to add new (fossil) carbon to the carbon that is already in circulation between the atmosphere and the biosphere is the fundamental driver of human-caused global climate change. Bioenergy production can reduce net greenhouse-gas emissions by contributing to healthier and more resilient forests and by eliminating the reduced-carbon emissions that are associated with the alternative fates for biomass resources that are not converted into useful energy. In order to allow these benefits to be expressed in a way that will allow them to be a part of future greenhouse-gas reduction programs, the net reductions in biogenic greenhouse gases can be denominated as carbon offsets that can be used in whatever cap-and-trade programs are eventually instituted. Theoretically, offsets should be available for the reduction in greenhouse-gas burden associated with the avoided alternative disposal of biomass fuels, net of the biogenic greenhouse gases emitted by the power plant, and for the long-term increase in forest sequestration due to the performance of forest treatments, again net of the power-plant emissions, from using the treatment removals for energy production.

Conclusion

Bioenergy production reduces atmospheric greenhouse-gas levels by enhancing long-term forest-carbon sequestration and by reducing the greenhouse-gas potency of the carbon gases associated with the return of biomass carbon to the atmosphere that is an intrinsic part of the global carbon cycle. These greenhouse-gas benefits are provided in addition to the benefit common to all renewable energy production of avoiding the use of fossil fuels. The value of the greenhouse-gas offsets that are expected to become available in the next several years should improve the competitiveness of energy production from biomass and biogas resources in the marketplace of the future.