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THE ROLE OF BIOMASS ENERGY IN STABILIZING GLOBAL CLIMATE CHANGE

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ABSTRACT

The causes, effects, and options for stabilizing global climate change are discussed with an emphasis on the global use of biomass energy as a feasible stabilization option. The mechanism by which biomass energy reduces emissions of carbon dioxide is discussed along with characteristics which make it an attractive energy supply option, particularly when biomass fuel is used to produce electricity. The role of biomass energy both in the present and future is discussed as are the potential barriers to its more widespread use.

GLOBAL CLIMATE CHANGE: CAUSES, EFFECTS, AND STABILIZATION OPTIONS

As a result of human activity, the atmospheric concentrations of greenhouse gases are increasing. For example, over the period from the industrial revolution to the present day, the concentration of carbon dioxide (CO_2), a major greenhouse gas, has risen from 280 ppm to 355 ppm [1]. Greenhouse gases are believed to create a warming effect by resisting the outward flow of infrared radiation more effectively than the inward flow of solar radiation. About 57% of the projected warming over the 1980-2050 timeframe is attributed to CO_2, making it the largest contributor [1]. The Intergovernmental Panel on Climate Change (IPCC) in their 1992 report estimates that, since the late 1800s, the global mean surface temperature has increased about 0.3°C [2]. The IPCC also estimates the potential global warming effects: a 0.3°C per decade increase in temperature and a 6 cm per decade rise in global mean sea level during the next century for a "business as usual" scenario [2].

In the case of CO_2, the most important source globally is fossil fuel combustion. Combustion of fossil fuels and the associated greenhouse gas emissions will increase globally with the growth in energy demand, which is estimated to be 2.4% per year between 1988 and 2005 [3]. Broad strategies for stabilizing global climate change brought on by an increase in greenhouse gas emissions from combustion sources include: (1) Increasing energy conversion efficiency and conservation associated with fossil fuels; (2) Utilizing non-fossil energy sources such as wind, solar, hydro, and biomass; (3) Utilizing fuel substitution such as replacing coal with natural gas; and (4) Sequestering carbon via reforestation.

BIOMASS ENERGY

Benefits

The use of biomass to produce energy in the form of heat, steam, electricity, or liquid transportation fuels reduces CO_2 emissions when used as a substitute for fossil fuels. If biomass is grown or harvested for energy at an amount equal to that burned for a given period, there would be no buildup of CO_2, because the CO_2 released in combustion is compensated for by that absorbed during photosynthesis. For example, when biomass is used renewably as a substitute for coal, 200 lb CO_2/ million Btu (86 kg/GJ) is prevented from entering the atmosphere.

Biomass energy has some important benefits in addition to being a viable global climate change stabilization option. Cultivation of biomass "energy plantations" would complement reforestation efforts by utilizing existing forested and agricultural lands which are "closed" to reforestation. As a result of revenue from the sale of electricity and liquid transportation fuels such as ethanol and methanol, the net cost of offsetting CO_2 emissions by substituting biomass for fossil fuels could be near zero or even negative, making biomass easier to implement than fuel substitution or energy efficiency improvements [4]. Unlike other renewable energy technologies, biomass energy needs no storage capability which tends to increase the cost of implementation. In addition to mitigating global warming, biomass energy has other environmental benefits including the reduction of biomass wastes and residues going to landfills; reduction of criteria pollutants like nitrogen and sulfur oxides since biomass contains negligible sulfur and has a low fuel-bound nitrogen content; improvement of air quality through reductions in ground level ozone and carbon monoxide (CO) when transportation fuels derived from biomass are utilized; and reduction of volatile organic compounds, CO, and carcinogens through prevention of the open burning of biomass residues.

Current and Future Role

Currently, only biomass residues in the form of wood wastes (mill and forestry residues) and agricultural wastes (rice hulls, sugar cane fiber, etc.), which are available at near-zero or negative cost, are used to produce energy. When energy in the form of electric power is generated from these low-cost biomass fuels, traditional steam-electric power technology is utilized, which tends to be inefficient and capital-intensive at the modest scales characteristic of biomass power plants [5]. These modest scales (less than 100 MW_e) are required as a result of the dispersed, limited supply of biomass fuel, which must be harvested from the countryside and transported to the plant [5]. Therefore, as a matter of economic sense, it is necessary to construct small, decentralized plants near the fuel supply to avoid the high cost of transporting fuel long distances.

The future role of biomass in the total energy supply mix is likely to grow with the development of energy plantations and improvements in energy conversion technologies. The development of energy plantations consisting of short-rotation, high productivity species may provide long-term, renewable supplies of biomass fuel and feedstocks. It is believed that, with further research, future productivities of 20 t/ha/yr can be achieved which would reduce the cost of delivering dry biomass from $33-50 to $24-32 per m^3 [6]. These higher cost "energy crops" and harder-to-recover residues are likely to be used for energy as low-cost biomass residues are exhausted. For electric power applications, in order to make the use of higher cost fuels/feedstocks economically attractive at modest scales, technologies are needed that offer high efficiency and low unit capital cost [5]. These requirements are likely to be met by adapting integrated gasification/combined cycle (IGCC) technology to biomass. Net efficiencies for biomass IGCC plants could exceed 50% which would surpass the 20-25% efficiencies of similar scale, biomass steam-electric plants [7]. The unit capital cost for the gas turbine in IGCC plants is relatively insensitive to scale unlike the steam turbine in steam-electric plants [5]. Biomass is a good candidate for gasification, relative to coal, since it contains a high volatiles content and gasifies rapidly. Also, unlike coal gasification plants, biomass IGCC plants would not require a process step to remove sulfur from the fuel gas.

Overcoming Hurdles

Before the above developments are fully implemented, technical, economic, and environmental "hurdles" must be overcome. The largest technical hurdle involves the removal of alkali compounds, formed primarily from sodium and potassium in the biomass, and particulates from fuel gas exiting a biomass gasifier. Such "cleanup" of the gas is required to prevent alkali compounds from entering the gas turbine and condensing on turbine blades, thereby fouling the turbine. These alkali compounds may either condense on particulate or be in the vapor phase prior to entering the gas turbine. Demonstrations of a cleanup system and the biomass IGCC plant as a whole are needed at a small scale and at increasingly larger scales in order to evaluate cost and performance. This offers an opportunity for public/private partnerships to accelerate the development, demonstration, and commercialization of these technologies. Plant owners/operators need to secure long-term supplies of biomass in order to guarantee stable fuel/feedstock costs and availability. Environmental implications of cultivating large-scale energy plantations also need to be addressed; these include maintaining adequate nutrient and carbon contents in the soil, controlling the use of fertilizers, pesticides, and herbicides, maintaining biological diversity, conserving agricultural lands, and controlling erosion.

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Pollution	Carbon Dioxide	Pollution Control	13B	07B
Biomass	Electricity	Stationary Sources	08A, 06C	20C
Energy	Heat	Global Climate Change	14G	20M
Climate Changes	Steam		04B	07D
Greenhouse Effect			04A	
Stabilization				

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