Biomass and Global Warming:
Double Solution or Trouble with Pollution?

Paper for "5 vor 12" Special Issue on Global Warming, Nov. 1988

Uwe Fritsche, Öko-Institut (Institute for applied ecology), Energy Division

Abstract

Biomass can play a key role in the issue of global warming due to its double function concerning greenhouse gas emissions. First, the use of biomass as a fuel can reduces directly the net CO_2 emissions when substituting fossil fuels, and, in addition, reduces the amount of CH_4 emissions due to coal mining and oil & gas extraction. Second, re-foresting can reduce indirectly the atmospheric CO_2 load by increasing the amount of biomass-fixed carbon in the standing crop.

The possible medium-term reduction of atmospheric CO_2 based on both function is sufficient to postpone climatic changes for several decades, thus giving time to develop and implement other means to reduce greenhouse gas emission rates, especially by energy conservation and solar energy.

Both elements of a biomass strategy to lessen climatic risks offer - when properly managed - also other positive environmental effects like reduction of sulfur emissions and soil prevention.

Consequently, international co-operation towards environmentally benign biomass options is recommended, and forestry is likely to be the key to it.

Introduction

Anthropogenic emissions of CO_2 are now widely recognized as a major cause for possible global warming due to the so-called greenhouse effect, counting for some 50 % of the anticipated climatic change[1].

Biomass is linked to the carbon dioxide problem by two factors, both related to the very nature of biomass as a material composed of mainly carbon:

* the fixation of atmospheric C in biomass during the photosynthetic built-up of organic matter, resulting in C-storage and, hence, reduction of atmospheric CO_2 load
* the oxidization of carbon when biomass is burned or mineralized by microorganism activity, resulting in CO_2 emissions

Biomass and the Global Carbon Cycle

To date, roughly 560 billion tons of C are stored globally in terrestrial biota, some 1,100 billion tons of C are fixed in soil and detritus, and approx. 60 billion tons of C are removed annually from the atmosphere by net primary production through photosynthetic activity of plants[2]. The latter value equals the amount of carbon released to the atmosphere by natural decomposition of biomass, so that the net result of biologic activity regarding CO_2 is zero.

The Role of Forests

The largest amount of organic C is fixed in forests throughout the world, counting for some 500 billion tons of carbon. The annual fixation by net primary production of forests is roughly 30 billion tons of C, and more than half of these in tropical (rain and seasonal) forests which fix C at a rate of 0.8 kg/m²/a compared to 0.4 kg C/m²/a for temperate and boreal forests.

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1 Bach W 1988: The Endangered Climate, in: Krause F, Bach W (eds.) 1988: Energy and Climatic Change: What can Western Europe do?, Study for the Dutch Ministry of Housing, Physical Planning and Environment (preprinted 1988 for the German Commission on Climatic Change, Paper 11/45)

2 see for discussion of values Bolin B et al. (eds.) 1986: The Greenhouse Effect, Climatic change, and Ecosystems, SCOPE report 29; Chichester, p. 123 ff

Though woody biomass is effective in capturing atmospheric CO_2 and buffering large portions of cycled C, significant amounts of CO_2 are released to the atmosphere when vegetation is burned or removed without re-planting[3].

Today, deforestation and changing land use count for an emission of approx. 1 billion ton of C per year, which is quite a share when compared to the global emission rate of some 5 billion t C/a caused by fossil fuel burning[4].

The deforestation takes place especially in tropical forests at a staggering rate of some 500,000 km^2 per year. Because woody biomass is not only removed, but also burned under uncontrolled conditions (slash burning), large amounts of other emissions than CO_2 are released, too - among these substances like PAN, NO_x and C_nH_m (including CH_4) which are not only a threat to plant life and human health but also contribute to the greenhouse effect[5].

Biomass as an Energy Source

Besides the clear-cutting of forests for non-forestry land-use, CO_2 emissions from woody biomass and other residues arise from the use as fuel all over the world.

The total share of biomass figures for some 13 % of today's global primary energy demand[6], and counts for some 3 % of the energy use in Industrialized Countries, but for roughly one third in Developing Countries - about 2 billion people rely almost entirely on biomass fuels[7]. While the net CO_2 emissions of this energy source are zero if the same amount of biomass is re-grown, this energy source seems attractive for further exploitation.

