SMOKE AND MIRRORS

A Report on Biomass, Bio-energy and Global Warming

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Dedicated to Janet Faye, who provided the inspiration, the title and the drive to complete it.

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Foreword

This report is based in part on many years of work by the Blue Ridge Environmental Defense League in the communities of the Southeast. For a quarter of a century we have dedicated a large part of our resources to preventing the damage created by the burning of waste materials: municipal solid waste, animal manure, sewage sludge, hazardous wastes and radioactive wastes. We have succeeded in shutting down operating incinerators and halting the construction of new ones. For a period of time, it seemed the tide had turned against the wholesale acceptance of burning waste. However, during this decade we have seen a proliferation of new proposals for incineration wrapped in novel packages and coat-tailing on contemporary issues. Hence the title, *Smoke and Mirrors*.

The threat of global warming caused by the rise in greenhouse gases has sparked genuine interest in alternative fuels. Among these fuel sources are biomass, a largely carbon-based fuel source which includes by-products and waste materials as well as dedicated resources. The technology of biomass is still developing but our experience in communities with ethanol plants and waste incinerators indicates these plants suffer from some of the same flaws as the fossil-fueled units which they are supposed to replace. In addition to waste-burning units, bio-fuels based on woody biomass and agricultural products are being promoted by commercial vendors and favored with government subsidies.

Clearly, the evidence supporting human impact on global warming is mounting steadily, approaching scientific certainty. Also, the carbon cycle in which plants and animals exchange carbon dioxide and oxygen is a fact of nature. However, promoting biomass energy based on a so-called carbon-neutral impact is wrong. Carbon-neutral may sound plausible to some renewable energy advocates and too many opinion leaders, but upon examination, the carbon-neutral construct used to justify combustion of biomass fuel has no sound scientific support. And the fundamental problems of waste incineration and fossil fuel combustion also plague biomass units whether they are branded waste-to-energy, pyrolysis, bio-energy or plasma arc.

Biomass energy systems do release global warming gases. This is not in dispute. What are problematic are the assumptions and the justifications upon which bio-energy advocates seek to excuse their progeny from being good carbon citizens.

This report delves into two broad questions about biomass energy: What are the impacts on human health and the environment caused by the thermal energy technologies? And what are the true impacts on the carbon cycle? *Smoke and Mirrors* is a detailed investigation into the science, the technology and the hyperbole of biomass energy.

Executive Summary

A clean energy future, a future that does not include a landscape devastated by waste incinerators and biomass plants, cannot happen without a cultural awareness of the ecological cost of energy. Those who promote biomass as a substitute for coal, or as a "bridge" to a vague clean energy future, have been largely unchallenged. The erroneous assumptions of the industrial mind-set that dominates our energy discussions have not been questioned. Biomass combustion, whether it is in rural communities or urban centers, carries with it an unacceptable ecological cost. Public awareness of that cost is the first step in the campaign to Stop Biomass Combustion, and it is our key goal.

We call for "carbon negative" renewable energy. Proponents of biomass incineration refer to their technology as "carbon neutral" and claim that they are only releasing greenhouse gases that would be released anyway. This contention ignores other technologies, such as anaerobic digestion, that avoid such uncontrolled emissions. It also fails to account for the emissions from the transportation, processing and distribution of animal feed and products associated with factory farms. Landfill methane presents similar problems in the difficulty of controlling methane emissions over the entire life of landfills from construction through the post-closure period and beyond.

Greenhouse Gas Emissions Contribute to Global Warming

Human activity is contributing to global warming. Global climate is created by the sun's impacts on the earth, its oceans and atmosphere. The greenhouse effect is the warming of the planet caused by gases in the atmosphere which convert or hold radiation from the sun as heat. Scientists have studied this phenomenon for centuries.

The gases which contribute to the greenhouse effect include nitrous oxide (N_2O), methane (C_4H_4) and carbon dioxide (CO_2). In order of importance as global warming agents, the most significant by far is carbon dioxide.

Measurements of atmospheric CO_2 began late in the nineteenth century. Since that time, the level of CO_2 has risen over 20%. The steady rise is attributed to human activity; i.e., industrial processes. [KIMBALL] Because of the volume of carbon dioxide emissions, it is the most important anthropogenic greenhouse gas.

The 1992 United Nations Framework Convention on Climate Change embodies the Precautionary Principle which requires protective action even when there is imperfect knowledge of cause and effect. But evidence for anthropogenic—human caused—impacts on global warming continues to mount.

Biomass is Part of the Problem, Not Part of the Solution

Biomass is organic matter; carbon is its principal element. Biomass energy systems release global warming gases including carbon dioxide. What is problematic is the assumption that biomass energy technologies are carbon neutral. Bio-energy proponents often draw an analogy to the plant–animal carbon cycle to explain how biomass energy facilities mimic biological processes. However, in order to reduce their carbon footprint, biomass power plant advocates rely on offsets and credits to balance their intrinsic pollution.

One of the methods employed to make bio-energy plants appear carbon neutral is to claim that electric power produced by the combustion of biomass *displaces* electric power produced by conventional power plants and, therefore, that the biomass plant's emissions count as a credit against the emissions from biomass fuel production. In other words, getting net carbon emissions from the generation of a unit of electricity from bio-energy to be 5% to 10% of the emissions from fossil fuel-based electricity is accomplished by *not counting them*; i.e., *treating* them as carbon neutral.

At present, air pollution in the United State is caused largely by emissions from the combustion of fossil fuels for the purposes of, in descending order, electric power generation, vehicular transportation, industrial production and residential and commercial heating. Electric power production alone is responsible for 40% of the nation's carbon dioxide (CO_2) emissions. [NRDC] Electric power plants also generate 70% of the sulfur dioxide (SO_2) and 20% of the nitrogen oxides (NO_x).

Theoretically, biomass burning could displace coal burning. But why convert the atmospheric emissions to a credit? Bio-energy advocates are mistaken when they assume any and all biomass energy sources are beneficial or carbon neutral. Substituting biomass for fossil fuels does not reduce carbon emissions, because the CO_2 released to the air is roughly the same per unit of energy regardless of the source. [SEARCHINGER]

Biomass power is not carbon neutral. The combustion of fuel made from biomass is a physical-chemical process; it has no bio-chemical or biological foundation. For example, a wood-fueled power plant is not part of the natural world, it is an industrial process. Both wood and coal come from the natural world. But when burned, neither one is carbon neutral. There is no "closed-loop" carbon cycle which would encompass power plant or vehicle emissions.

Half-measures Will Not Do

Many alternative energy advocates promote biomass as an answer to the problems of global warming and fossil fuels. Energy industry entrepreneurs promote biomass power as clean, cost-effective economic development. They assert that biomass plants do not add any additional pollutants to the environment and that the carbon dioxide released by combustion would be there anyway. But producing biomass fuel creates high levels of air pollution. Volatile organic compounds and nitrogen oxide emissions from biomass fuel production are high when compared to emissions from conventional oil wells and refineries. [ARGONNE] If the emissions of the biomass system are as large as or larger than those from a fossil-fueled plant, where is the benefit? Further, why would identical compounds be considered benign/positive in one case and malignant/negative in another?

To date, federal and state legislative solutions have been a mix of good and bad ideas. For example, in 2007 Congress enacted The Energy Security and Independence Act which mandated energy efficiency; accelerated development of solar and geothermal energy; and a modernized the electric grid. However, it also called for carbon capture for fossil fuel and the development of new types of bio-fuel. During the last few years, Congress has considered many other greenhouse gas bills. How these legislative actions and rulemakings will play out is yet to be determined. So far, the U.S. Supreme Court's ruling in favor of regulating carbon dioxide under the existing Clean Air Act still stands. Many states have developed renewable energy portfolio standards which promote biomass energy.

The southeastern region of the United States relies on non-renewable fossil fuel for 77% of its energy, largely coal. As a result, the 16 southern states account for 41% of US carbon dioxide emissions. Before constructing any new power plants, before drilling new oil wells or leveling more mountains, it would be better if we were to trim the region's profligate consumption of energy. In fact, it is clear that we must do what we can as soon as possible to reduce emission of carbon dioxide and other global warming gases. Moreover, it is important to take steps which will truly slow, stop and reduce global warming; half measures—including biomass—will not do.

Conclusion

Global warming is a planetary crisis which demands concerted, substantial and meaningful action. The scientific basis connecting human activity with the rise in global temperature is mounting. The rising levels of greenhouse gases—carbon dioxide, methane and nitrous oxide—in the atmosphere have been tied to expanding human civilization during the last 250 years.

Biomass fuel is not carbon neutral. Catch-22 ambiguities stem from the fundamentally irrational concept of good carbon-bad carbon. The dilemma is resolved by discarding the assumption that biomass fuel is carbon neutral and admitting the premise that all carbon dioxide sources—biogenic and anthropogenic—cause global warming.

Moreover, the assumption that biomass is carbon neutral tends to cut short systematic comparisons with fossil fuels by automatically excluding the impact of biomass carbon dioxide emissions on global warming. Such analyses are essential to prevent unintended consequences such as investments of capital and other resources in false solutions, disruption of agricultural economies caused by overproduction, ecological damage caused by deforestation, negative public health impacts caused by air pollution and, of course, more destructive global warming.

Biomass Energy Policy Recommendations

Three hundred years of accelerating fossil fuel consumption have left us with contaminated land and water, polluted air and an unacceptable level of global warming gases in the atmosphere. Continuing down that same road with biomass fuel will only lead to an increasingly dangerous planet. The following recommendations provide a reference point in the vital discussion about our energy future.

- Exclude all waste combustion as eligible renewable resources and eliminate mandates such as swine waste and poultry waste set-asides.
- Ban the disposal of organics in landfills for the purpose of landfill gas generation.
- Require methane gas collection from all existing landfills and wastewater treatment plants.
- Encourage source separation of food waste and other organics for composting and anaerobic digestion.
- Eliminate all government subsidies, tax breaks and public incentives for landfill gas and biomass incineration.
- Oppose cap and trade, carbon offsets and carbon trading programs.
- Oppose large-scale base-load biomass power plants and the co-firing of biomass in existing coal-fired power plants.
- Encourage the development of community-based, decentralized solar, wind, geothermal, small hydro and anaerobic digester facilities at an appropriate scale.
- Encourage the use of combined heat and power with proper safeguards to protect public health and the environment.
- Ban the use of genetically engineered crops and trees to generate electricity or produce bio-fuels for transportation.
- Implement a moratorium on new biomass incinerators, co-firing of biomass with coal and new bio-fuels refineries.
- Support third-party independent energy efficiency programs.
- Adopt Zero Waste goals and policies to reduce consumption and conserve energy.
- Eliminate toxics and contaminants in products to facilitate reuse, recycling and composting.
- Encourage local agriculture and economic development at a scale that reduces energy consumption and supports sustainable communities.
- Oppose the replacement of natural forests and traditional agriculture with energy crops and tree plantations.
- Eliminate all exemptions to the National Environmental Policy Act and state environmental policy acts.
- Count all greenhouse gas emissions from all sources in the production of energy and bio-fuels-no "carbon neutral" exemptions.
- Make environmental justice the common denominator in energy policy, regulations and permitting.

1. Policy

1.1 Definition-"What is biomass?"

Biomass is a broad term for the bulk of biologically produced matter on earth. In the context of energy production, it is generally accepted to include materials which are produced for such purposes or which are by-products of human industry. So the term may include, for example, both corn grown for ethanol and household trash.

According to the Southern Bioenergy Roadmap, "Biomass is organic materials derived from plants and animals and includes agricultural and forestry residues, municipal solid wastes, industrial wastes, and land and aquatic crops grown solely for energy purposes."[1]

Biomass is organic matter; carbon is its principal element. A comprehensive biomass list also includes paper mill black liquor, wastewater treatment plant sewage sludge, landfill gas methane, furniture manufacturing wood waste, scrap tires, poultry and hog manure.

1.2 Bio-Myths

During the last few years, statements extolling the virtue of becoming the "Saudi Arabia of Biomass" have surfaced in North Carolina, South Carolina, Georgia, Alabama, and elsewhere. A host of bio-energy entrepreneurs are looking for friendly local officials and chambers of commerce. But before the deal is struck, we must ask: *Should* the South be the Saudi Arabia of biomass? The Blue Ridge Environmental Defense League's renewable energy policy opposes virtually all the biomass proposals we have studied. Waste-to-energy, gasification, pyrolysis, plasma arc and similar bio-energy technologies invariably have smokestacks which emit toxic air pollution and greenhouse gas.

For example, burning chicken manure for power trades three tons of organic fertilizer for a barrel of petroleum. (See our analysis in Section 3.2.) Burning wood produces more carbon dioxide than coal for the same amount of heat. It is simply untrue that *'Biomass energy, like wood and crops, is less polluting than coal and can help combat global warming particularly in the short term."*[2]

Cutting down trees for the purpose of energy production eliminates the forest's ability to absorb carbon dioxide. Once the trees are felled, the damage is done. There is

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1 *Southern Bioenergy Roadmap*, Pennock C, Doron S, (2009) Executive Summary Endnote 2, published by the Southeastern Agriculture and Forestry Energy Resources Alliance (SAFER) and the Southern Growth Policies Board, www.saferalliance.net. The *Southern Bioenergy Roadmap* promotes the "research, production and distribution of bioenergy" by, among other things, "improving the regulatory environment of the industry" and "mitigating the risk to entrepreneurs" through tax incentives, tax credits, loans and grants. See "The Center for Climate Strategies" at www.climatestrategies.us

2 *Southern Alliance for Clean Energy, Anne Blair Program Manager-Clean Diesel and Bioenergy,, e-mail 2/25/09*

no evidence to support that statement that *"An important criterion of sustainability is ensuring that every step of the production process maintains this closed-loop of the carbon-cycle and that the resource is regrown."*[3]

Biomass combustion emits huge amounts of nitrogen oxides, sulfur dioxide, carbon monoxide and carbon dioxide. It is flatly wrong to claim that "*Biomass-powered electricity is 'emissions free.'*" [4]

Upon close analysis, claims that biomass reduces greenhouse gas fall by the wayside. The rare exceptions may include examples of anaerobic digestion and other processes which mimic natural systems instead of industrial technologies. However, these techniques are not yet serious contenders for large scale energy production for vehicular fuel or electric generation. Chapter 3 of *Smoke and Mirrors* provides analyses of energy crops, forest residue and other biomass.

1.3 International Policy

Greenhouse gas emissions have concerned scientists for decades. In 1988 the United Nations Intergovernmental Panel on Climate Charge was established to address the impacts of global warming. In 1992 the UN Framework Convention on Climate Change emphasized human activity as a driver of global warming. Nations participating in the Convention committed themselves to the following actions:

> Each of these Parties shall adopt national policies and take corresponding measures on the mitigation of climate change, by limiting its anthropogenic emissions of greenhouse gases and protecting and enhancing its greenhouse gas sinks and reservoirs.[5]

The Framework Convention embodies the Precautionary Principle[6] which requires protective action even when there is imperfect knowledge of cause and effect. But evidence for anthropogenic—human caused—impacts on global warming continues to mount. The 2007 report of the Intergovernmental Panel on Climate Change states:[7]

> Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years. The global increases in carbon dioxide concentration are due

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[3] *Ibid*

[4] *Dimensions 2008-2009: Corporate Responsibility Report*, Dominion Resources, Inc., page 20, www.dom.com

[5] United Nations Framework Convention on Climate Change, 1992, Article 4 Commitments 2(a), FCCC/INFORMAL/84, GE.05-62220 (E) 200705

[6] Wingspread Statement on the Precautionary Principle, Jan. 1998, http://www.sehn.org/wing.html

[7] IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment, Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp.

primarily to fossil fuel use and land use change, while those of methane and nitrous oxide are primarily due to agriculture.

Human activity is contributing to global warming. This is no longer in dispute. In fact, it is clear that we must do what we can as soon as possible to reduce emission of carbon dioxide and other global warming gases. Moreover, it is important to take steps which will truly slow, stop and reduce global warming; half measures will not do.

The Kyoto Protocol uses a time horizon of 100 years;[8] that is, it assesses global warming potential during the next century. But the long term impacts of CO_2 emissions from biomass combustion are on the order of centuries and therefore may fall outside the scope of Kyoto. Further, the method employed by the IPCC for calculating the carbon emissions for the Kyoto Protocol omitted carbon dioxide emissions from growing and harvesting of biomass crops. (SEARCHINGER) The key to greenhouse gas reductions is the overall balance of carbon, the trade-off of debits and credits, emissions and sinks.

Bio-energy advocates are mistaken when they assume any and all biomass energy sources are beneficial or carbon neutral. "Replacing fossil fuels with bio-energy does not by itself reduce carbon emissions, because the CO_2 released by tailpipes and smokestacks is roughly the same per unit of energy regardless of the source."[9] Clearly, a comprehensive assessment of biomass impacts must preclude the wholesale adoption of bio-energy in the 21st Century.

1.4 The National Picture

In the United States, air pollution is caused largely by emissions from the combustion of fossil fuels for the purposes of, in descending order, electric power generation, vehicular transportation, industrial production and residential and commercial heating. Petroleum, natural gas and coal provided 83.4% of the nation's energy supply in 2008. Total energy supply and use is illustrated in Figure 1, next page.

Transportation Fuels

In 2007 Congress approved the Energy Independence and Security Act (EISA) which sets a national renewable fuel standard in four categories of fuel derived from biomass and sets a goal of 36 million gallons per year from all sources by 2022. The Biomass Fuel Standards are:[10]

1. Biomass-Based Diesel: 1 billion gallons per year by 2012, produced from fats and oils not co-processed with petroleum and meeting a 50% lifecycle greenhouse gas threshold.

