BIOMASS AND ITS IMPACT ON THE ENVIRONMENT

Lýdia Dedinská, Vieroslava Čačková, Milan Kvakovský

ABSTRACT

Biomass power, derived from the burning of plant matter, raises more serious environmental issues than any other renewable resource except hydropower. Combustion of biomass and biomass-derived fuels produces air pollution; beyond this, there are concerns about the impacts of using land to grow energy crops. How serious these impacts are will depend on how carefully the resource is managed. The picture is further complicated because there is no single biomass technology, but rather a wide variety of production and conversion methods, each with different environmental impacts.

1. INTRODUCTION

The term "biomass" encompasses diverse fuels derived from timber, agriculture and food processing wastes or from fuel crops that are specifically grown or reserved for electricity generation. Biomass fuel can also include sewage sludge and animal manure. Some biomass fuels are derived from trees. Given the capacity of trees to regenerate, these fuels are considered renewable. Burning crop residues, sewage or manure - all wastes that are continually generated by society - to generate electricity may offer environmental benefits in the form of preserving precious landfill space OR may be grown and harvested in ways that cause environmental harm.

2. BIOMASS POWER PLANTS

At present, most biomass power plants burn lumber, agricultural or construction/demolition wood wastes. Direct Combustion power plants burn the biomass fuel directly in boilers that supply steam for the same kind of steam-electric generators used to burn fossil fuels. With biomass gasification, biomass is converted into a gas - methane - that can then fuel steam generators, combustion turbines, combined cycle technologies or fuel cells. The primary benefit of biomass gasification, compared to direct combustion, is that extracted gasses can be used in a variety of power plant configurations.

Whether combusting directly or engaged in gasification, biomass resources do generate air emissions. These emissions vary depending upon the precise fuel and technology used. If wood is the primary biomass resource, very little SO2 comes out of the stack. NOx emissions vary significantly among combustion facilities depending on their design and controls. Some biomass power plants show a relatively high NOx emission rate per kilowatt hour generated if compared to other combustion technologies.

3. AIR POLLUTION

Inevitably, the combustion of biomass produces air pollutants, including carbon monoxide, nitrogen oxides, and particulates such as soot and ash. The amount of pollution emitted per unit of energy generated varies widely by technology, with wood-burning stoves and fireplaces generally the worst offenders. Modern, enclosed fireplaces and wood stoves pollute much less than traditional, open fireplaces for the simple reason that they are more efficient. Specialized pollution control devices such as electrostatic precipitators (to remove particulates) are available, but without specific regulation to enforce their use it is doubtful they will catch on.

Emissions from conventional biomass-fueled power plants are generally similar to emissions from coal-fired power plants, with the notable difference that biomass facilities produce very little sulphur dioxide or toxic metals (cadmium, mercury, and others). The most serious problem is their particulate emissions, which must be controlled with special devices. More advanced technologies, such as the whole-tree burner (which has three successive combustion stages) and the gasifier/combustion turbine combination, should generate much lower emissions, perhaps comparable to those of power plants fuelled by natural gas.

Facilities that burn raw municipal waste present a unique pollution-control problem. This waste often contains toxic metals, chlorinated compounds, and plastics, which generate harmful emissions. Since this problem is much less severe in facilities burning refuse-derived fuel (RDF)-pelletized or shredded paper and other waste with most inorganic material removed-most waste-to-energy plants built in the future are likely to use this fuel. Co-firing RDF in coal-fired power plants may provide an inexpensive way to reduce coal emissions without having to build new power plants.

Using biomass-derived methanol and ethanol as vehicle fuels, instead of conventional gasoline, could substantially reduce some types of pollution from automobiles. Both methanol and ethanol evaporate more slowly than gasoline, thus helping to reduce evaporative emissions of volatile organic compounds (VOCs), which react with heat and sunlight to generate ground-level ozone (a component of smog). According to Environmental Protection Agency estimates, in cars specifically designed to burn pure methanol or ethanol, VOC emissions from the tailpipe could be reduced 85 to 95 percent, while carbon monoxide emissions could be reduced 30 to 90 percent. However, emissions of nitrogen oxides, a source of acid precipitation, would not change significantly compared to gasoline-powered vehicles.

Some studies have indicated that the use of fuel alcohol increases emissions of formaldehyde and other aldehydes, compounds identified as potential carcinogens. Others counter that these results consider only tailpipe emissions, whereas VOCs, another significant pathway of aldehyde formation, are much lower in alcohol-burning vehicles. On balance, methanol vehicles would therefore decrease ozone levels. Overall, however, alcohol-fuelled cars will not solve air pollution problems in dense urban areas, where electric cars or fuel cells represent better solutions.

4. GREENHOUSE GASES

A major benefit of substituting biomass for fossil fuels is that, if done in a sustainable fashion, it would greatly reduce emissions of greenhouses gases. The amount of carbon dioxide released when biomass is burned is very nearly the same as the amount required to replenish the plants grown to produce the biomass. Thus, in a sustainable fuel cycle, there would be no net emissions of carbon dioxide, although some fossil-fuel inputs may be required for planting, harvesting, transporting, and processing biomass. Yet, if efficient cultivation and conversion processes are used, the resulting emissions should be small (around 20 percent of the emissions created by fossil fuels alone). And if the energy needed to produce and process biomass came from renewable sources in the first place, the net contribution to global warming would be zero.