3 Bach 1988, op. cit.

4 Commission on Climatic Change of the Federal Parliament of Germany 1988: Protection of Earth's Atmosphere - An International Challenge, Interim Report; Bonn (in German)

5 Commission on Climatic Change 1988, op. cit., p.539 ff

6 Hall D, Overend R 1987: Biomass for Ever, in: Hall D, Overend E (eds.): Biomass - Renewable Energy, Wiley Interscience

7 Beijer Institute 1989: Bioenergy - contribution to environmentally sustainably development; study for the United Nations Environmental Programme (draft version); Nairobi, p.3

Fossil Fuel Facts

If biomass is considered as an alternative to fossil fuels, the obvious effects would be that no additional C is released to the atmosphere. Furthermore, CO_2 emissions related to the extraction and processing of fossil fuels would vanish, and the emissions of methane (CH_4) from coal mining and oil & gas extraction (flared/vented gas)[8] could be reduced, too.

The latter fact is even more important than the CO_2 reduction alone, because methane is a more "potent" greenhouse gas than CO_2. The relative greenhouse potential (RGP) of a methane molecule is 32 times the RGP of a carbon dioxide molecule[9], or roughly 10 times on a weight base.

Old Stuff for New Use: Bioenergy

To replace fossil fuels, biomass (especially wood) can serve as a renewable energy source in both industrialized and developing countries, offering not only more local income due to reduced oil bills, but also improve soils, water retention capability and serve as a wind-breaker, as a forthcoming UNEP study has pointed out[10].

The technical means to grow, harvest and use biomass for energy have been improved considerably in the last decade[11], offering more energy services from given biomass. The knowledge about socio-economic effects of increased biomass activity and strategies to manage social and economic problems are available world-wide[12], so that bioenergy can be implemented without societal constraints.

The Limits of Growth

Nevertheless, a biomass-for-energy strategy faces several basic problems.

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8 values taken from: Rotty R, Marland G 1986: Fossil Fuel Combustion - Recent Amounts, Patterns, and Trends of CO2, in: Trabalka R, Reichle D (eds.): The Changing Carbon Cycle - A Global Analysis; New York, p.481 ff

9 values taken from: Commission on Climatic Change 1988, op. cit., p.363

10 Beijer Institute 1989, op. cit.

11 Hall, Overend 1987, op. cit.

12 Bejer Institute 1989, op. cit.

First, the production of biomass for food and feedstocks requires the same principal inputs as the production for energy use, so that conflicts between traditional and "new" types of biomass production can arise (and, in fact, have occurred already, as the example of the biofuel politics in Brazil points out[13]).

Second, the availability of additional productive land and related ecological factors (climate, water) is restricted, especially in industrialized countries, so that the amount of new bioenergy area is discussed controversially[14].

Third, the use of biomass can cause health effects, if inappropriate devices are applied or the equipment is badly handled[15]. Even dioxine emissions can result from straw burning under poor combustion conditions[16]. Therefore, biomass-for-energy strategies require modern, low-polluting technologies, which are available for wood[17] and straw[18] combustion, and fermentation[19].

These constraints to an increased use of biomass narrow the possible part of biomass as a solution for the global warming issue, but the available amounts are worth the job to acquire.

The Real Thing: Energy Efficiency

The principal limitations of a biomass strategy to reduce CO_2 emissions have to be taken in mind when solutions for the global warming problem are sought.

As several studies have shown, the fundamental approach to reduce CO_2 is not to look at the supply side of the global energy system, and just switch over to other fuels, but to concentrate on the demand (or user's) side:

13 GATE 1986: Biofuels for Developing Countries?, German Appropriate Technology Exchange Group; Eschborn

14 Burschel P, Weber M 1988: Der Treibhauseffekt - Bedrohung und Aufgabe für die Forstwirtschaft, in: Allg. Forst Zeitschr. 37

15 Koenig J et al. 1988: Wood smoke - health effects and legislation, in: The Northwest Environmental Journal vol.4 p. 41-54