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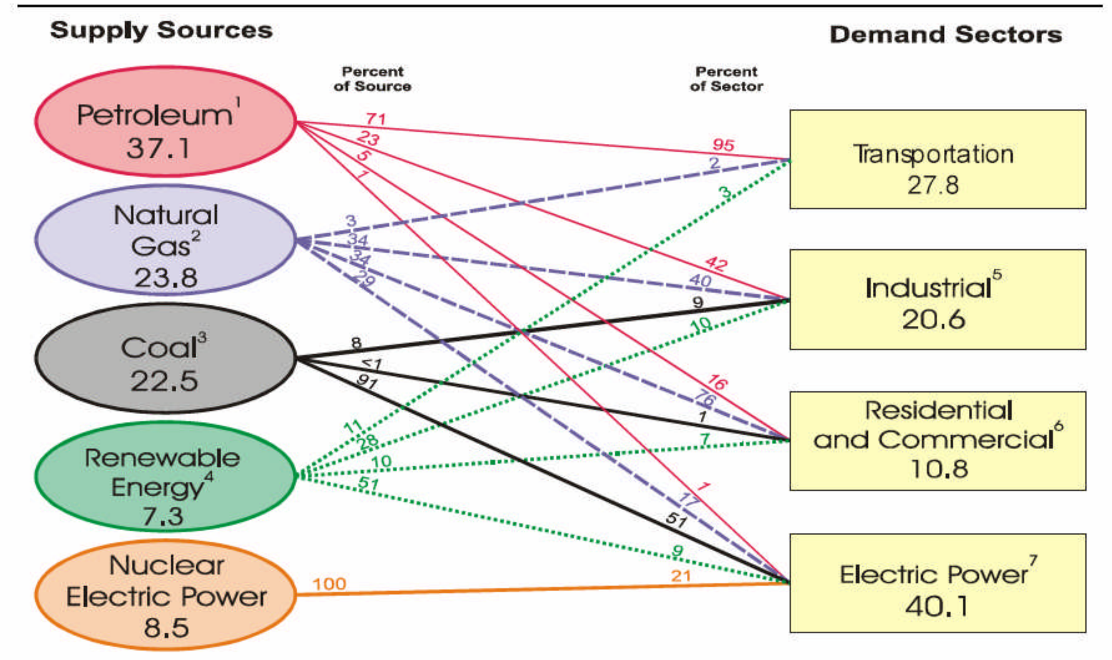
8 IPCC Expert Meeting on the Science of Alternative Metrics, 18-20 March 2009, Meeting Report, http://www.ipcc.ch/pdf/supporting-material/expert-meeting-metrics-oslo.pdf

9 "Fixing a Critical Climate Accounting Error" Timothy D. Searchinger et al. *Science*. October 2009. http://www.sciencemag.org/cgi/content/short/326/5952/527

10 National Renewable Fuel Standard Program - Overview April 14 - 15, 2010, Office of Transportation and Air Quality, US Environmental Protection Agency, http://www.epa.gov/otaq/fuels/renewablefuels/compliancehelp/rfs2-workshop-overview.pdf

2. Cellulosic Biofuel: 16 billion gallons by 2022, produced from cellulose, hemicellulose, or lignin and meeting a 60% lifecycle GHG threshold.
3. Advanced Biofuel: Total of 21 billion gallons by 2022, produced from anything except corn starch ethanol (including cellulosic biofuels and biomass-based diesel) and meeting a 50% lifecycle GHG threshold.
4. Renewable Biofuel: Total of 36 billion gallons per year by 2022 produced from corn starch or any other qualifying renewable fuel at new facilities and meeting a 20% lifecycle GHG threshold.

Figure 1: Annual Energy Supply and Use (Quadrillions of BTUs)[11]



The EISA calls upon EPA to determine "lifecycle greenhouse gas thresholds" based on the all stages of feedstock production, refining, distribution, delivery and end use of the fuel. Relative global warming potential is to include both direct and indirect greenhouse gas emissions such as land use changes. How comprehensive this analysis will be remains to be seen.

The United States reached a legal turning point in 2007 when the U.S. Supreme Court ruled that carbon dioxide must be considered a pollutant under the Clean Air Act.[12] In a close decision, the court ruled in favor of the states and public interest groups seeking to regulate carbon dioxide under the existing Clean Air Act. The case turned on whether CO_2 is considered a pollutant and therefore subject to regulation under Clean Air Act Section 202(a)(1). The Act requires vehicle emission standards for any air pollutant which endangers public health or welfare.

[11] U.S. Energy Information Administration, *Annual Energy Review 2008*, Report No. DOE/EIA-0384, Tables 1.3, 2.1b-2.1f , 10.3, and 10.4. http://www.eia.doe.gov/emeu/aer/pecss_diagram.html
[12] *Massachusetts v. Environmental Protection Agency*, 549 U.S. 497 (2007)

Electric Power Plants

Fossil fuel power plants burning coal, oil and natural gas dominate the power generation sector, providing 69% of the nation's electric energy. Aging coal-fired plants, most of them constructed before the passage of the Clean Air Act in 1970, continue to operate despite an understanding that they would be phased out and were, therefore, granted exemptions from regulations. This loophole has resulted in a spate of lawsuits and settlements to enforce provisions of the Clean Air Act. For example, before modifying an aging coal-fired facility, power companies must submit the plan to EPA to ensure that an obsolete plant subject to a lower standard is not kept in operation without installing modern pollution equipment.

A major modification of a pollution source requires the operator to submit to a review of the modernization under provisions known as New Source Performance Standards. For example, the EPA called for the shut down of Duke Energy's coal plants because they were modified without approval. In 2000, the U.S. Justice Department, filed a complaint against Duke Energy in the U.S. District Court in Greensboro, North Carolina, for violations of the New Source Review (NSR) provisions of the CAA. The EPA said that 29 projects performed at 25 of Duke Energy's coal-fired units were major modifications. In 2007 American Electric Power was forced to sign the largest environmental enforcement consent decree in US history for New Source Review violations.[13] Alabama Power, South Carolina Public Service Authority, Virginia Electric Power Company and ten other electric utilities were subject to similar actions by EPA.

Today the electric power industry is a major source of global warming pollution, emitting 40% of the nation's CO_2 emissions, more than any other sector including transportation and other industry.[14] Electric power also generates 70% of the SO_2, 20% of the NO_x and 68% percent of the mercury emissions to the air.

Congressional Legislation

Abortive attempts by Congress to address the problem of global warming include the Climate Security Act (Lieberman and Warner)[15] and the Low Carbon Economy Act (Bingaman and Specter).[16] These bills, had they passed, would have depended on a market-driven system of allowances, auctions and trading to reduce carbon emissions to 1990 levels by 2030. Another failed bill was the American Clean Energy and Security Act of 2009, HR 2454 (Waxman-Markey). The stated purpose of Waxman-Markey was to "create clean energy jobs, achieve energy independence, reduce global warming pollution and transition to a clean energy economy." Wind, solar and geothermal energy

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[13] US EPA Compliance and Enforcement, "Cases and Settlements," http://cfpub.epa.gov/compliance/cases/

[14] *Benchmarking Air Emissions of the 100 Largest Electric Power Producers in the United States*, May 2008, http://www.nrdc.org/air/pollution/benchmarking/2006/benchmark2006.pdf

[15] For more information, see: "EPA Analysis of the Lieberman-Warner Climate Security Act of 2008," S. 2191 in 110th Congress, March 14, 2008, available at: http://www.epa.gov/climatechange/downloads/s2191_EPA_Analysis.pdf

[16] For more information see: Bingaman-Specter "Low Carbon Economy Act" of 2007, http://energy.senate.gov/public/_files/LowCarbonEconomyActTwoPager0.pdf

were included; however, the bill also promoted carbon sequestration and the burning of waste and unclean biomass. HR 2454 sanctioned the following as renewable electric power fuels: landfill gas; wastewater treatment gas; coal mine methane; municipal solid waste and construction, demolition, or disaster debris. The bill approved waste-to-energy combustion, gasification and pyrolysis. The bill's biomass fuels included trees, wood, or brush part of a federally recognized timber sale; feed grains and other agricultural commodities; wood waste and wood residues, animal waste and byproducts including fats, oils, greases, and manure, food waste and yard waste, and byproducts from pulp or paper production facilities.[17]

From our perspective, biomass was a fatal flaw in HR 2454 because carbon dioxide emitted when waste is burned to generate electricity would not be measured in the same way as CO_2 from fossil fuel; i.e., it is considered a plus rather than a minus. Moreover, the bill would have prohibited greenhouse gas "from being listed as a criteria pollutant under the Clean Air Act on the basis of its effect on global climate change."[18]

In her Congressional testimony on renewable energy legislation, [19] Attorney Margaret Sheehan said:

> According to the Energy Information Administration, which does official energy statistics for the U.S. Government, by 2020, under a 20% Renewable Electricity Standard, which is the goal under the HR 2454, the U.S. will produce 70 gigawatts of electricity from biomass burning. That translates to 700 millions tons of CO2 from biomass burning in 2020 – that's a lot of CO2 from a so called clean and green renewable source.
>
> The Waxman Markey American Clean Energy and Security Act, H.R. 2454, subsidizes biomass burners that emit 1.5 times more CO2 per megawatt than burning coal. The Bill calls biomass burning "clean and green" and renewable– it is neither.

It is a common practice in federal and state legislation to mix good ideas in with bad ones. For example, in 2007 Congress enacted The Energy Security and Independence Act[20] (HR 6) which improved the energy efficiency of motor vehicles, electrical appliances and buildings; accelerated research and development of solar and geothermal energy; and pressed for modernization of the electric distribution grid. However, it also called for carbon capture R&D and the development of so-called advanced biofuels; i.e., vehicle fuels made from materials other than corn (target: 21 billion gallons by 2022).

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[17] HR 2454, American Clean Energy and Security Act, Renewable Electricity Standards, Sub. A, Sec. 101
[18] HR 2454, Subtitle C, Section 331
[19] Remarks of Attorney Margaret E. Sheehan, Testimony to the U.S. House of Representatives Briefing on H.R. 2454 (Waxman Markey Clean Energy Bill) June 19, 2009
[20] http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=110_cong_bills&docid=f:h6enr.txt.pdf

Although the above bills did not become law, we expect similar measures to be raised in Congressional legislation.

Non-governmental Organizations

Non-governmental organizations span the spectrum on biomass. For example, the National Resources Defense Council "supports the development of bioenergy that reduces environmental impacts, such as global warming pollution, and avoids creating social impacts such as higher food prices while protecting the critical ecological values of our natural forests and grasslands."[21] Friends of the Earth supports a sustainable and efficient energy policy, but finds that biomass is unsustainable and inefficient:

> This drive to substitute fossil fuels with biofuels is driven in large part by an assumption that bio-based energy is sustainable for the planet. However, biofuels can create significant environmental harm. Large-scale agricultural production of corn and other crops used for biofuels often involves massive fertilizer inputs, use of large quantities of water, and soil erosion. Also, rather than helping prevent global warming, biofuels can actually cause global warming as a result of deforestation and the destruction of other natural ecosystems.[22]

How public policy is affected by state and federal legislation and public interest groups is yet to be determined. However, as we will demonstrate in the following pages of this report, biomass is not clean source of energy and is not the solution to global warming.

1.5 The South

The southeastern region of the United States relies on non-renewable fossil fuel for 77% of its energy, largely coal. As a result, the 16 southern states account for 41% of US carbon dioxide emissions. [CHANDLER] In the fourteen southern states, there are 41 bio-diesel and 12 ethanol refineries manufacturing 22% of the bio-diesel and 6.4% of the ethanol produced in the United States. [SAFER] But before constructing any new power plants or refineries, before drilling new oil wells or leveling more mountains, it would be better if we were to trim the region's profligate consumption of energy which extends to all end uses of energy.

> The South accounted for 43.6 percent of the nation's total energy consumption in 2006, considerably more than its share of the country's population – 34.8 percent (U.S. Census Bureau, 2008). Its higher-than-average per capita energy consumption is true for each of the major end-use sectors: residential buildings

[21] "Homegrown Energy from Biofuels" http://www.nrdc.org/energy/biofuels.asp, last revised 4/27/2009
[22] Friends of the Earth website at http://www.foe.org/energy/biofuels

(39.8%), commercial buildings (37.9%), industry (50.9%), transportation (41.4%), and electric power (42.9%).[23]

In light of the above, what might be the impact of large scale biomass energy production have on the South's economy and environment? The *Southern Bioenergy Roadmap* released in 2009 paints a rosy picture. "If you have heard it said that the South is the Saudi Arabia of biomass, this helpful report shows you how this resource can be tapped," said John Bonitz of the Southern Alliance for Clean Energy.[24] Dr. Ross McCluney of the Florida Solar Energy Center found this position on biomass to be problematic for environmental, health and ethical reasons. Regarding corn-based ethanol, he wrote:

> The environmental impacts of corn ethanol are enormous:[25]
>
> 1. Corn production causes more soil erosion than any other crop grown.
> 2. Corn production uses more nitrogen fertilizer than any other crop grown and is the prime cause of the dead zone in the Gulf of Mexico.
> 3. Corn production uses more insecticides than any other crop grown.
> 4. Corn production uses more herbicides than any other crop grown.
> 5. More than 1,700 gallons of water are required to produce 1 gallon of ethanol.
> 6. A total of 12 gallons of sewage effluent are released per gallon of ethanol produced.
> 7. Enormous quantities of carbon dioxide are produced, including the large quantity of fossil energy used in production, large quantities of carbon dioxide are released during fermentation, and when the soil is tilled soil organic matter is exposed and oxidized. All this speeds global warming.
> 8. Related to the total operation, including the burning of the ethanol, the air pollution problem is significant.
> 9. Environmental ethics of converting food (corn) into fuel when billions of people are malnourished

Dr. McCluney consulted with experts in the field who said:

> Currently the U.S. is producing 5 billion gallons of ethanol (DOE), without charging for all the oil and natural gas inputs required in producing and converting the corn into ethanol. This is using 20% of all U.S. corn and represents only 1% of U.S. petroleum use. If 100% of U.S. corn were used, it would provide only 7% of current U.S. petroleum use.[26]

Woodland biomass, also known as "forest residue," is claimed to be part of the South's energy resources. The Southern Alliance for Clean Energy states, "Our analysis indicates that residues from existing forest operations (not new harvests) are an essential

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[23] *Meta-Review of Efficiency Potential Studies and Their Implications for the South*, Sharon (Jess) Chandler and Marilyn A. Brown, School of Public Policy. Georgia Inst. of Technology, Working Paper # 51, Section 2.2 Energy Demand in the South, page 7, August 2009

[24] Southern Alliance for Clean Energy press release, February 17, 2009

[25] "Biomass Fuel is not a Slam-Dunk for Environmentalists," Dr. Ross McCluney, monograph, July 5, 2007

[26] *Ibid*, Attributed to Dr. David Pimentel, Cornell University College of Agriculture and Life Sciences

component to the southeast's clean energy future."[27] However, this statement relies on the myths of the closed-loop carbon cycle and the carbon neutrality of biomass. Section 3.1 of *Smoke and Mirrors* details how standing forests provide the most effective carbon storage, even on marginal soils. [MARLAND]

1.6 The States

While all state renewable portfolio standards include biomass as an eligible energy resource, not all define biomass in the same way.

North Carolina

In 2007, North Carolina General Assembly ratified Senate Bill 3 (NCGS § 62-2 et seq.), which established a Renewable Energy and Energy Efficiency Portfolio Standard which defines biomass as: "agricultural waste, animal waste, wood waste, spent pulping liquors, combustible residues, combustible liquids, combustible gases, energy crops, or landfill methane; or waste heat derived from a renewable energy resource."[28]

No other state RPS includes specific set-asides for swine waste and poultry litter. This provision alone in Senate Bill 3 made North Carolina a "guinea pig" in regulating renewable energy from animal wastes. Originally the definition excluded "unsegregated wastes; painted, treated, or pressurized wood; wood contaminated with plastic or metals; and tires." It was determined by the North Carolina Biomass Council that the definition of biomass should be as inclusive as possible, and one should allow permit conditions and sampling requirements to ensure the necessary environmental protection."[29]

A report by the North Carolina Utility Commission found that there was 600 MW of existing non-utility owned renewable energy capacity in North Carolina. Hydroelectric made up one third of the total with most of the balance from biomass co-generation and a very small amount from landfill gas and municipal solid waste incineration. Biomass facilities produce electricity primarily for industrial uses, but a 50 MW Wood Energy Plant in Craven County provides electricity to the grid under the NC GreenPower, a voluntary donation program with approximately 8000 subscribers.[30]

North Carolina's Renewable Energy and Energy Efficiency Portfolio Standard requires all investor-owned utilities in the state to supply 12.5% of 2020 retail electricity sales (in North Carolina) from eligible energy resources by 2021. Municipal utilities and electric cooperatives must meet a target of 10% renewables by 2018 and are subject to slightly different rules.[31]

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[27] Anne Blair, Program Manager Clean Diesel and Bioenergy, Southern Alliance for Clean Energy, February 25, 2009, e-mail to Ross McCluney.

[28] N.C. Gen. Stat. § 62-133.8(a)(8)

[29] The NC Biomass Roadmap May 2007

[30] *Analysis of a Renewable Portfolio Standard for the State of North Carolina*, http://www.lacapra.com/downloads/NC_RPS_Report.pdf

[31] Source: North Carolina Utilities Commission, http://www.ncuc.commerce.state.nc.us

Virginia

In 2007, the Virginia legislature enacted a Voluntary Renewable Energy Portfolio Goal (SB1416) which offers financial incentives to investor-owned utilities via increased rates of return to encourage the use of eligible renewable energy resources generated or purchased in-state. Eligible sources include solar, wind, geothermal, hydropower, wave, tidal, and biomass.[32] (UMINN)

Virginia has dedicated 25% of the state's share of $40 million from the federal economic stimulus to biomass and waste-to-energy projects. On the project list is agricultural waste, landfill gas and other biomass.[33] The balance of funds from the American Recovery and Reinvestment Act are dedicated to energy efficiency and residential rebate programs.