Similarly, if biomass wastes such as crop residues or municipal solid wastes are used for energy, there should be few or no net greenhouse gas emissions. There would even be a slight greenhouse benefit in some cases, since, when landfill wastes are not burned, the potent greenhouse gas methane may be released by anaerobic decay.

5. IMPLICATIONS FOR AGRICULTURE AND FORESTRY

One surprising side effect of growing trees and other plants for energy is that it could benefit soil quality and farm economies. Energy crops could provide a steady supplemental income for farmers in off-seasons or allow them to work unused land without requiring much additional equipment. Moreover, energy crops could be used to stabilize cropland or rangeland prone to erosion and flooding. Trees would be grown for several years before being harvested, and their roots and leaf litter could help stabilize the soil. The planting of coppicing, or self-regenerating, varieties would minimize the need for disruptive tilling and planting. Perennial grasses harvested like hay could play a similar role; soil losses with a crop such as switch grass, for example, would be negligible compared to annual crops such as corn.

If improperly managed, however, energy farming could have harmful environmental impacts. Although energy crops could be grown with less pesticide and fertilizer than conventional food crops, large-scale energy farming could nevertheless lead to increases in chemical use simply because more land would be under cultivation. It could also affect biodiversity through the destruction of species habitats, especially if forests are more intensively managed. If agricultural or forestry wastes and residues were used for fuel, then soils could be depleted of organic content and nutrients unless care was taken to leave enough wastes behind. These concerns point up the need for regulation and monitoring of energy crop development and waste use.

Energy farms may present a perfect opportunity to promote low-impact sustainable agriculture, or, as it is sometimes called, organic farming. A relatively new federal effort for food crops emphasizes crop rotation, integrated pest management, and sound soil husbandry to increase profits and improve long-term productivity. These methods could be adapted to energy farming. Nitrogen-fixing crops could be used to provide natural fertilizer, while crop diversity and use of pest parasites and predators could reduce pesticide use. Though such practices may not produce as high a yield as more intensive methods, this penalty could be offset by reduced energy and chemical costs.

Increasing the amount of forest wood harvested for energy could have both positive and negative effects. On one hand, it could provide an incentive for the forest-products industry to manage its resources more efficiently, and thus improve forest health. But it could also provide an excuse, under the "green" mantle, to exploit forests in an unsustainable fashion. Unfortunately, commercial forests have not always been soundly managed, and many people view with alarm the prospect of increased wood cutting. Their concerns can be met by tighter government controls on forestry practices and by following the principles of "excellent" forestry. If such principles are applied, it should be possible to extract energy from forests indefinitely.

6. CONCLUSIONS

The collection of biomass fuels can have significant environmental impacts. Harvesting timber and growing agricultural products for fuel requires large volumes to be collected, transported, processed and stored. Biomass fuels may be obtained from supplies of clean, uncontaminated wood that otherwise would be land filled or from sustainable harvests. In both of these fuel collection examples, the net environmental plusses of biomass are significant when compared to fossil fuel collection alternatives. On the other hand, the collection, processing and combustion of biomass fuels may cause environmental problems if, for example, the fuel source contains toxic contaminants, agricultural waste handling pollutes local water resources, or burning biomass deprives local ecosystems of nutrients that forest or agricultural waste may otherwise provide.

REFERENCES

[1] AEA, 2008. Evaluation of national plans submitted in 2006 under the National Emission Ceilings Directive 2001/81/EC. Technical Report for the European Commission by AEA Energy and Environment.

[2] Blok, K.; Phylipsen, G. J. M. and Bode, J.W., 1997. The Triptique approach. Burden differentiation of CO2 emission reduction among European Union Member States. Discussion paper. Utrecht University, Department of Science, Technology and Society. Paper presented at the Informal workshop for the European Union Ad Hoc Group on Climate, 16–17 January 1997, Zeist.

[3] EEA, 2007a. Greenhouse gas emissions trends and projections in Europe 2007. EEA Report No 5/2007, European Environment Agency.

[4] EEA, 2006. Air pollution at street level in European cities. EEA Technical report No 1/2006, European Environment Agency.

[5] Michael Brower: Cool Energy: Renewable Solutions to Environmental Problems, MIT Press, 1992, 220 pp.

[6] EEA, 2007b. Europe's environment — The fourth assessment. State of the environment report 2007, European Environment Agency.

Authors:

Ing. Lýdia Dedinská
Technical University of Košice
Fakulty of Electrical Engineering and Informatics
Department. of Electric Power Engineering
Mäsiarska 74, 041 20 Košice, Slovak Republic
E-mail: Lydia.Dedinska@tuke.sk

Ing. Vieroslava Čačková
Technical University of Košice
Fakulty of Electrical Engineering and Informatics
Department. of Electric Power Engineering
Mäsiarska 74, 041 20 Košice, Slovak Republic
E-mail: Vieroslava.Cackova@tuke.sk

Ing. Milan Kvakovský
Technical University of Košice
Fakulty of Electrical Engineering and Informatics
Department. of Electric Power Engineering
Mäsiarska 74, 041 20 Košice, Slovak Republic
E-mail: Milan.Kvakovsky@tuke.sk