16 Nielsen P, Pedersen J 1986: Dioxinudslip fra halmfyr, Jysk Teknologisk/dk Teknik, EM-Journal-nr 1433/86-9, Jysk Teknologisk Forlag

17 BPA 1989: Environmental impacts of advanced biomass combustion systems, Bonneville Power Administration, Portland

18 Johansson M 1987: Straw fired plants for heat and power production in Denmark, paper presented at the UN-ECE Symposium on the status and prospects of new and renewable sources of energy, France, 8-12 Juni 1987

19 Commission of the European Community 1988: EUROFORUM New Energies, Proceedings vol. I-III; London

substantial amounts of more energy services can be met with the same energy input or, vice versa, the same amount of energy services can be met with lower energy supply (and, hence, less pollution) when the conversion of primary energy to useful energy is more efficient[20].

Means to do so are abundant: using power plant's waste heat for hot water production (cogeneration), install more efficient fluorescent lighting bulbs, control electric motors by microprocessors, reduce heat losses and cooling loads of buildings through insulation etc. - the list is long.

As the global energy study of Rosenberg et al has shown, efficient use of energy is more productive to reduce CO_2 emissions than any other means[21]. The study of Krause and Bach for Europe offered extremely high potentials for energy conservation even in modern high-industrialized western countries, and proved that efficiency is several times cheaper than energy from new nuclear power stations[22].

In addition to the building of "conservation power plants" or installing "NegaWatts", other renewable energy sources than biomass can contribute a lot to the world's energy needs: Solar heating and cooling, solar electricity, small-scale wind and hydropower offer CO_2-free and, as a recent OECD study has shown[23], environmentally acceptable ways to provide energy all over the world.

Buying Time With Biomass

Though the opportunities for energy efficiency and solar-based renewables are tremendous, the necessary changes in whole energy systems are tremendous, too. The changes do not only require significant (political) efforts to overcome constraints (i.e. low fossil fuel prices), they also take time - a guesstimate for the timeframe is some 50 years.

20 Commission on Climatic Change 1988, op. cit., p.491 ff

21 Goldemberg J et al 1988: Energy for a Sustainable World; New York

22 Krause F, Bach W (eds.) 1988: Energy and Climatic Change: What can Western Europe do ?, Study for the Dutch Ministry of Housing, Physical Planning and Environment

23 OECD 1988: Environmental Impacts of Renewable Energy Sources; Paris

In contrast, the accumulation of CO_2 in the atmosphere and the possible climatic change require quick action - the earlier a ton of CO_2 is not emitted, the greater is the effect to reduce climatic risk[24].

Thus, the challenge of endangered climate is twofold[25]:

* to reduce the emission of greenhouse gases, especially CO_2 and CH_4, to the lowest achievable level and
* to do so in the fastest way possible.

Although a biomass strategy cannot compensate the total of fossil-fuel-based CO_2 emissions, it can buffer considerable amounts of C in new forests or high-productive aqua-farms. Because the deforestation can be reduced (and stopped!) in the near-term, and be inverted to reforesting, the associated storage of C in the new biomass helps to postpone a possible greenhouse warming. This strategy is recognized in several studies as viable[26], and can, depending on the area which is re-planted, fix up to 10-100 billion tons of carbon[27], thus buying some decades of necessary time.

Forests First!

Besides aqua-agricultural biomass systems, forests are the best-known means to store carbon and to offer a ready-to-use fuel. Therefore, (re)forestation is the thing to start with - and it can be started in both industrialized and developing countries.

Future forest politics have to address the challenging options of a new biomass strategy all over the world.

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24 Krause F 1988; Statement for the Commission of Climatic Change's Public Hearing "The Greenhouse Effect, Part II: Possibilities to Mitigate Climatic Changes" at Bonn, June 20, 1988; Commission Paper 11/140 (in German), p.17 ff

25 Bach 1988, op. cit.

26 see for example: DOE Carbon Dioxide Research Division 1988: The prospect of solving the CO2-problem through global reforestation; Washington DC

Postel S,Heise L 1988: Reforesting the Earth; Worldwatch Paper 83; Worldwatch Institute; Washington DC

27 Burschel, Weber, op. cit.