Tennessee

The University of Tennessee defines biomass as dedicated energy crops, agricultural crops and trees, food and feed crop residues, aquatic plants, industrial, municipal and agricultural solid wastes, forestry residues, and other fundamental cellular structures such as sugars, starch, and lignocellulose.[34]

Tennessee Valley Authority has a renewable energy incentive program for electric customers in its seven-state service area. Homeowners and businesses who install biomass electric generating units can become "Generation Partners," from whom TVA will purchase the power at $0.03 per kilowatt-hour above the retail electricity rate. For more information about the program, go to www.generationpartners.com (UMINN)

Maryland

In 2004 Maryland enacted a Renewable Energy Portfolio Standard (Public Utility Companies Code § 7-701 et seq.) which requires utilities and distributors to increase renewable generation to 20% from Tier 1 resources in 2022 and beyond, and 2.5% from Tier 2 resources through 2018. (UMINN) Tier 1 includes qualifying biomass and methane from a landfill or wastewater treatment plant in addition to solar, wind, geothermal and ocean energy. Tier 2 includes poultry litter and waste-to-energy in addition to hydroelectric power.

"Qualifying biomass" includes saw mill residue except sawdust and wood shavings, precommercial soft wood thinning, slash, brush, yard waste, pallets, crates, dunnage, tree crops, vineyard materials, grain, legumes, sugar, and other crop by-

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[32] For more information, see: Virginia Department of Mines, Minerals and Energy, http://www.mme.state.va.us/DE/Alternative_Fuels/alternativefuels.shtml

[33] Waste Recycling News, 10/7/09, www.wasterecyclingnews.com

[34] "Land, Life and Science," University of Tennessee Institute of Agriculture, Vol. 4, No. 1, 2006, http://www.utbioenergy.org/TNBiofuelsInitiative/

products or residues, gas produced from the anaerobic decomposition of animal waste or poultry waste, and cultivated plants to produce electricity.[35]

South Carolina

In 2007 South Carolina enacted a Biomass Energy Tax Credit (S.C. Code § 12-6-3620) which allows a 25% reduction in license fees or taxes towards the purchase of power generating equipment used to create heat, steam, or electricity from a fuel which is at least 90% biomass. The credit is capped at $650,000 per taxpayer per year.[36] (UMINN)

The state's Energy Freedom and Rural Development Act added further incentives for biomass energy. Biomass facilities burning "wood, wood waste, agricultural waste, animal waste, sewage, landfill gas, and other organic materials" may earn $0.01 per kilowatt-hour or $0.30 per 100,000 Btu; the money is paid from the state's general fund and is capped at $2.1 million total per year through 2018 and $100,000 per taxpayer per year. (NCSU)

Georgia

In 2006 Georgia created an exemption from sales and use taxes for biomass fuels used to make electricity and/or steam (HB 1018).[37] The legislation defines biomass as "agricultural crops, plants, trees, wood, wood wastes and residues, sawmill waste, sawdust, wood chips, bark chips, and forest thinning, harvesting, or clearing residues; wood waste from pallets or other wood demolition debris; peanut shells; pecan shells; cotton plants; corn stalks; and plant matter, including aquatic plants, grasses, stalks, vegetation, and residues, including hulls, shells, or cellulose containing fibers." (NCSU)

Alabama

In 2006 Alabama developed the Biomass Energy Program to assist in the installation of biomass energy systems. Participating businesses may get up to $75,000 in interest subsidy payments for biomass projects. Biomass fuels eligible include wood chips, sawdust, bark and landfill gas.[38] (UMINN)

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[35] Maryland Renewable Energy Portfolio Standard Program, accessed May 9, 2010 at: http://webapp.psc.state.md.us/Intranet/sitesearch/faq_new.cfm

[36] South Carolina Code of Laws http://www.scstatehouse.net/CODE/T12C006.HTM

[37] North Carolina State University, Database of State Incentives for Renewables & Efficiency, http://www.dsireusa.org/incentives/index.cfm?re=1&ee=1&spv=0&st=0&srp=1&state=GA

[38] Source: Alabama Department of Economic and Community Affairs: accessed May 16, 2010 at: http://www.adeca.state.al.us/C16/Biomass%20Energy%20Program/default.aspx

2. The Science of Global Warming

Global climate is created by the sun's impacts on the earth, its oceans and atmosphere. The greenhouse effect is the warming of the planet caused by gases in the atmosphere which convert or hold radiation from the sun as heat. Scientists have studied this phenomenon for centuries. The generally accepted base year for global warming studies is pre-industrial 1750.

The gases which contribute to the greenhouse effect include nitrous oxide (N_2O), methane (C_4H_4) and carbon dioxide (CO_2). In order of importance as global warming agents, the most significant by far is carbon dioxide. (See Table A).

Table A: List gases by volume, impact and CO2 equivalents.

Greenhouse gas	Concentration in atmosphere (ppm)	Relative CO_2 equivalent [a]
Carbon dioxide CO_2	365	1
Methane CH_4	1.745	23
Nitrous oxide N_2O	0.314	296
Tetrafluoromethane CF_4	0.00008	5700
Hexafluoromethane C_2F_6	0.000003	11900
Sulfur hexafluoride SF_6	0.000004	22200
Hydrofluorocarbons HFC	0.000022	120 to 12000

a. *IPCC Third Assessment Report (2001)*

The *relative CO_2 equivalent* is the amount of carbon dioxide that would cause the same impact—the equivalent time-integrated radiative forcing—as that of another long-lived greenhouse gas a mixture of GHGs. [IPCC-AR4] Omitted from the above table is water vapor. However, climatologists do consider water vapor to be a major greenhouse gas.

> [T]he climate system is forced by a number of factors, e.g., solar impact, the greenhouse effect, etc. For the greenhouse effect, clouds, water vapor, and CO2 are of the utmost importance. [39]

However, the impact of water vapor is difficult to quantify. It traps heat, but it also reflects sunlight; so, at present it is difficult to determine its overall impact on global temperatures.

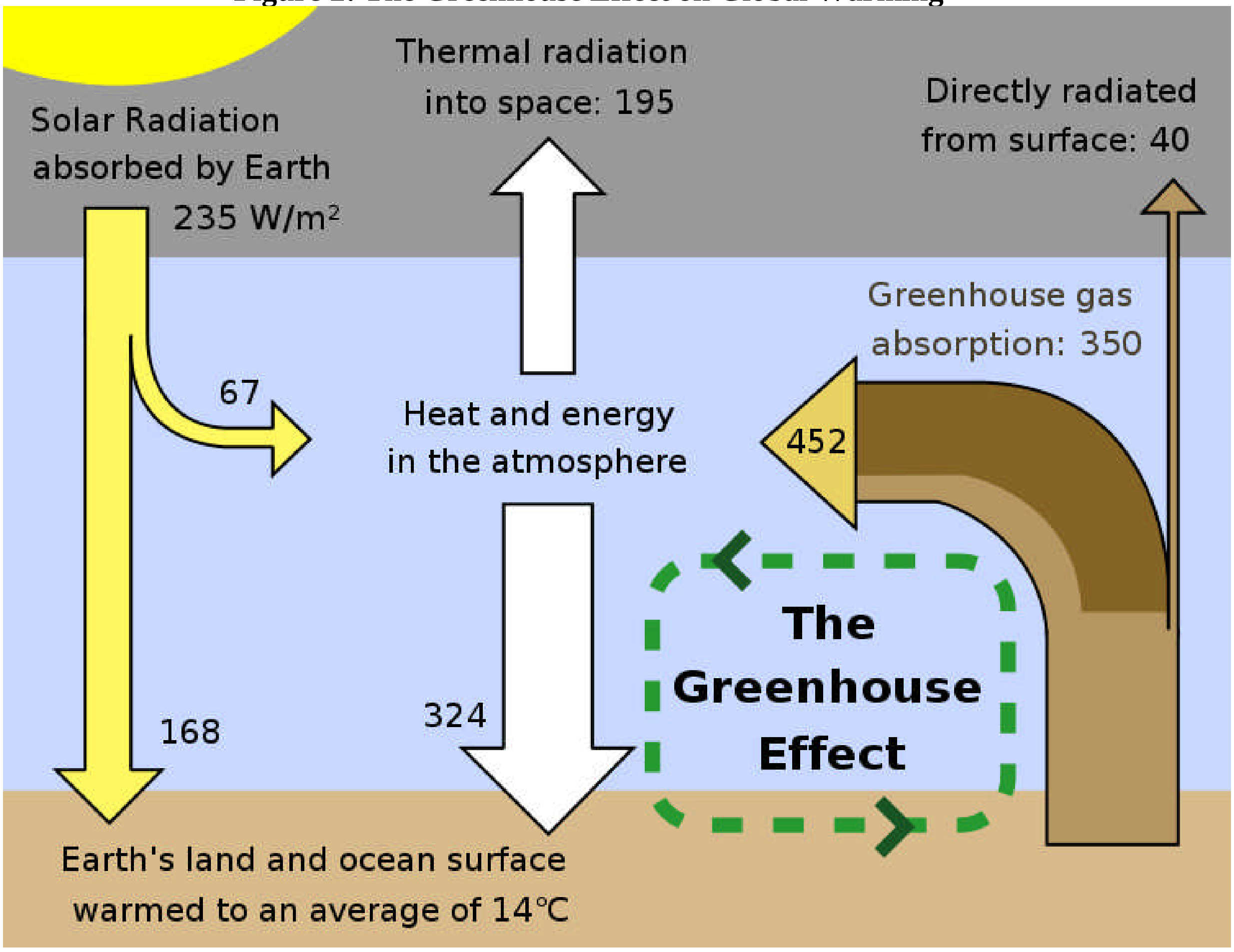
> Water Vapor is the most abundant greenhouse gas in the atmosphere, but as yet is still fairly poorly measured and understood. However, huge scientific uncertainty exists in defining the extent and importance of this feedback loop.[40]

[39] "The radiative forcing due to clouds and water vapor," V. Ramanathan and Anand Inamdar, *Frontiers of Climate Modeling,* eds. J. T. Kiehl and V. Ramanathan. Cambridge University Press, 2006. http://www-ramanathan.ucsd.edu/FCMTheRadiativeForcingDuetoCloudsandWaterVapor.pdf

[40] National Oceanic and Atmospheric Administration, National Climatic Data Center, http://lwf.ncdc.noaa.gov/oa/climate/gases.html

Global climate is a product of a vast interplay of energy involving the sun, the atmosphere, the oceans and the land. Figure 2 below page illustrates the phenomenon.

Figure 2: The Greenhouse Effect on Global Warming[41]



As shown above, solar radiation is the source of heat warming the planet. The sun provides 7,000 times more energy to the earth's surface than current global energy consumption.[42] Plainly, capturing but a small fraction of this potential would vastly outweigh the potential of biomass combustion, plus many other polluting forms of power.

When the global system is in balance, solar energy, the greenhouse effect and the earth's temperature are in equilibrium. As illustrated above, 235 Watts per square meter (W/m^2) of solar radiation absorbed by the earth's atmosphere and surface (67 +168 W/m^2) equals the radiation back into space from the atmosphere and the surface (195 + 40 W/m^2). Other symmetries include: Heat from the sun and the atmosphere to the earth's surface (168 + 324 W/m^2) equals heat radiation to the atmosphere and space from

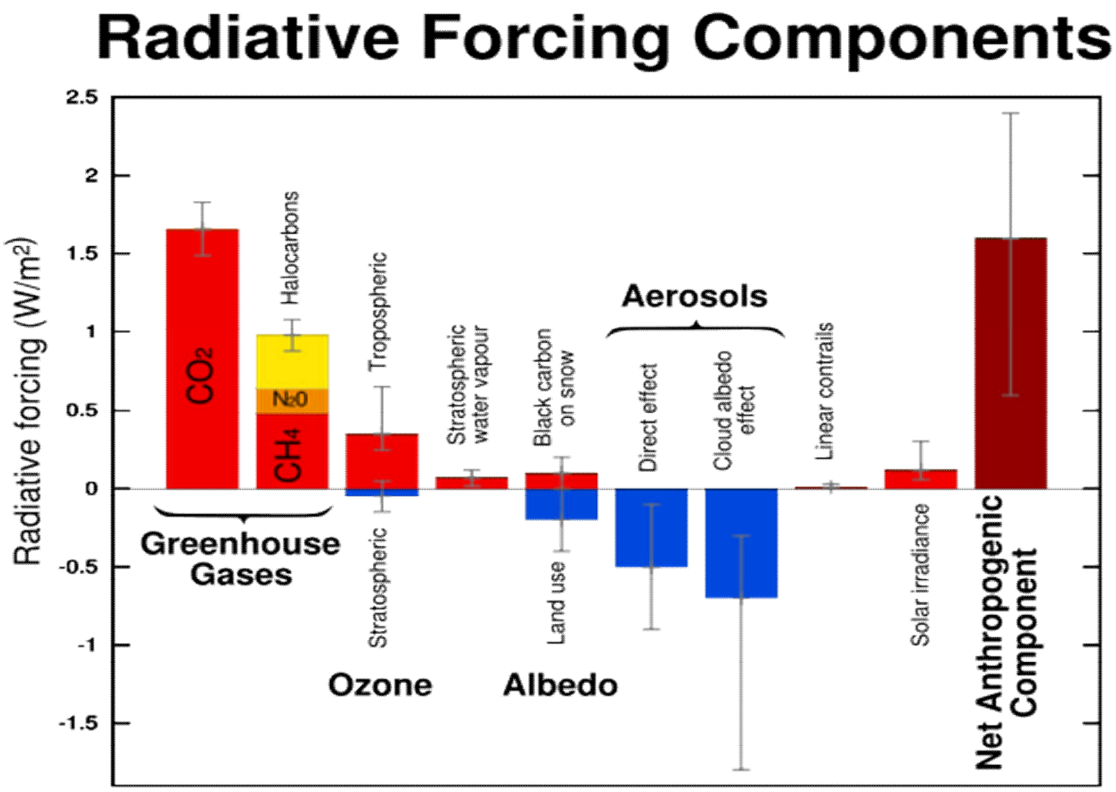
[41] "Greenhouse Effect," Wikipedia, http://en.wikipedia.org/wiki/File:Greenhouse_Effect.svg
[42] Nielsen, R. 2005, 'Solar Radiation', http://home.iprimus.com.au/nielsens/

earth's surface (452 + 40 W/m^2); The heat from the earth's surface and the sun absorbed by the atmosphere (452+67 W/m^2) equals the heat from the atmosphere radiated to space and the earth's surface (195 + 324 W/m^2). However, according to climatologists, the system is not in balance. Dr. James Hansen stated:

> Our climate model, driven mainly by increasing human-made greenhouse gases and aerosols among other forcings, calculates that Earth is now absorbing 0.85 ± 0.15 watts per square meter more energy from the Sun than it is emitting to space. This imbalance is confirmed by precise measurements of increasing ocean heat content over the past 10 years. Implications include: (i) expectation of additional global warming of about 0.6°C without further change of atmospheric composition; (ii) confirmation of the climate system's lag in responding to forcings, implying the need for anticipatory actions to avoid any specified level of climate change; and (iii) likelihood of acceleration of ice sheet disintegration and sea level rise.[43]

Radiative Forcing is a measure of the energy balance of a system. Figure 3 illustrates the anthropogenic, or human-caused, impacts on global climate.

Figure 3: Radiative Forcing Components[44]

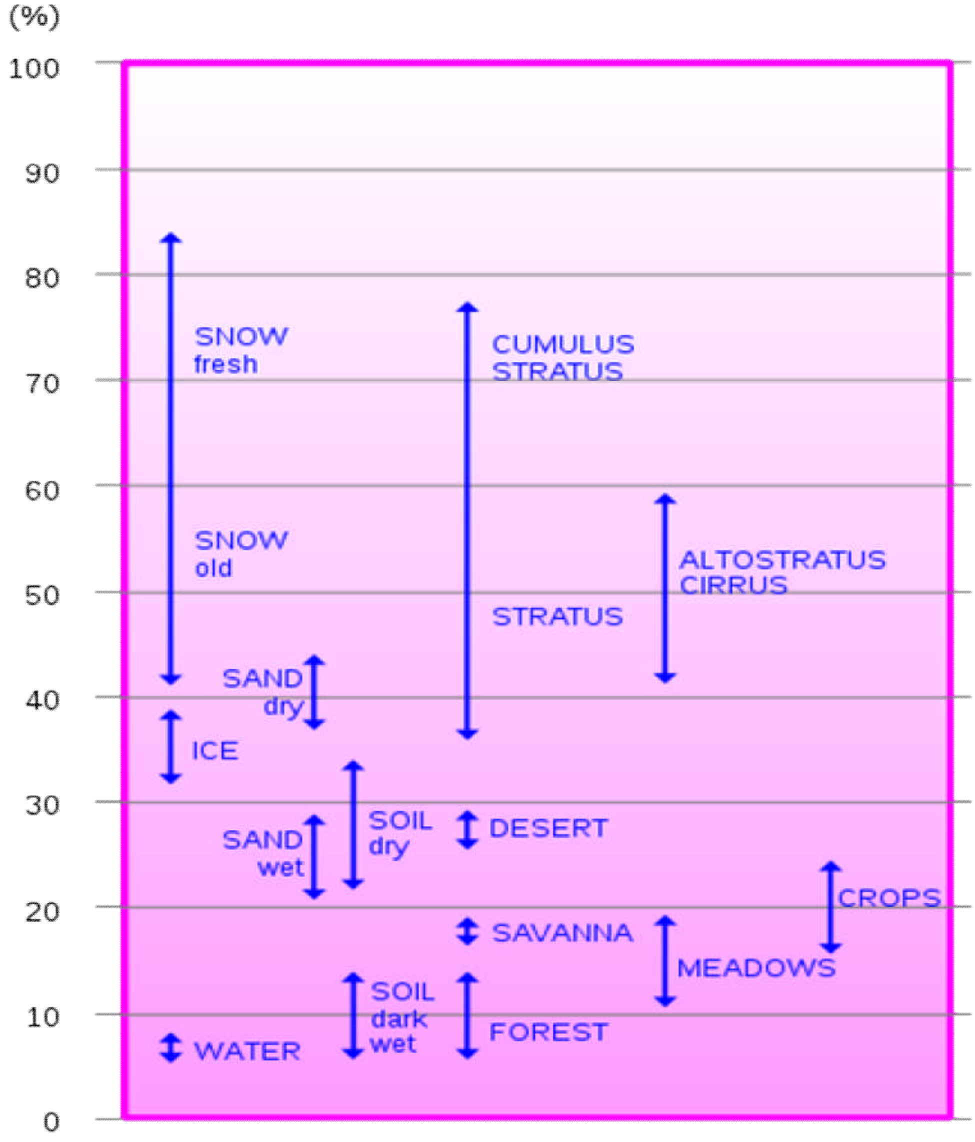


[43] Hansen, J., et al. 2005, Science, 308, 1431, doi:10.1126/science.1110252.
[44] Wikipedia: Radiative-forcings.svg at http://en.wikipedia.org/wiki/File:Radiative-forcings.svg

The red bars indicate positive forcing, which raises global temperature; the blue bars indicate negative forcing, which reduces global temperature. The net effect, the sum of all these factors, is +1.5 watts per square meter, indicated by the bar at right. Greenhouse gases, ozone, albedo and aerosols are the major parameters. Aerosols are particles or droplets in the air.

Albedo is the reflectivity of a surface. Snow and deserts have high albedo; forests and oceans have low albedo. Figure 4 illustrates this phenomenon.

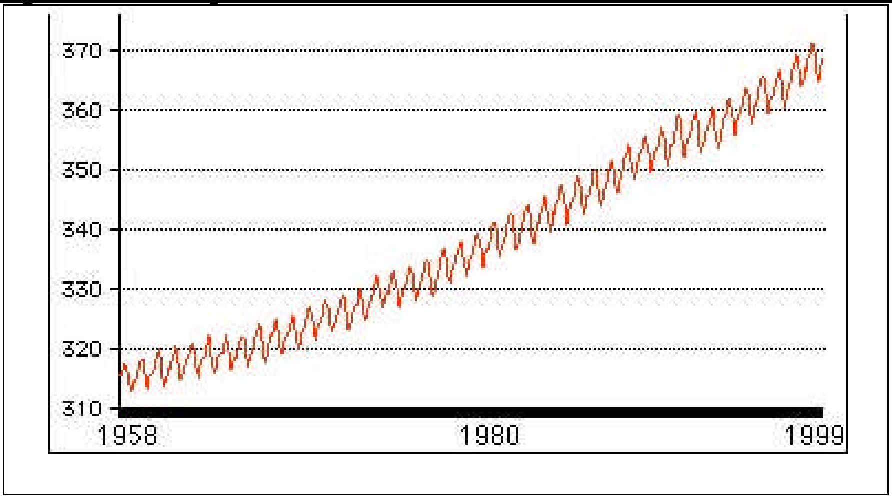
Figure 4: Relative Albedo of Earth's Surface and Troposphere[45]



[45] Wikipedia, http://en.wikipedia.org/wiki/File:Albedo-e_hg.svg

The carbon dioxide level in the atmosphere is steadily increasing. Figure 5 illustrates the rise during the last half of the 20th Century.

Figure 5: Atmospheric Carbon Dioxide Concentrations 1958–1999[46]



Concentrations of CO_2 are in parts per million measured in the air at the summit of Mauna Loa, Hawaii. Measurements of atmospheric CO_2 began late in the nineteenth century. Since that time, the level of CO_2 has risen over 20%. The steady rise is attributed to human activity; i.e., industrial processes. [KIMBALL] Carbon dioxide is the most important anthropogenic greenhouse gas. [IPCC-AR4]

The Intergovernmental Panel on Climate Change reached the following conclusions in 2007: [47]

- Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level.
- Global GHG emissions due to human activities have grown since pre-industrial times, with an increase of 70% between 1970 and 2004
- Global atmospheric concentrations of CO2, methane (CH4) and nitrous oxide (N2O) have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years
- Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic GHG concentrations.

[46] *Kimball's Biology Pages*, Copyright ©2009 John W. Kimball, PhD, from the sixth edition of *Biology* published in 1994, http://biology-pages.info

[47] *Climate Change 2007: Synthesis Report, Summary for Policymakers*, An Assessment of the Intergovernmental Panel on Climate Change. This summary, approved in detail at IPCC Plenary XXVII (Valencia, Spain, 12-17 November 2007), represents the formally agreed statement of the IPCC concerning key findings and uncertainties contained in the Working Group contributions to the Fourth Assessment Report. http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf

- It is likely that there has been significant anthropogenic warming over the past 50 years averaged over each continent (except Antarctica).

The probability that global warming is caused by natural climatic processes alone is less than 5%. According to the Intergovernmental Panel on Climate Change, "Warming of the climate system is unequivocal…Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic GHG concentrations."[48] The trend continues in the 21st Century:

> The atmospheric concentrations of CO_2 and CH_4 in 2005 exceed by far the natural range over the last 650,000 years. Global increases in CO_2 concentrations are due primarily to fossil fuel use, with land-use change providing another significant but smaller contribution. It is very likely that the observed increase in CH_4 concentration is predominantly due to agriculture and fossil fuel use. The increase in N_2O concentration is primarily due to agriculture. [49]

Global warming is a planetary crisis which demands concerted, substantial and meaningful action. The scientific basis connecting human activity with the rise in global temperature is mounting. The rising levels of greenhouse gases—carbon dioxide, methane and nitrous oxide—in the atmosphere have been tied to expanding human civilization during the last 250 years.

2.1 Debunking Carbon Neutrality

What does carbon neutral mean? Is energy from biomass carbon neutral? These questions are critical to determining if making energy from biomass is part of the solution to global warming or part of the problem.

Many alternative energy advocates promote biomass as an answer to the problems of global warming and fossil fuels. Energy industry entrepreneurs promote biomass power as clean, cost-effective economic development. They assert that biomass plants do not add any additional pollutants to the environment and that the carbon dioxide released by combustion would be there anyway. Some even claim that biomass-powered electricity is "emissions free."[50]

Biomass energy systems do release global warming gases. This is not in dispute. What are problematic are the assumptions and the justifications used to define thermal processing technologies as carbon neutral. This chapter will explore the science upon which bio-energy proponents rely to convince others that burning biomass is carbon neutral.

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[48] *Fourth Assessment Report*, Intergovernmental Panel on Climate Change, 2007, http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf

[49] *Ibid*, IPCC AR4, Section 2.2, page 37

[50] From Dominion Resources, Inc. annual update: "Dimensions 2008-2009: Corporate Responsibility Report," page 20, available at www.dom.com

The potential environmental problems of biomass energy systems have been known for decades and are widely published.[51] These problems include negative impacts on air, water, land and human health:

- Fugitive dust emissions, aggravated by extensive removal of crop residues on biomass plantations, can adversely affect air quality
- Direct combustion of biomass can emit nitrogen oxide, carbon monoxide, and particulates.
- Thermochemical biomass conversion processes produce small amounts of hydrogen sulfide and phenols that affect air quality.
- Water requirements of terrestrial biomass plantations may restrict the development of competing uses of water in some regions.
- Sediment loads to waterways and fugitive dust emissions from biomass plantations may affect water quality.
- Anaerobic digestion produces a sludge which, if not disposed of properly, may cause pollution of surface and groundwaters.
- Large land requirements of terrestrial biomass plantations may restrict the development of competing uses of land in some regions. (The total acreage needed to supply 1 percent of the Nation's present energy requirements ranges from 1.5 to 4.5 million acres, or 32 to 96 square miles of land per quad of energy grown as biomass, 1 quad = 10^{15} Btus)
- Removal off agricultural and silvicultural residues and total harvesting or clear-cutting schemes reduce the amount of organic matter that decaying residues contribute to the soil; this may limit future crop or forest growth.
- Thermochemical conversions produce tar and oil products that superficially resemble coal tar, a known carcinogen.

Biomass power plants rely on a series of assumptions which would balance their intrinsic pollution with offsets and credits in order to reduce their carbon footprint. Without such bases, the claims of biomass power fail the carbon neutral test. One of these assumptions is that electric power produced by the combustion of biomass *displaces* electric power produced by coal-fired or nuclear power plants and, therefore, that the biomass plant's electric power emissions count as a credit against the emissions from the biomass fuel production. For example, a waste-to-energy engineering paper states: "WTE is the most effective GHE-reducing option because the recovered energy offsets the generation of electricity from fossil fuels."[52]

However, if the emissions of the biomass system are as large as or larger than those from a fossil-fueled plant, there is no benefit. Further, why would identical compounds be considered benign/positive in one case and malignant/negative in another?

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[51] This list is reproduced from *Handbook of Energy Technology: Trends and Perspectives*, (1982) ISBN: 0-442-22555-5, V. Daniel Hunt, Chapter 9. Environmental Aspects, Biomass Energy Systems, page 538. The footnote with an * is in the original text.

[52] "Use of Life-Cycle Analysis To Support Solid Waste Management Planning for Delaware," Kaplan et al, *Environmental Science & Technology*, Vol. 43, No. 5, 2009, p. 1267, Department of Civil, Construction, and Environmental Engineering, North Carolina State University

A report by Argonne Labs states the biomass pollution problem: "Most studies conducted so far have concluded that producing biofuel will double total NOx emission compared to conventional petroleum-based fuels." And: "The limitation of the proposed options is an increase in total VOC emissions for almost all options"[53] Here we see that air pollution from biomass fuel production is high compared even to emissions from conventional oil wells and refineries. In order to offset such high levels, the analysis resorts to the assumption that biomass electric energy displaces conventional electric power plant pollution. In other words, biomass pollution is good; coal-oil-natural gas pollution is bad.

Biomass proponents often rely on the analogies to the carbon cycle to explain how their energy facilities mimic natural processes. For example, a guide for wood-fueled power plants defines burning as part of the carbon cycle:

> Carbon cycle**:** The process of transporting and transforming carbon throughout the natural life cycle of a plant from the removal of CO_2 from the atmosphere to the accumulation of carbon in the plant as it grows, and the release of CO_2 back into the atmosphere when the plant naturally decays or is burned.[54]

An International Energy Agency study claims carbon emissions from biomass fuels are only 5% to 10% those of fossil fuel:

> Net carbon emissions from generation of a unit of electricity from bioenergy are 10 to 20 times lower than emissions from fossil fuel-based electricity generation (Boman and Turnbull, 1997; Mann and Spath, 2000; Elsayed et al., 2003).[55]

Following the chain of authorities in the study's references to Elsayed *et al* regarding carbon neutrality, we learn how the 90–95% emission reduction was arrived at:

> A major indicator of emissions is the carbon requirement which is the total CO_2 emissions from a biofuel technology, <u>excluding those captured by the cultivation</u>

[53] May Wu, Ye Wu, and Michael Wang, *Mobility Chains Analysis of Technologies for Passenger Cars and Light-Duty Vehicles Fueled with Biofuels: Application of the GREET Model to the Role of Biomass in America's Energy Future (RBAEF) Project*, Argonne National Laboratory-Energy Systems Division, ANL/ESD/07-11 (May 2005) pages 33 and 37.

[54] Wood to Energy Glossary, Centers for Urban and Interface Forestry PO Box 110806 / Bldg. 164, Mowry Rd., Gainesville, FL 32611-0806 The InterfaceSouth Web site (www.interfacesouth.org) was developed by and is maintained through a partnership between the USDA Forest Service Southern Research Station and the University of Florida, School of Forest and Resource Conservation. http://www.interfacesouth.org/woodybiomass/resource_appendix/Glossary.pdf

[55] IEA Bioenergy Task 38 Greenhouse Gas Balances of Biomass and Bioenergy Systems, Matthews and Robertson, Second edition, "Answers to ten frequently asked questions about bioenergy, carbon sinks and their role in global climate change: 1.What is the difference between CO2 emissions from bioenergy and from fossil fuels?" page 2, http://ieabioenergy-task38.org/publications/faq/, accessed 5 March 2010

> of the original source of biomass, divided by its specified energy output, measured in kg CO_2/MJ.[56] (emphasis added)

Later in the same paper, the fundamental assumption is stated clearly:

> It should be noted that comparison of total carbon dioxide outputs is possible because the combustion of liquid biofuels is, in effect, treated as "carbon neutral" in terms of the carbon dioxide emitted and subsequently absorbed by growing biomass.[57] (emphasis added)

In other words, getting the net carbon emissions from generation of a unit of electricity from bioenergy to be 10 to 20 times lower than emissions from fossil fuel-based electricity generation is accomplished by *not counting them*; i.e., *treating* them as carbon neutral.

Another example: A device employed to further the illusion of biomass as a clean, carbon neutral fuel is the GREET Model, a computer model developed by Argonne National Laboratory. GREET—Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation—is a "well-to-wheel" model spreadsheet which is useful in comparing production and use of various vehicle fuels: ethanol. biodiesel, gasoline, natural gas, etc. An analysis of the model states:

> Considering variations in output product(s) and their relative energy share, especially given the large portion of electric power generated as a co-product in some cases, we recognize that an energy and emission comparison would not be complete if fuels are the only products examined. Comparison of all the output products (fuel, electricity, and chemicals) for each option would provide more insight into the benefits of biomass. GREET results were thus further analyzed for each production option on a per-ton-of-biomass-feed basis. Energy consumption and emissions associated with production of conventional fuels, electric power (U.S. mix), and chemical (soy protein) were assumed to be displaced by biofuels, bio-power export, and protein from switchgrass. All six biofuel options provide net petroleum and fossil fuel displacements and reductions in GHGs, CO2, and SOx.[58] (emphasis added)

Here again the intrinsic assumptions which give biomass an apparent advantage over conventional fuels are articulated. Energy consumption and air emissions resulting from conventional sources are *offset* by those from bio-fuels. In other words, subtracting

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[56] Carbon and Energy Balances for a Range of Biofuels Options, Elsayed, MA et al, Project No. B/B6/00784/REP, URN 03/836, Sheffield Hallam University Resources Research Unit, March 2003, page 19 http://www.forestresearch.gov.uk/pdf/fr_ceb_0303.pdf/$FILE/fr_ceb_0303.pdf, accessed 5 March 2010

[57] Ibid

[58] May Wu, Ye Wu, and Michael Wang, *Mobility Chains Analysis of Technologies for Passenger Cars and Light-Duty Vehicles Fueled with Biofuels: Application of the GREET Model to the Role of Biomass in America's Energy Future (RBAEF) Project*, Argonne National Laboratory-Energy Systems Division, ANL/ESD/07-11 (May 2005), page 37, (citations omitted).

rather than adding biomass impacts into the global warming equation is the sole basis for the reduction.

The effect of these assumptions is borne out in the environmental impact statement for a cellulosic ethanol refinery: "The reductions in greenhouse gas emissions are due largely to the emissions credit for the electricity being exported to the grid."[59] The *sine qua non* of biomass carbon neutrality is this credit-debit flip, tantamount to a butcher's finger on the scale.

A global warming researcher said that assuming from the outset that biomass combustion is carbon neutral means that a forest would have the same carbon footprint whether it is standing or cut down. [JOHNSON] Plainly, the trees are more beneficial standing for ecological reasons. Less obvious is the impact of the unjustified assumption in carbon footprint life-cycle assessments. He states:

> Most guidance for carbon footprinting, and most published carbon footprints or LCAs [life-cycle assessments], presume that biomass heating fuels are carbon neutral. However, it is recognised increasingly that this is incorrect: biomass fuels are not always carbon neutral. Indeed, they can in some cases be far more carbon positive than fossil fuels.[60]

A third example: A waste industry report asserts the position that burning garbage is carbon neutral:

> There are two types of carbon dioxide emissions: biogenic and anthropogenic. The combustion of biomass generates biogenic carbon dioxide. Although waste-to-energy facilities do emit carbon dioxide from their stacks, the biomass-derived portion is considered to be part of the Earth's natural carbon cycle. The plants and trees that make up the paper, food, and other biogenic waste remove carbon dioxide from the air while they are growing, which is returned to the air when this material is burned. <u>Because they are part of the Earth's natural carbon cycle, greenhouse gas regulatory policies do not seek to regulate biogenic greenhouse gas emissions</u>.[61] (emphasis added)

Unmentioned in the above report is the fact that because such waste burners are relatively minor sources and therefore are not considered a significant factor in the international plans to halt global warming. But can biogenic combustion be carbon neutral? Margaret Sheehan testified that this cannot be:

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[59] *Draft Environmental Impact Statement for the Proposed Abengoa Biorefinery Project near Hugoton, Stevens County, Kansas*, US Department of Energy, Golden Field Office, Office of Energy Efficiency and Renewable Energy, DOE/EIS-0407D, September 2009, page F-25

[60] Johnson E, "Goodbye to carbon neutral: Getting biomass footprints right," Environ Impact Asses Rev (2008), doi:10.1016/j.eiar.2008.11.002

[61] "Waste Not, Want Not: The Facts behind Waste-to-Energy," Report by Ted Michaels, President Integrated Waste Services Association, September 2008, page 5

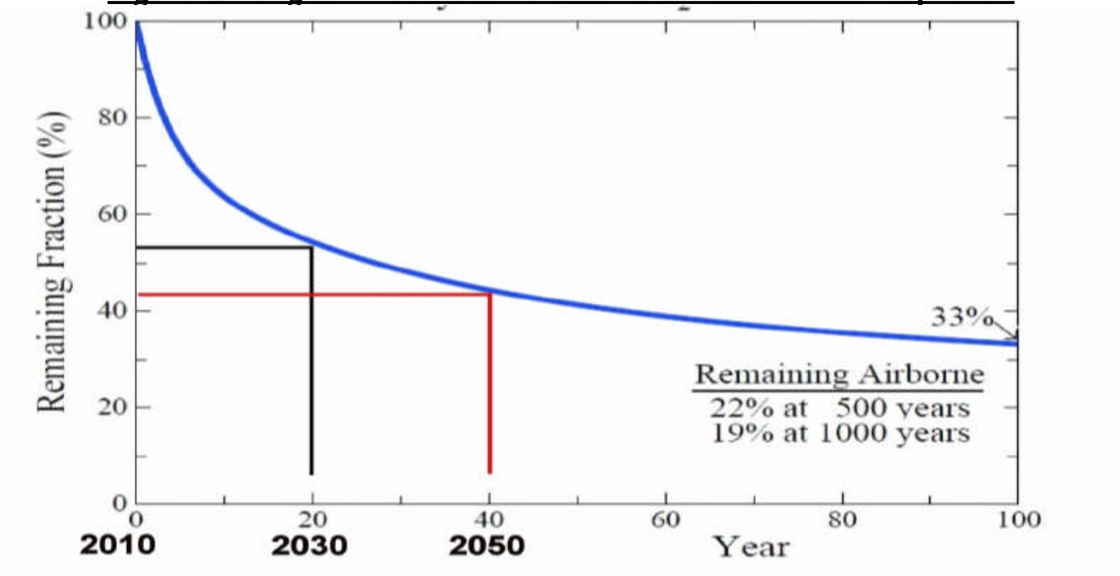
> When the issue of CO_2 emissions from biomass is raised, you will hear some in industry assert that generating energy by burning wood is “carbon neutral.” They argue the CO_2 emissions don’t count because the carbon in the trees is “biogenic – i.e. part of the natural carbon cycle and that emitting CO_2 by burning a tree has the same global warming impact as emitting the same amount of CO_2 as when the tree decomposes over time. This is a red herring defies common sense. Burning emits a sudden burst of carbon in to the atmosphere- this is a man made, anthropogenic, not a natural, event, and is therefore not “biogenic.” It is this CO_2 emitted into the air now that impacts climate change today and that has to be addressed now.[62]

In fact, the natural carbon cycle takes a very long time to return the carbon dioxide gas to non-gaseous carbon. The US EPA published the following finding:

> Indeed, for a given amount of CO_2 released today, about half will be taken up by the oceans and terrestrial vegetation over the next 30 years, a further 30 percent will be removed over a few centuries, and the remaining 20 percent will only slowly decay over time such that it will take many thousands of years to remove from the atmosphere.[63]

Burning biomass from forests immediately adds CO_2 to the atmosphere where it remains for decades. Figure 6 illustrates these long-term effects:

Figure 6. Long-term Carbon Dioxide Residence in the Atmosphere[64]



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[62] Remarks of Attorney Margaret E. Sheehan, U.S. House of Representative Briefing on H.R. 2454, Waxman Markey Clean Energy Bill, June 19, 2009
[63] 74. Fed Reg.18886, page 18899, April 24, 2009, *Proposed Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act*
[64] Source: “Dangerous human-made interference with climate: A GISS modelE study,” Published Nov 22 2006 by The Oil Drum: Europe, Archived Nov 28 2006, accessed http://www.energybulletin.net/node/2296

Based on the above, we conclude that biomass fuel is not carbon neutral. Further, the assumption that biomass is carbon neutral tends to cut short systematic comparisons with fossil fuels by automatically excluding the impact of biomass carbon dioxide emissions on global warming. Such analyses are essential to prevent unintended consequences such as investments of capital and other resources in false solutions, disruption of agricultural economies caused by overproduction, ecological damage caused by deforestation, negative public health impacts caused by air pollution and, of course, more destructive global warming. Catch 22-style ambiguities stem from the irrational good carbon-bad carbon paradigm. The dilemma is resolved by discarding the assumption that biomass fuel is carbon neutral and admitting the premise that all carbon dioxide sources—biogenic and anthropogenic—cause global warming.

2.2 The Natural Carbon Cycle

The central assumption that biomass is "carbon neutral" is false. The natural carbon cycle is a virtual circle between living and non-living things. Plants depend on carbon dioxide in the air as humans and other animal life forms rely on oxygen. This plant-animal carbon cycle can rightly be called "natural." However, the combustion of organic materials in industrial processes is anything but natural and should not be considered so.

The natural carbon cycle is the result of millions of years of evolution. It is a complex process which relies on the sun's energy and photosynthesis. Green plants take up carbon dioxide and dispose of oxygen. Animals breathe in oxygen and exhale carbon dioxide. The natural carbon cycle is based on:

1. Respiration: glycolysis (breakdown) of glucose, hydrolysis of adenosine triphosphate releasing energy, synthesis of water and carbon dioxide (carbon and hydrogen from glucose plus inspired oxygen) and
2. Photosynthesis: photophosphorylation (splitting) of water and reduction of carbon dioxide to join hydrogen with carbon to make glucose and oxygen.

The stoichiometric chemical equation for respiration-photosynthesis looks like this: [KIMBALL]

$$C_6H_{12}O_6 + 6O_2, \Delta G \leftrightarrow 6CO_2 + 6\, H_2O, \Delta G$$

Glucose + oxygen ↔ carbon dioxide + water

(Where $C_6H_{12}O_6$ is glucose, Δ G is energy)

From left to right, the equation represents respiration, the process by which animal life uses glucose and oxygen to release energy. From right to left, the equation represents plant photosynthesis, driven by the energy from the sun. This equation does not represent any kind of combustion. The dual arrows symbolize the fact that the chemical process is reversible; that is, it works both ways. The biology textbook illustration in Figure KB shows the natural carbon cycle as an interchange between air, water, plants and animals.

Autotrophs—plants—make their own food with the energy of the Sun. Heterotrophs—animals—utilize organic carbon in the form of plant sugars for growth.

Inside the circle of Figure 7, the unnatural carbon cycles are also shown: burning and industrial processes. "Oxidation" is a reaction in which oxygen combines chemically with another substance. Chemically, the term also extends to the loss of electrons by an atom without combining with oxygen. These burning oxidation paths amount to virtual short circuits of the natural carbon cycle and lack a corresponding short-term process akin to photosynthesis to return the carbon released to the biological loop. Generally, the stoichiometric chemical equation for burning hydrocarbons is:

$$C_xH_y + \left(x + \frac{y}{4}\right) O_2 \rightarrow \; xCO_2 + \left(\frac{y}{2}\right) H_2O$$ [65]

$$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$$

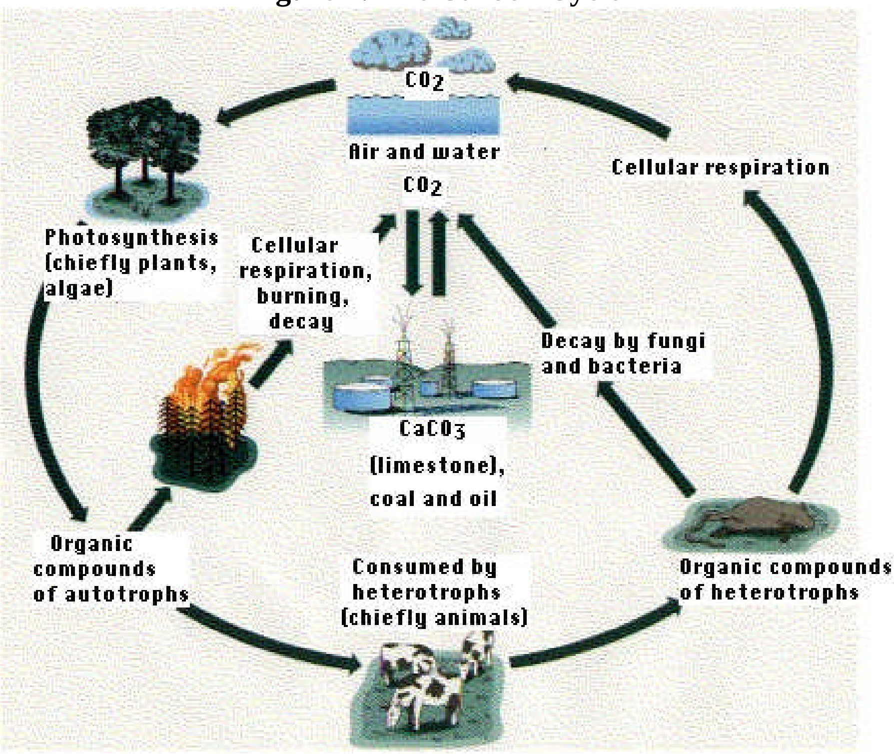
Propane and oxygen yields carbon dioxide and water

So for example, the combustion of wood or paper, largely the carbohydrate cellulose:

$$CH_2O + O_2 \rightarrow CO_2 + H_2O, \Delta G$$

Wood + oxygen → carbon dioxide + water

Figure 7: The Carbon Cycle[66]



[65] http://en.wikipedia.org/wiki/Combustion
[66] *Kimball's Biology Pages*, Copyright ©2009 John W. Kimball, PhD, from the sixth edition of *Biology* published in 1994, http://biology-pages.info

The combustion of fuel made from biomass is a physical chemical process; it has no bio-chemical or biological foundation. The wood combustion-oxidation equation is not reversible. Instead, biomass energy proponents rely heavily on economic incentives and omit meaningful environmental analysis. For example, the 127-page Southern Bioenergy Roadmap[67] centers on economic factors, fuel availability, energy policy, and public opinion but has only one page on carbon dioxide which merely compares the several states' overall and per capita CO_2 emissions.

Biomass power plants have smokestacks

Photo at: http://nobiomass.org/images/usplant_650.jpg

[67] *Southern Bioenergy Roadmap*, A project of the Southeast Agriculture & Forestry Energy Resources Alliance (SAFER) and the University of Florida, Charity Pennock and Scott Doron, Southern Growth Policies Board, 2009, http://www.saferalliance.net

3. Biomass as Fuel

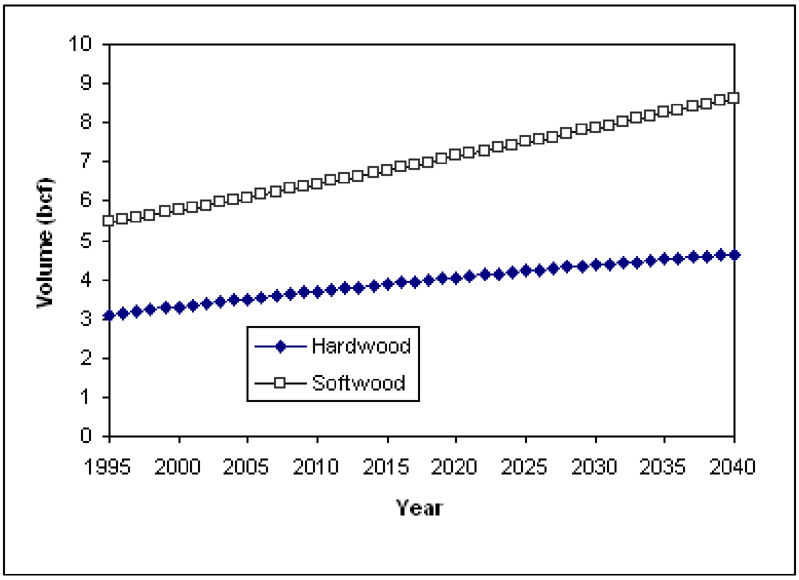
This section will explore the many types of biomass with the potential for use as fuel: agricultural and forest products, municipal and industrial waste, and crops grown for energy purposes.

3.1 Wood and Forest By-products

Trees "are our planet's lungs".[68] That's how Thom Hartmann describes in his book *"The Last Hours of Ancient Sunlight"* the role trees play in the recycling of carbon dioxide from the atmosphere to oxygen for people and animals to breathe. In addition to balancing carbon dioxide and oxygen, trees are critical to rainfall patterns, replenishment of groundwater, the health of soils and increasingly the removal of excess carbon in the atmosphere.

The US Forest Service estimates that timber production in the United States will increase by roughly a third between 1995 and 2040 (see Figure 8) and that nearly all the increases will come from the South.[69]

Figure 8: Timber Supply Projections, 1995–2040, billions of cubic feet



This new pressures on forests come from several directions: new "wood-waste" biomass power plants, co-firing of wood in existing coal-fired power plants, cellusoic ethanol or biofuels and the export of wood-chips and pellets to European biomass plants. A 2009 energy analysis identified 965 MW of new or expanded wood waste plant

[68] Thom Hartmann, *The Last Hours of Ancient Sunlight*, page 44.
[69] USDA Forest Service, Southern Forest Resource Assessment, 01-Jun-2009, http://www.srs.fs.usda.gov/sustain/report/summry/summary-07.htm

capacity in ten southeastern states.[70] Related threats to the region's forests include the conversion of existing forests to monoculture 'tree farms" and the introduction of new genetically modified trees.

Moreover, a US Geological Survey study found that forests in the eastern United States declined between 1973 and 2000. According to this study, "Most net forest loss occurs as result of mechanical disturbance of forests for timber production, which keeps some land free of forest, and as a result of urban expansion, which is generally a permanent change."[71] The potential consequences for the region are catastrophic.

No Help for Global Warming

Land use and forest management practices are critical considerations when policymakers implement measures that increase the use of forests for fuel. The implications of land use change under various policy approaches was modeled and represented graphically in a study by the Pacific Northwest National Laboratory.[72] The study found that:

> As the use of bioenergy increases, land uses shift from food and fiber crops, forests, and unmanaged ecosystems to dedicated biomass crops. This in turn increases terrestrial carbon emissions globally—a perverse result of curbing energy and industrial emissions.

These data show that substituting biomass energy for fossil-fueled electric power plants and other industrial processes and omitting corresponding impacts on land-use results in an anomalous rise in greenhouse gas emissions.

According to the PNNL model, taxing carbon emissions from fossil-fuel smokestacks (cap and trade) but not the impacts of biomass power not only would increase greenhouse gas emissions, it would also result in the utter eradication of natural or unmanaged forests and pastureland.

Figure 9 on the following page illustrates how this negative effect on land use patterns would alter the planetary ecosystem during this century. In this scenario, fossil fueled electric and industrial emissions are controlled to limit atmospheric CO_2 concentrations to 450-ppm.

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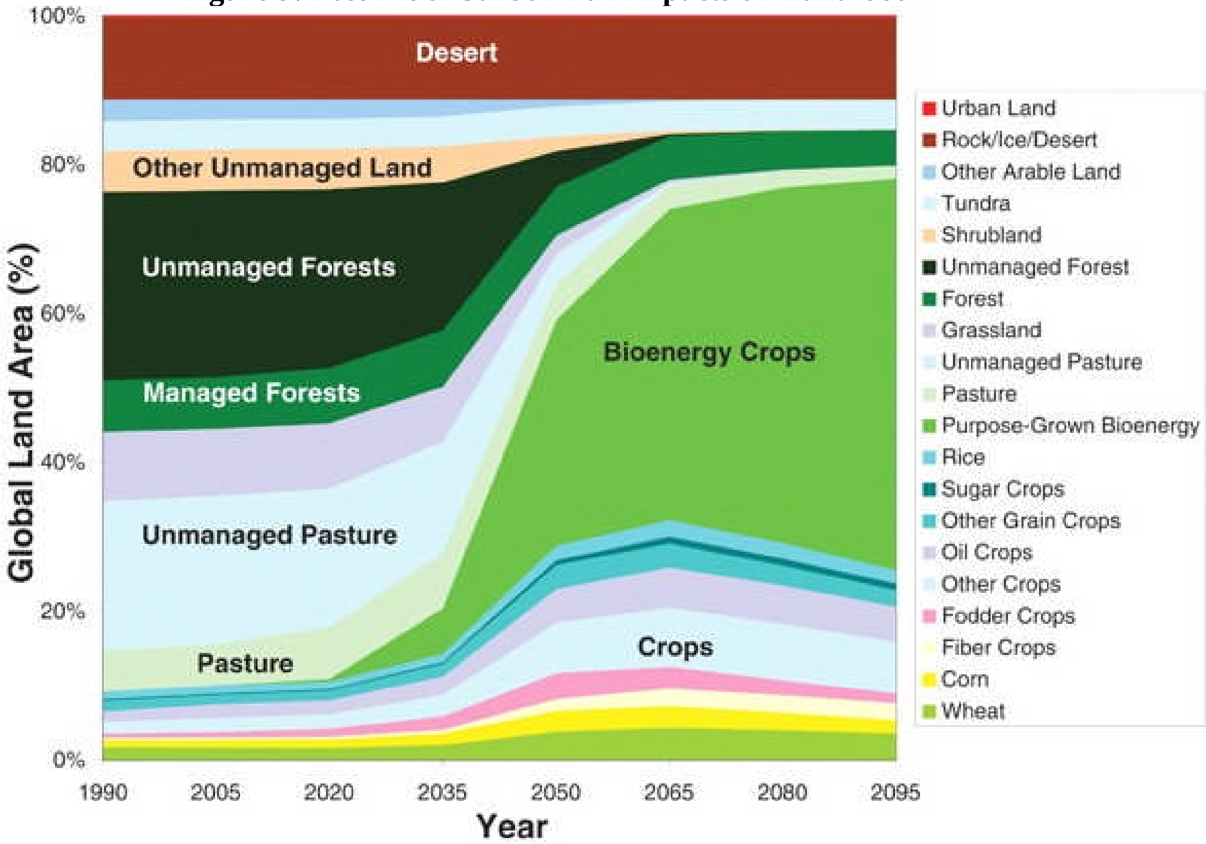
[70] "Planned biomass in the Southeast" Jesse Gilbert and Taylor Allred SNL Financial, August 17, 2009, http://www.snl.com/Interactivex/article.aspx?CDID=A-9855863-9821&Printable=1

[71] American Institute of Biological Sciences (2010, April 7). Eastern US forests resume decline. *ScienceDaily*. Retrieved May 20, 2010, from http://www.sciencedaily.com/releases/2010/04/100407094447.htm

[72] "Implications of Limiting CO2 Concentrations for Land Use and Energy" *Science*, 29 May 2009: Vol. 324 no. 5931 pp. 1183-1186 DOI: 10.1126/science.1168475, http://www.sciencemag.org/content/324/5931/1183.full

Figure 9: Fossil-fuel Carbon Tax Impacts on Land Use



At the federal level, even the Department of Energy acknowledges a lack of understanding about the impact of the rapidly expanding shift to bioenergy and biopower. A June 2, 2010 grant announcement explained the need for new models and management tools to assure sustainability at the watershed level. As the DOE announcement explained,

> The lack of verifiable and reliable environmental data at the watershed scale for high-yielding energy crops and other feedstocks removed from the landscape to ascertain the sustainability of these production systems has been identified as a barrier to the development of a large and significant biofuel and biopower industry. Furthermore, there exists only limited information and few tools for implementing and managing sustainable high-yield energy crops across the landscape.[73]

Close to one billion years of plant evolution have made cellulose very stable and resistant to biochemical attacks. Cellulose can be quickly decomposed and hydrolyzed only by mechanical grinding or steam exploding and severe chemical attack by hot concentrated sulfuric acid or sodium hydroxide. Biochemical enzymatic attacks take a

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[73] U. S. Department of Energy "Development of Methodologies for Determining Preferred Lanscape Designs for Sustainable Bioenergy Feedstock Production Systems at a Watershed Scale DE-FOA-0000314

long time and have low efficiency.[74] For example, about 81%more energy is required to produce a liter of ethanol using wood than the energy harvested as ethanol.[75] The industrial facilities with which human society has wide experience in the chemical transformation of cellulose include paper mills. This alone should provide adequate warning of the difficulty and danger of using cellulose for power.

Dirtier Than Coal

Burning wood instead of coal releases approximately 11% more carbon into the air per kilowatt of electric power generated. Although the per-ton carbon content of coal is greater than that of wood, more wood must be burned to produce an equivalent amount of heat. The US EPA states, "Nearly all of the fuel carbon (99 percent) in wood residue is converted to CO2 during the combustion process."[76] Nitrogen dioxide and methane are also emitted from wood burners. Pollution controls, operating efficiency and maintenance affect actual emissions in all types of electric generating units. But all things being equal, the carbon load of a wood burning facility is greater, leading to greater potential emissions of carbon compounds including carbon dioxide. Table B compares the annual carbon fuel content of 50 megawatt electric generating plants burning wood and coal.

Table B. Relative Annual Carbon Content of Electric Power Plant Fuels

	BTU/ton	% Carbon	kWh/BTU	kWh/year	Tons of fuel	Tons of carbon
Wood	17 million	49	0.000293	4.38E+08	88,235	43,729
Coal	26 million	68	0.000293	4.38E+08	57,692	39,231

Based on US EPA data,[77] actual carbon dioxide emissions from wood fueled boilers would be 6% higher than the equivalent coal-fired power plant. As we see in statements promoting biomass, "CO_2 emitted from this source is generally not counted as greenhouse gas emissions because it is considered part of the short-term CO_2 cycle of the biosphere."[78] Although the claim comports with the conventional wisdom on biomass, it is nevertheless incorrect.

Nature wastes nothing

The slippery slope to accelerated deforestation begins with forest residue, or woody biomass. This is largely slash and wood from growing or downed trees left behind from timber operations. Proponents of woody biomass for fuel characterize this material as waste wood. However, the term "waste" in a forest context is an alien

[74] Pimentel, *Ibid*, Section 15.3.1, Page 380
[75] Pimentel, D. and T. Patzek. 2008. Ethanol Production Using Corn, Switchgrass and Wood; Biodiesel Production Using Soyybean. Pages 373-394 *in* D. Pimentel (Ed.) *Biofuels, Solar and Wind as Renewable Energy Systems: Benefits and Risks.* Springer: Dordrecht, The Netherlands. Section 15.5 Wood Cellulose Conversion into Ethanol, page 383
[76] United States Environmental Protection Agency AP-42 Emission factors, Wood Residue Combustion in Boilers, page 1.6-2
[77] US Environmental Protection Agency AP-42 Emission Factors, page 1.1-42, Table 1.1-20
[78] Environmental Protection Agency AP-42 Emission Factors, page 1.6-2

concept. Fuel from forest resources for the production of electricity would include virtually everything that grows there:

> Forest residues, as defined here, include low-value materials resulting from harvesting, thinning, and land-clearing operations for replanting from commercial logging and silvicultural operations. Wood waste harvested during commercial logging and silvicultural operations may include tops, limbs, bark, and whole trees. The whole trees may result from thinning, unmerchantable timber, or land clearing for replanting. Sometimes referred to as "virgin wood," this resource typically consists of wood, needles, leaves, and bark. The moisture content ranges from 40 to 60 percent, with higher moisture contents in actively growing plants and lower levels in dormant plants.[79]

As shown in Section 2.1, "Debunking Carbon Neutrality," biomass wood burning advocates claim that just because it is biomass, it is carbon neutral.

> Unlike fossil fuels, wood represents a carbon-neutral source of energy. This means that using energy from biomass will not increase the overall amount of carbon dioxide in the atmosphere, if the production of the trees is managed on a sustainable basis (Matthews and Robertson 2005). This fact may sound surprising since combusting wood releases carbon dioxide into the atmosphere; however, the process of growing trees removes carbon dioxide from the atmosphere. Therefore, the carbon emitted from burning wood is reabsorbed as new trees grow. As long as we grow as many or more trees than we burn, woody biomass use contributes less to global climate change than using fossil fuels for energy generation.[80, 81]

In fact, "biowaste" is an engineering classification of plant and animal parts unused in an industrial process. This dated human concept is completely alien to natural ecosystems, which must recycle their matter completely in order to survive. Excessive "biowaste" removal robs ecosystems of vital nutrients and species, and degrades them irreversibly.[82]

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[79] ORNL/TM-2002/199, Processing Cost Analysis for Biomass Feedstocks, Phillip C. Badger, Oak Ridge National Laboratory, at http://bioenergy.ornl.gov/pdfs/ornltm-2002199.pdf

[80] Wood to Energy Fact Sheet, Climate Change and Carbon, Oxarart and Monroe, published by Cooperative Extension Service, University of Florida, Institute of Food and Agricultural Sciences in cooperation with the United States Department of Agriculture, available at http://www.interfacesouth.org/woodybiomass/fact_sheets/FS_Climate_Carbon.pdf

[81] Reference in Wood to Energy Fact Sheet: Matthews, R. and K. Robertson. 2005. Answers to ten frequently asked questions about bioenergy, carbon sinks and their role in global climate change. IEA Bioenergy, Task 38. http://www.ieabioenergy-task38.org/publications/faq/

[82] Pimentel, D. and T. Patzek. 2008. Ethanol Production Using Corn, Switchgrass and Wood; Biodiesel Production Using Soyybean. Pages 373-394 *in* D. Pimentel (Ed.) *Biofuels, Solar and Wind as Renewable Energy Systems: Benefits and Risks.* Springer: Dordrecht, The Netherlands. Section 15.3.2.2 Biomass Availability, page 381

Forests are Carbon Sinks

Woody biomass is a special case of the general hypothesis that bioenergy is carbon neutral. As seen in Chapter 2, the underpinning of this theory rests upon nothing more than an assumption that burning biomass carbon has no effect on global warming.

Numerous studies support the growth and maintenance of forests as a means of removing carbon from the air for the long periods of time necessary for reducing global warming. Forests are large carbon sinks; that is, they store, or sequester, large amounts of carbon as wood. Burning releases the carbon into the atmosphere as the greenhouse gas CO_2. Is burning wood carbon neutral? Not necessarily. Using wood fuel gathered from mature stands of trees upsets the carbon balance in a negative way; on balance, it is better to leave the carbon sequestered in woodlands. Likewise, the cultivation of marginal land for energy crops is a net negative in terms of its carbon footprint. It is better to dedicate such lands to long-term forest growth with no harvesting. In other words, the data show that sequestration of carbon in forests is a beneficial a means of curbing global warming, and better than burning the wood for heat or power. [MARLAND]

> For forests with large standing biomass and low productivity the most effective strategy is to protect the existing forest. For land with little standing biomass and low productivity, the most effective strategy is to reforest or otherwise manage the land for forest growth and C storage.[83]

With repeated challenges to the "carbon neutral" claims of the biomass industry and the increasing uncertainty about the role of forests in mitigating climate change relative to their potential source for fuel, regulators and elected officials must resist the temptation to swap new carbon in today's trees for old carbon in fossil fuels.

3.2 Agricultural Crops and By-products

Nationwide, corn and soybeans are the major crops grown for production of fuel. These products are thought to replace petroleum, but studies of biodiesel and corn ethanol production show that energy inputs are greater than the energy of the fuel produced. (PIMENTEL)

> The environmental impacts of producing either ethanol or biodiesel from biomass are enormous. These include: severe soil erosion; heavy use of nitrogen fertilizer; and use of large quantities of pesticides (insecticides and herbicides). In addition to a significant contribution to global warming, there is the use of 1,000–2,000 liters of water required for the production of each liter of either

[83] Marland G, Marland S. Should we store carbon in trees? In: Wisniewski J, Lugo AE, editors. Water, air, and soil pollution, vol. 64 1–2. Special Issue "Natural sinks of CO2"; 1992. p. 181–95. No. 1992.

ethanol or biodiesel. Furthermore, for every liter of ethanol produced there are 6–12 liters of sewage effluent produced.[84]

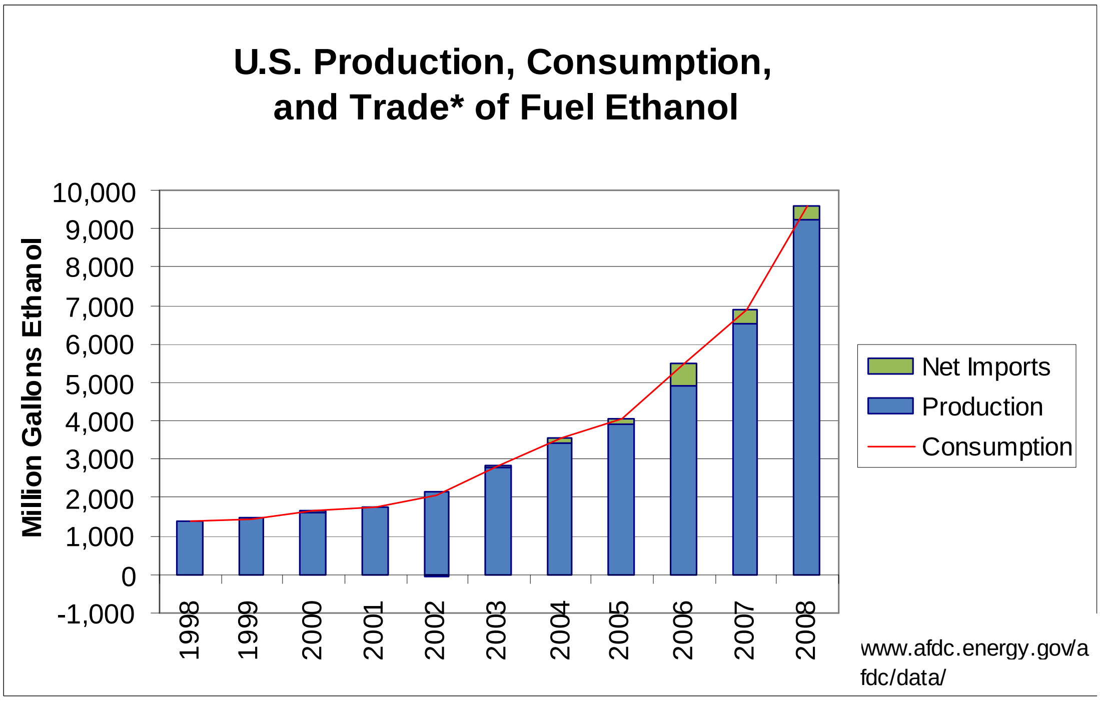
Corn ethanol

Manufacturing fuel from corn is an energy wasting enterprise. Not only does it fail to deliver a net gain in energy, corn ethanol damages the soil and uses enormous amounts of water. According to the US Department of Energy, the rising production of ethanol used 25% of the corn produced in the United States in 2007 (see Figure 10).

> The largest energy inputs in corn-ethanol production are for producing the corn feedstock, plus the steam energy, and electricity used in the fermentation/distillation process. The total energy input to produce a liter of ethanol is 7,474 kcal. However, a liter of ethanol has an energy value of only 5,130 kcal. Based on a net energy loss of 2,344 kcal of ethanol produced, 46% more fossil energy is expended than is produced as ethanol.[85]

Widespread use of corn-based fuel cannot have a significant impact on the nation's thirst for oil. If all the corn produced in the United States was used to make ethanol, it would reduce petroleum demand by 7%. Federal and state subsidies for ethanol amount to about $6 billion per year. (PIMENTEL)

Figure 10: Rising Production of Ethanol



[84] Pimentel, D. and T. Patzek. 2008. Ethanol Production Using Corn, Switchgrass and Wood; Biodiesel Production Using Soybeans, Section 15.9, Page 390

[85] Pimentel, Section 15.2.2, page 376

Ethanol manufacturing uses large quantities of water, which is especially problematic in the arid regions where much of the nation's corn is grown.

> [T]he production of 1 liter of ethanol requires 1,700 liters of freshwater both for corn production and for the fermentation/distillation processing of ethanol (Pimentel and Patzek, 2005). In some Western irrigated corn acreage, like some regions of Arizona, ground water is being pumped 10-times faster than the natural recharge of the aquifers.[86]

Although better production techniques may improve these numbers over time, rising production levels and the associated negative environmental impacts point to a crisis down the road.

Manure: poultry and hog

Actual air emissions from a poultry waste-fueled plant as reported by the operator. Table C lists some of the major pollutants and annual emissions from the 38.5 megawatt plant in Thetford, UK which uses poultry litter for fuel.

Table C. Annual Air Pollution Totals from Poultry Litter Power plant[87]

Pollutant	**Air Emissions 2004**
Carbon Dioxide	455,006 tons
Carbon Monoxide	258 tons
Sulphur Oxides (SO2)	351 tons
PM10	23 tons
Nitrogen Oxides (NO2)	619 tons

In Thetford's annual emissions report we see that a relatively small power plant emitted substantial levels of pollution and greenhouse gas. Carbon dioxide emissions, which contribute to global warming, were nearly half a million tons.

The burning of poultry litter eliminates a valuable organic fertilizer which would have to be replaced by mineral fertilizers. So, in addition to the pollutants from the smokestack, one must include the energy used to produce the fertilizer replacement for poultry litter. Table D on the following page details the energy which is required to produce the nitrogen, phosphorus and potassium (NPK) in mineral fertilizers.

Proponents of poultry waste energy plants neglect to account for fertilizers needed to replace poultry litter. The energy of production (second column) for mineral fertilizers is part of the energy debt created by burning poultry litter. In other words, burning poultry litter results in the use of fossil fuel energy to produce a replacement, creating additional air pollution and greenhouse gas emissions. Nearly 36 thousand BTUs are

[86] Pimentel, Section 15.4, page 382
[87] British Environmental Agency, http://maps.environment-agency.gov.uk /wiyby/queryController? topic= pollution&ep=2ndtierquery&lang=_e&layerGroups=1&x=585200.0&y=286800.0&extraClause=AUTHORISATION_ID~'AP0844'&extraClause=YEAR~'2004'

needed to produce a pound of the nitrogen, phosphorus and potassium (NPK) in mineral fertilizers.

Table D. Energy Needed to Manufacture Fertilizer[88]

Average energy requirements for nitrogen, phosphate, and potash (BTUs/lb)						
Nutrient	**Production**	**Packaging**	**Transportation**	**Application**	**Total**	**Equivalent** [1]
N	29,899	1,119	1,936	688	33,642	0.240
P_2O_5	3,313	1,119	2,452	645	7,529	0.054
K_2O	2,753	774	1,979	430	5,936	0.042

[1] Gallons of #2 fuel oil (diesel) to produce one pound of nutrient.

The percentage of nitrogen, phosphorus and potassium (N, P2O5 and K2O) in 3 million tons of poultry litter shows that about 530 million pounds of vital minerals are directly available for agricultural use. If instead 3 million tons of poultry litter were burned to produce electric power, we estimate that it would take 1.2 million barrels of diesel fuel per year to replace this organic fertilizer with chemical fertilizers.[89]

What would be the energy impact of replacing organic poultry fertilizer with mineral fertilizers? For example, approximately 3 million tons per year of poultry litter is produced annually in North Carolina.[90] Table E details the potential impacts of replacing poultry litter with chemical fertilizers in North Carolina.

Table E. Annual Energy and Fuel Oil Needed to Replace NC Poultry Litter

	Content %	*Pounds/year (3 million tons litter)*	*BTU/pound (Table 1)*	*BTU/year*	*Fuel oil per pound* [1]	*Fuel oil gallons per year*
N	3.522	211 million	29899	6.32E+12	0.24	50,716,800
P_2O_5	2.971	178 million	3313	5.91E+11	0.054	9,626,040
K_2O	2.343	141 million	2753	3.87E+11	0.042	5,904,360

[1] Gallons of #2 fuel oil (diesel) to produce one pound of nutrient

The percentage of nitrogen, phosphorus and potassium (N, P_2O_5 and K_2O) in 3 million tons of poultry litter shows that about 530 million pounds of vital minerals are directly available for agricultural use. If 3 million tons of poultry litter were burned to produce electric power, we estimate that it would take 1.2 million barrels of diesel fuel per year to replace this organic fertilizer with chemical fertilizers.

[88] Fluck, R.C. (ed.) Energy in Farm Production. vol.6 in Energy in World Agriculture. Elsevier, New York. pp.177-201.1992
[89] "Electric Power from Poultry Waste is Not Green," monograph, Zeller L, July 20, 2007, available at: www.bredl.org/pdf2/ElectricPowerfromPoultryWasteNotGreen070720.pdf
[90] "Could chicken litter light your house?" *News & Observer*, Raleigh, NC, June 18, 2007

Using animal waste as a renewable energy resource presents a range of problems relative to dioxin. There is no “safe” level of emissions for this carcinogen. Poultry litter in particular can be contaminated with metals that contribute to dioxin formation.

Switchgrass

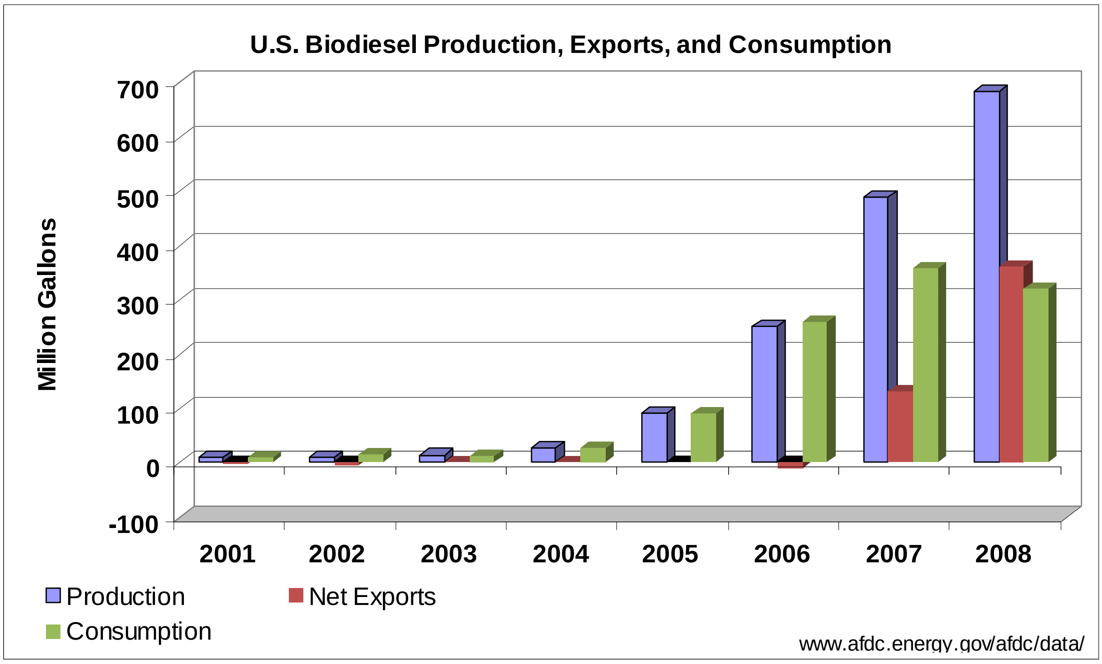
Making ethanol from switchgrass results in a net energy loss of 68% and costs about $3.52 per gallon to produce. (PIMENTEL)

Bio-diesel

Soybeans are the principal source of oil used for the production of bio-diesel fuel. See Figure 11. Although somewhat more productive than some agricultural fuels, soybean bio-diesel shares the fatal flaws of energy debt and cost.

> The total input for the 1,000 kg of soy oil is 13.8 million kcal. In addition, 125 kg of methanol must be added to produce biodiesel fuel. The methanol has an energy value of 587,500 kcal. With soy oil having an energy value of 9 million kcal, then there is a net loss of 53% in energy. A credit should be taken for the soy meal that is produced; this has an energy value of 7.4 million kcal, but it must be emphasized that this soy meal is not liquid fuel but livestock feed. The price per kilogram of soy biodiesel is about $1.12. Note, soy oil has a specific gravity of about 0.92; thus soy biodiesel value per liter is 97c per liter. This makes soy oil about 1.8 times more expensive than diesel fuel.[91]

Figure 11: Biodiesel Production



[91] Pimentel, Section 15.7, Page 386

3.3 Industrial and Municipal Waste Products

Used Tires

Tire combustion is associated with excessive emissions of air pollution, whether burned alone or mixed with other fuel such as coal. Burned alone, tires emit high levels of lead and carbon compounds, consequences of tire manufacturing and use. Carbon black may comprise 25% of a tire. Lead used to balance automobile wheels causes high levels of the toxic metal to be emitted even after their removal from the tire. Burned together with coal, tires increase the emissions from the boiler over those from burning coal alone. Adding 30% tire-derived fuel to a coal-fired industrial plant caused the increase of toxic air pollutants listed in Table F:

Table F: Tire Derive Fuel Increased Emissions

Air Pollutant	Increase
Tetrachlorodibenzofuran (TCDF)	2,230%
Tetrachlorodibenzodioxin (TCDD)	1,432%
Total polychlorinated biphenyls (PCB)	2,608%
Chromium (hexavalent)	727%
Lead	388%

Tires are made of four compounds: styrene, butadiene, extender oils and carbon black. Although they will burn, they do not always burn completely. Incomplete combustion releases more compounds.

> A basic principle is that the incomplete combustion of tires may yield dozens of organic compounds, with some not naturally occurring in coal, but the technical issue is that tires contain several hazardous constituents and inadequate combustion may result in the release to the air and the creation of new compounds forming downstream of the combustion devices. As a result of benzene contained within the styrene and aromatic extender oils in tires, thus benzene and related compounds may be readily become released into the atmosphere in varying concentrations during combustion depending upon incineration parameters.[92]

The large volume of benzene present in the tire and its high temperature requirement for complete combustion provides a pathway for creation of more highly toxic species such as dioxins, furans, PCBs and polyaromatic hydrocarbons.

> In summary, synthetic rubber tires contain significant concentrations of toxic and hazardous chemicals. Incineration of tires has the clear potential to produce

[92] Letter from Dr. Neil Carman, Clean Air Program Director, Lone Star Sierra Club, to Steve Jones, Chairman Policy, Research, and Technical Assistance Committee, California Integrated Waste Management Board, October 22, 1997

> toxic emissions of numerous carcinogenic, mutagenic and teratogenic chemicals.[93]

Burning tires or tire-derived fuel even in a well-controlled combustion facility can produce toxic air pollution and negative impacts in nearby communities.

Municipal Solid Waste garbage, primary: WTE; secondary: landfill gas

Solid waste, household commercial and industrial, is defined as biomass in some states. Thermal destruction of this waste, whether done by gasification, plasma arc, or other technology, is essentially combustion—that is, burning. These technologies have much in common: they take in various wastes and expose them to high temperatures. Air emissions from the different types differ by the amount of pollution emitted, not by the type. Mass burn incinerators are *excess air* combustion units; waste is burned in the presence of more air than is necessary to oxidize the materials in the firebox. Gasification and plasma arc units utilize *starved air* combustion to create a gas which is then burned in second chamber. Both starved air and excess air combustors emit the same pollutants into the atmosphere, but in different amounts. The US EPA compiles emission levels for many categories of waste burning units, including excess air and starved air types.[94] With pollution control devices in place, gasification units emit 28% more nitrogen oxides and 83% dioxins than incinerators. Excess air combustors emit 6.8% more lead, 7.1% more sulfur dioxide and 55% more carbon monoxide. Emissions of some pollutants are largely unchanged; in both types of combustion heavy metals such as mercury are atomized and released into the atmosphere in elemental form. In terms of global warming gases, a medium-sized 400 ton per day incinerator would emit 143,810 tons of CO_2 annually. A gasification plant would emit an equal amount. So, it is untrue that:

> WTE is the most effective GHE-reducing option because the recovered energy offsets the generation of electricity from fossil fuels.[95]

Simply adding heat recovery or steam generating capacity to such units allows them to qualify as "waste-to-energy" plants; however, claiming an offset does not reduce the level of CO_2 emitted, it merely shifts it from a debit to a credit. Here again, just because it's "green," carbon dioxide emitted from biomass fuel is wrongly considered to be offsetting the identical gas from fossil-fuel.

Energy recovery from waste burners of all types pales in comparison to the energy needed to manufacture new products. Producing energy from waste requires incineration or oxidation; that is, variations on burning. The burning of waste by any means causes negative environmental effects. Nitrogen oxides, sulfur dioxide, particulate

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[93] *Ibid*

[94] US Environmental Protection Agency, Compilation of Air Pollutant Emission Factors, Volume 1, Fifth Edition, AP-42

[95] *Use of Life-Cycle Analysis To Support Solid Waste Management Planning for Delaware*, Kaplan et al, North Carolina State University, Environmental Science & Technology, Vol. 43, No. 5, 2009, pp. 1264-1270, © American Chemical Society

matter, carbon monoxide, acid gases, lead, cadmium and mercury, and dioxins and furans are emitted into the atmosphere. Gasification facilities produce an intermediate mixture of carbon monoxide, hydrogen and other gas which is subsequently burned. Gasification plants' air emissions include the same pollutants as mass-burn incinerators: nitrogen oxides, sulfur dioxide, particulate matter, carbon monoxide, hydrogen chloride, hydrogen fluoride, ammonia, heavy metals mercury and cadmium, dioxins and furans.

According to the US EPA, paper comprises roughly 34% of municipal solid waste. Recycling one ton of mixed paper saves the energy equivalent of 185 gallons of gasoline.[96] In terms of heat value alone, burning one ton of paper to make power instead of recycled paper creates an energy debt of nearly 8 million BTUs; in other words, burning paper squanders 152% of the energy which could otherwise be recovered by recycling (Table G). To this add the negative impacts on air quality, water quality, forest habitat and public health. Recycled paper uses 58% less water and reduces 74% of the air pollution compared to virgin paper. (HANDBOOK)

Table G: Energy Debt of Burning Paper

Fuel	Heat value BTU
185 gallons gasoline[97]	23,125,000
2000 pounds of paper[98]	15,180,000
Energy debt per ton	**7,945,000**

Municipal solid waste contains 12% plastic. Using MSW for fuel releases into the atmosphere the carbon in plastic products and containers made from petroleum. Burning petroleum-based materials is similar to burning oil in terms of adding to greenhouse gases.

The balance of the combustible organic waste includes 13% yard waste and 12% food, both of which are better suited for composting. The non-combustibles include metals, 8%, and glass, 5%, neither of which should be put into a energy recovery firebox.

Energy is wasted by burying or burning solid waste. Energy recovery from waste burners of all types pales in comparison to the energy needed to manufacture new products. Paper made from trees requires double the energy of recycled paper. Each ton of recycled paper saves about two dozen trees and 410 gallons of fuel needed to produce new paper. And beverage cans made from aluminum ore require 20 times as much energy to produce compared with cans made of recycled aluminum. Table H on the following page lists the relative benefits of using recycled materials instead of virgin raw materials:

[96] "Municipal Solid Waste Generation, Recycling and Disposal in the United States: Facts and Figures for 2008," http://www.epa.gov/epawaste/nonhaz/municipal/msw99.htm
[97] College of Natural Resources at the University of Wisconsin Stevens Point, Energy Conversion and Resource Tables, http://www.uwsp.edu/CNR
[98] *Air Pollution Engineering Manual*, Second Edition, Danielson, United States Environmental Protection Agency, Office of Air Quality Planning and Standards, May 1973

Table H. Energy Savings and Environmental Benefits of Recycling[99]

Reduction of:	Aluminum	Steel	Paper	Glass
Energy Use	95%	60%	50%	20%
Air Pollution	95%	85%	74%	20%
Water Pollution	97%	76%	35%	-
Water Use	-	40%	58%	50%

Combustion Units

Combustion facilities come in a variety types: pyrolysis, gasification, plasma arc and waste-to-energy. However, all rely on some form of burning to reduce the fuel to a useable form. And all have atmospheric emissions of waste gas containing a mixture of toxic air pollutants and carbon dioxide. The different types of combustion technologies are detailed below. However, their similarities outweigh their differences.

- Rotary Kilns have a refractory-lined rotating cylinder in which waste is burned. A burner in the wall of the kiln ignites the waste and ash is emptied from opposite end. Rotating seals needed to prevent air leakage create temperature control problems; constant motion during combustion causes high particulate emissions.
- Pulsed Hearth Incinerators operate with excess air in refractory chambers. The "pulse" is pneumatic and moves waste and ash through the incinerator, similar to fluidized beds. Although there are no moving parts in the high temperature chambers, these units have high maintenance costs.
- Waste Fired Boilers have a refractory lined water-cooled combustion chamber. This system does not have a secondary combustion chamber, making gas residence time at high temperature difficult. These units require high maintenance.
- Starved Air Combustion units have two combustion chambers: a primary operated below the stochiometric air requirement and a second with excess air. Solid waste is fed into the primary chamber, releasing moisture and volatile gas. The synthetic gas is then burned in the secondary chamber. Air inlet problems and very high temperatures in these units cause reliability and maintenance problems.
- Stepped Hearth Incinerators have two chambers: the primary in which waste is burned at temperatures of up to 1550oF. A mechanical ram pushes waste and gas into a secondary chamber which has temperatures as high as 1800oF. Moving parts and turbulence in the combustion area lead to high maintenance requirements and high particulate levels.
- Pyrolysis and Gasification expose waste to temperatures above 1400oF in the absence of oxygen. Waste is converted to hydrogen and carbon monoxide gas,

[99] Source: The Solid Waste Handbook: A Practical Guide, William D. Robinson, Editor, ISBN: 978-0-471-87711-0, March 1986

carbon char, inert materials and heavy metals. The synthetic gas is burned in a second chamber at temperatures above 2200oF.

- Plasma Arc or plasma torch units differ from other pyrolysis units by utilizing an electric arc to heat waste, creating the synthetic gas. Contrary to some vendor's claims, every plasma arc proposal for waste processing includes combustion.

Health: Human and Environmental

Reducing greenhouse gas impacts from solid waste management requires an assessment of four basic methods: recycling, land filling, and two types of combustion. The data presented in Table I shows that the greatest reduction in greenhouse gas emissions is also the best method for reducing all types of air pollution.

Table I: Summary of Per Ton Emissions by Management Method[100]

Management Method *	**Pounds of Emissions (Reduction)/Increase Per Ton**						
	Climate Change	**Human Health – Particulates**	**Human Health - Toxics**	**Human Health-Carcinogens**	**Eutrophi-cation**	**Acidifi-cation**	**Ecosystem Toxicity**
	(eCO_2)	**(ePM2.5)**	**(eToluene)**	**(eBenzene)**	**(eN)**	**(eSO2)**	**(e2,4-D)**
Recycle/ Compost	(3620)	(4.78)	(1587)	(0.7603)	(1.51)	(15.86)	(3.48)
Landfill	(504)	2.82	275	0.0001	0.10	2.38	0.21
WTE Incineration	(143)	(0.30)	68	0.0019	(0.01)	0.04	0.29
Gasification/ Pyrolysis	(204)	(0.36)	(1)	(0.0000)	(0.05)	(0.93)	0.09

Numbers in parentheses are negative, meaning reduction of harmful impacts.

Pound for pound, recycling and composting reduce greenhouse gas emission 7 times better than landfilling, which is better than the two combustion methods. Subtitle D landfills with efficient gas capture systems reduce eCO_2 two and a half times as much as gasification and pyrolysis facilities, and three and a half times as much as waste-to-energy incinerators. (TELLUS)

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100 *Assessment of Materials Management Options for the Massachusetts Solid Waste Master Plan Review, Final Report*, Tellus Institute, Boston MA, Massachusetts Department of Environmental Protection Contract EQEH193, December 2008

4. Biomass Energy Economics

The biomass public relations juggernaut has spread its message well. Upon closing of a biomass deal, an elected official stated, “This new plant will bring much-needed jobs and tax revenue to our county.”[101] Hearing about a new biomass plant locating in his county, another elected official gushed, “It’s historical. It’s monumental.”[102]

Despite the assurances, the promises of biomass made by company representatives and alternative energy advocates are exaggerated. For example, recycling of paper, aluminum, glass, steel and other materials is now a big business providing jobs in many communities across the nation. Financial analysts are developing investment strategies based on the economic benefits of recovering used materials.

PROGRESSIVE INVESTOR[103]

Many people aren't aware of the central role the recycling industry plays these days. It has become a backbone of our economy, pulling in $236 billion in revenues last year and employing over a million people. The industry accounted for about 2% the U.S. gross domestic product in 2007.

At the current rate of resource depletion, especially from emerging economies like China, the world literally can no longer satisfy demand for paper and steel from virgin materials alone. Recycling has become an absolute necessity for industrial growth and stability. We couldn't print a newspaper, build a car, or ship a product in a cardboard box without recycled materials.

"Although we usually think of the benefits of recycling as reducing waste and protecting forests and habitats from mining and clearcutting," says Rona Fried, editor of Progressive Investor, "it is also a key solution for climate change. Making new materials from old ones is a classic example of energy efficiency - it vastly reduces the amount of energy (and resulting emissions) required to support our economy."

For example, making aluminum from scrap uses 96% less energy than from virgin minerals, while making iron and steel from scrap requires 74% less energy. Two thirds of the steel produced in U.S. is now made from recycled materials.

Food scraps, yard waste and other organic materials in landfills create methane gas in the anaerobic environment. Some advocate calling this biomass. According to the

[101] “Fibrowatt Announces Sampson County Site for First Power Plant Fueled by Poultry Litter,” County Chairman Jeff Wilson quoted in *Space Daily*, April 18, 2008

[102] “Fibrowatt picks site in Surry,” quoting County Commission Chairman Craig Hunter, *Winston-Salem Journal*, June 6, 2008

[103] Progressive Investor, Issue 53, April 1, 2008, www.sustainablebusiness.com, Progressive Investor is a monthly newsletter that guides investors and analysts toward green investments. Published by SustainableBusiness.com

experts, the smarter investment advice is: “It's much better to keep it out of the landfill and compost it - you get a higher value add that way, and that's true for all recyclables.”[104]

A 2002 University of Maryland study concluded that application to farmland provided the ***highest economic value to local farmers*** while proposals to burn litter to generate electricity represented a negative value.

> Electric power generators would not be able to afford to pay a positive price for poultry litter because electricity produced using poultry litter under these technologies is expensive relative to the alternatives available. The capital and operation and maintenance costs alone amount to between 5.1 and 8.4 cents per kilowatt-hour. Ash sales should bring in only between 0.7 and 1.3 cents per kilowatt-hour, while cleanout and transport costs amount to between 2.0 and 2.3 cents per kilowatt-hour. The before-tax net cost of producing electricity thus ranges between 5.1 and 9.5 cents per kilowatt-hour, far more than the wholesale price of electricity on the Delmarva Peninsula even with a renewable energy tax credit.[105]

Municipal solid waste combustion entrepreneurs have re-booted their incinerators as waste-to-energy facilities and promise economic development and green energy to unsuspecting local officials. Waste-to-energy is a term of art applied to such facilities which burn municipal solid waste, or MSW.

> The thermal treatment of MSW results in the generation of 500-600 kWh of electricity per ton of MSW combusted. European WTE facilities often recover another 600 kWh in the form of steam or hot water that is used for district heating.[106]

However, as seen in Table J on the following page, thermal technologies—combustion, gasification, pyrolysis—cannot deliver the same energy benefit as recycling. Even the best of these units have only one-third the energy potential of recycling.

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[104] Eric Prouty, Senior Analyst, Cannacord Adams (equities research firm), Progressive Investor Special Report: Investing in Recycling! Issue 52: February/ March 2008

[105] *Economic Value of Poultry Litter Supplies In Alternative Uses*, Erik Lichtenberg Doug Parker Lori Lynch, October 2002, Center for Agricultural and Natural Resource Policy, page 25

[106] “Waste-to-Energy: A Renewable Energy Source from Municipal Solid Waste,” Position Statement of the American Society of Mechanical Engineers Solid Waste Processing Division, www.asme.org

Table J: Net Energy Generation Potential Per Ton MSW[107]

Management Method	Energy Potential (kWh per ton MSW)
Recycling	2,250
Landfilling	105
WTE Incineration	585
Gasification	660
Pyrolysis	660
Anaerobic Digestion	250

The Tellus Institute study points out that energy generation potential estimates depend on a number of factors including the composition of the waste stream, the specific technology (e.g., fluid bed versus fixed bed for gasification), and the source of the data. However, all the technologies studied fall far short of the energy potential of recycling.

http://www.bwf-group.com/images/bio-mass-incineration-e8.jpg

[107] *Assessment of Materials Management Options for the Massachusetts Solid Waste Master Plan Review, Final Report*, Tellus Institute, Boston MA, Massachusetts Department of Environmental Protection Contract EQEH193, December 2008

5. Case Studies

Air pollution permits for biomass facilities allow excessive levels of pollution. A close examination of the permits, permit applications and other documents indicate that biomass power plants are not clean sources of power.

5.1 Covanta Energy, Chester County, South Carolina

Covanta's incinerator could emit 2.8 million pounds of pollution annually and 575 thousand tons of global warming carbon dioxide. Table K lists the annual totals of toxic air pollutants and carbon dioxide which could be emitted from Covanta's proposed waste-to-energy incinerator in Chester County.

Table K. Annual Air Pollution Emissions

AIR POLLUTANT	POUNDS
Carbon dioxide	1,150,480,000
Nitrogen oxides	2,079,040
Sulfur dioxide	323,536
Carbon monoxide	270,392
Hydrochloric acid	123,224
Particulates	36,208
Mercury	1,284.8
Lead	152.4
Chromium	17.52
Cadmium	15.83
Arsenic	2.47
Dioxin/furan	0.039

These annual emission totals are based on Covanta's publicly stated proposal to burn 1,600 tons municipal solid waste per day, using a dry scrubber pollution control device injecting lime slurry and a fabric filter.[108] We applied this throughput to the US EPA's AP-42 Emission Factors for municipal waste combustors. These would be the emissions from the plant to the atmosphere ***after*** the hot exhaust gases from waste burning pass through the pollution control devices.

The Occupational Safety and Health Administration sets limits of 0.05 mg/m^3 for mercury vapor for 8-hour shift and 40-hour work weeks. Our analysis indicates that even this higher level would be exceeded over most of the 100-acre site identified by Covanta.[109]

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[108] Waste throughput and pollution control information from Covanta Energy's fact sheet "About the Chester County WTE Project" 2009

[109] "Toxic Air Pollution Impacts from the proposed Covanta Energy Chester County WTE Project, A Technical Report," Louis Zeller, 3 December 2009

5.2 Hertford Renewable Energy, Ahoskie, North Carolina

Hertford Renewable Energy is a 50 MW unadulterated wood-fired boiler in Hertford County, North Carolina. HRE was the first new unadulterated woody biomass plant to apply for a permit since North Carolina enacted Session Law 2007-397 requiring the state's electric suppliers to provide electricity from renewable energy resources. The NC Division of Air Quality's draft permit lists one unadulterated wood-fired boiler with maximum heat input rate of 858 million Btu per hour and a biodiesel-fired startup burner of 215 million Btu per hour. The fuel is forest industry products such as chips and fines.

It is estimated that HRE consumes 600,000 tons of fuel per year to produce 400,000 megawatt-hour of electric power (1 megawatt-hour per 1.5 tons of biomass).[110] Fuel would is delivered to the plant by 85 to 200 trucks per day each hauling 25 tons of fuel. The power source is a vibrating grate stoker boiler; air pollution control technology is an electrostatic precipitator with a multicyclone and selective non-catalytic reduction.

Table L. Hertford Renewable Energy Emission Rates[111]

Pollutant	Emissions (Tons per year)
Carbon dioxide (CO_2)	
Nitrogen oxides (NO_x)	377.37
Particulates (PM-10)	139.92
Sulfur dioxide (SO_2)	93.98
Volatile organic compounds (VOC)	63.95
Ammonia (NH_4)	858.17
Carbon monoxide at 90-100%	941.03
Carbon monoxide at 60-90%	1127.41
Carbon monoxide at 40-60%	1503.22

The Decker Energy study estimated that the plant would require 1.5 tons of chips per megawatt-hour of electric power generation or 600,000 tons per year. Assuming that wood is 49% carbon, these forests *could sequester an additional 294,000 tons of carbon* instead of releasing it as carbon pollution from the power plant, sparing 120,000 acres of woodlands.[112] Using Decker's projections, 11,580,000 tons of chips equaling 5,674,200 tons of carbon would go up in smoke. In addition, emissions of volatile organic compounds (VOC), some of which are carcinogens, can result from wood fuel drying operations. (Table L)

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[110] "Alternatives Evaluation and Site Selection Study for the Proposed Hertford Renewable Energy, LLC Biomass Power Plant," Decker Energy International, Winter Park, Florida, May 2008

[111] NC Division of Air Quality Permit No. 09947R00, Carbon monoxide emissions vary according to the heat input. Higher emission rates per mmBTU are permitted at lower input.

[112] Production of wood biomass in the Southeast averaged 5 tons per acre in 2005, Source: "The Economics of Biomass Production in the United States" Graham et al, Oak Ridge National Laboratory, http://bioenergy.ornl.gov/papers/bioam95/graham3.html

5.3 EPCOR, USA

EPCOR USA North Carolina LLC is an Oak Brook, Illinois corporation that owns two electric generating plants in North Carolina: a 47 MW facility in Roxboro and an 86 MW plant in Southport. In 2009 the company converted both plants from coal-fired only to burn a combination of coal, adulterated and unadulterated waste wood, and tire derived fuel (TDF). The NC Division of Air Quality issued Title V permits for both plants in May 2009.

In October 2009 EPCOR filed two 380-page applications with the NC Utilities Commission asking the Commission for certification as renewable energy facilities and a determination that tire derived fuel is a biomass renewable energy resource as defined by NC's renewable energy statute. In 2010 the Utilities Commission permitted the company to earn renewable energy certificates for burning wood and the part of the tire scraps that contain natural rubber. While EPCOR argued that TDF is a "combustible residue", the Commission decided that such materials must be "biogenic" to qualify as biomass. EPCOR must demonstrate what portion of the TDF consumed is natural rubber and therefore qualifies as a renewable energy resource. The Commission certified Roxboro and Southport as renewable energy facilities.

5.4 Fibrominn, Benson, Minnesota

Fibrominn is a 50-megawatt electric power plant with a 715 million BTU/hour heat input in Benson, Minnesota. It is the only such plant operating in the United States. The primary fuel (75%) is turkey and chicken litter. The balance of the fuel includes agricultural wastes and wood chips. The volume of litter burned at the Minnesota plant is expected to total 700,000 tons per year. Steam generated from burning poultry litter will be used to run a turbine and produce electricity. Minnesota Pollution Control Agency issued an air permit for the Fibrominn Biomass Power Plant in compliance with MR 7007.1150 and 1500 air pollution control requirements which conform to federal emission limits. [113]

The plant began operating in 2007. Fibrominn was subjected to preconstruction New Source Review under the federal Clean Air Act. Pollution controls installed at the Fibrominn incinerator include a spray dryer absorber and a fabric filter baghouse to limit particulate pollution and selective non-catalytic reduction to reduce nitrogen oxides. Other major pollutants emitted by the plant include carbon monoxide, volatile organic compounds, sulfur dioxide, sulfuric acid mist, hydrogen chloride and carbon dioxide.

The North Carolina Division of Air Quality did an analysis of poultry litter incinerators and found that a Fibrominn-type plant would have trouble meeting North Carolina's state limits for arsenic. In fact, the DAQ's analysis revealed an annual

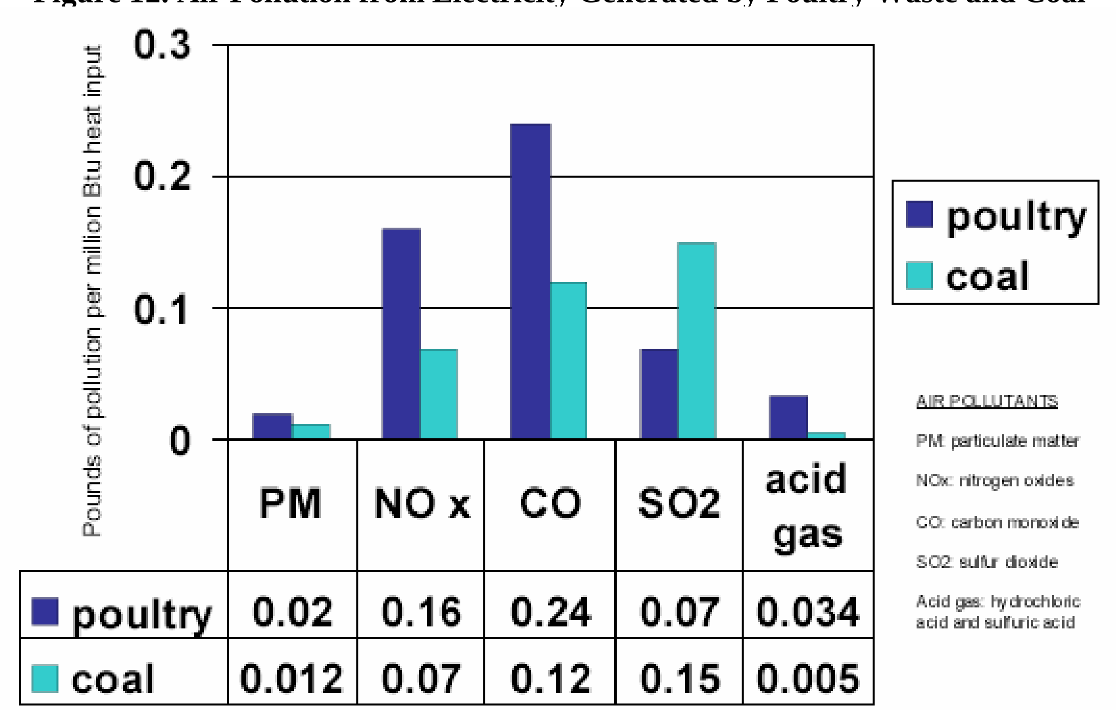
[113] Fibrominn Biomass Power Plant, Benson, Minnesota, Permit No. 15100038-004

ambient concentration of arsenic 277% of the acceptable ambient limit.[114] Arsenic is a toxic heavy metal emitted from the smoke stack burning poultry litter.

The Blue Ridge Environmental Defense League compared permit limits on emissions of particulate matter, nitrogen oxides, carbon monoxide, sulfur dioxide and acid gases from a recently opened poultry waste power plant in Minnesota with a coal-fired power plant proposed by Duke Energy in North Carolina. These plants are representative of the latest developments in technology and pollution control.

The pollution data in Figure 12 is taken from the state air permits for the two plants. The graph illustrates the relative air pollution impacts of power plants powered by poultry litter compared with boilers fired by coal. New coal-fired electric power plants in North Carolina would emit less than half the nitrogen oxides per mmBTU compared to the Fibrominn poultry-powered plant in Minnesota.

Figure 12. Air Pollution from Electricity Generated by Poultry Waste and Coal



	PM	NO x	CO	SO2	acid gas
poultry	0.02	0.16	0.24	0.07	0.034
coal	0.012	0.07	0.12	0.15	0.005

5.5 Duke Energy Electric Generation Units

In its Integrated Resource Plan, Duke Energy assessed the availability of biomass for co-firing in all of its coal plants in the Carolinas and switching its Unit 3 boiler at Dan River to 100% wood waste.

[114] "NC Toxics Emissions Evaluation from Poultry/Turkey Litter," NC Environmental Management Commission Air Quality Committee, Agenda Item 13, March 11, 2009

In February 2010 Duke applied to the North Carolina Utilities Commission for renewable energy certification of power plants at its Buck Steam Station and Lee Steam Station to burn chips from whole trees. In a pre-hearing brief filed with the Commission, Peter Stewart, of the consulting firm Forest2Market, provided analysis that only by chipping whole trees could the utilities meet their renewable energy requirements. Stewart said, "The volume of forest residues in the projected procurement area will simply not support the fuel needs of Duke Energy Carolinas' co-firing or repowering generation projects."[115]

Contradicting Duke's claims that whole trees are both necessary and acceptable as a renewable energy resource, Mead Westvaco intervened in the North Carolina docket and presented evidence that Duke's plans would compete with the forest products company for raw materials. Further, according to their filing, "Wood fuel derived from the clear cutting of land is anything but a renewable resource."[116]

Almost simultaneously with Duke's petition at the Utilities Commission, the North Carolina Environmental Management Commission (EMC) submitted a report to the General Assembly requesting legislative action to clarify the state's policy on woody biomass. The report found that, "A broad definition that allows the use of whole trees should be adopted only in conjunction with sustainable management requirements."[117] This EMC report concluded:

> The threshold issue that the implementing agencies and other stakeholders need clarification on is the definitional aspect of "biomass resource". Until the uncertainty is removed, the growth of the woody biomass market may be limited. However should this clarification result in the unequivocal inclusion of whole trees as woody biomass, due to the significant impacts from harvesting whole trees for energy generation the authority of the EMC to develop appropriate regulations or guidelines should be reaffirmed.[118]

The EMC report included a letter signed by Duke Energy, other North Carolina utilities and pro-biomass industry groups which cited a study by North Carolina State University entitled, "Estimating Biomass Supply in the U. S. South." The NCSU study reached this conclusion:

> The supply study illustrated that even with increased collection of biomass residuals, these resources would represent only a portion of the biomass resources necessary to meet the bioenergy demands of REPS [NC's Renewable Portfolio Standard], and that the demand for woody biomass materials, which SELC argues are the only wood products aside from energy crops that qualify as

[115] Docket E7, Sub 939 and Sub 940 Stewart Testimony NC Utilities Commission May 24, 2010 page 10
[116] Ibid Mead Westvaco Pre-Hearing Brief June 21, 2010 page 4
[117] NC Environmental Management Commission March 2010 "Evaluation of the Natural Resource Impacts of the Woody Biomass Industry in North Carolina". Page 10
[118] *Ibid,* page 16

"biomass resources" under Senate Bill 3, will quickly exceed supply and availability in the marketplace.[119]

5.6 Abengoa Biorefinery Project, Hugoton, Kansas

The plants air pollution limits are listed in Table M.[120]

Table M: Facility-wide emissions

Pollutant	Tons per year
Particulate matter	232.88
PM_{10}	215.13
$PM_{2.5}$	205.68
Nitrogen oxides	993.21
Sulfur dioxide	166.06
Carbon monoxide	1,065.54
Volatile organic compounds	157.45
Single hazardous pollutant	18.54
Total hazardous air pollutants	32.37
Carbon dioxide	1,623,537
Methane + nitrous oxide (as CO_2e)	32,637

5.7 Tire Energy Corporation, Martinsville, Virginia

The Tire Energy Corporation plant in the Martinsville, Virginia burned scrap tires for fuel. The plant opened in 2004 and was shut down in 2007, incinerating tires to make steam for the Martinsville Industrial Park. According to a company spokesman, the incinerator burned tires even when much of the steam generated could not be sold.[121] According to neighbors, the waste-to-energy plant emitted bad odors and black smoke.

The tire combustion facility operated by TEC was a rotary kiln incinerator rated at 38 million BTU/hour and 2400 pounds/hour. The pollution controls consist of baghouse filter system for particulate matter and a sodium bicarbonate ($NaHCO_3$) injection system for the control of sulfur dioxide (SO_2) and hydrogen chloride (HCl). In 2005 TEC failed its stack tests for emissions of lead compounds, sulfur dioxide, nitrogen oxides and particulate matter and paid a fine,[122] but the state revised the permit, allowing higher emissions. Officials said they had underestimated the amount of lead emissions caused by the use of lead weights to balance tires.[123]

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[119] *Ibid*, Appendix IV E. Duke Energy Carolinas et al.
[120] Reference: Draft EIS, US DOE/EIS-0407D, September 2009
[121] *The Roanoke Times*, "Henry County tire-burning facility shuts down," October 25, 2007, http://www.roanoke.com/business/wb/137117
[122] Virginia Department of Environmental Quality, Special Order by Consent, issued 19 April 2006
[123] *The Roanoke Times*, "New air quality tests may give Tire Energy a lift," June 1, 2006

Before it closed, the state permit for the TEC plant allowed 17,000 pounds of particulates, 77,000 pounds of NOx, 160,000 pounds of SO_2, 40,000 pounds of carbon monoxide and 20,000 pounds of volatile organic compounds to be emitted annually.

5.8 Wiregrass Power, LLC, Valdosta, Georia

The construction permit application for this plant was submitted by Golder Associates in December 2009 (No. 093-90124) and reviewed by the Georgia Environmental Protection Division. An air permit was issued effective July 19, 2010. The permit allows the construction of a 45 megawatt plant powered by wood and sewage sludge. Heat would be provided by a bubbling fluidized bed boiler with a heat input rate of 626 million British thermal units per hour (MMBtU/h). A close examination of the permit, the permit application and other documents indicates that the owner-operator sought to sidestep existing air quality regulations and escape stricter pollution reductions. Georgia Environmental Protection Division's permit allows Wiregrass Power to emit the pollutants in Table N and Table O.

Table N. Major Pollutants[124]

Pollutant	Tons per year
Major pollutants (criteria)	
Carbon monoxide	246.8
Nitrogen oxides	246.8
Particulate matter (PM)	135
PM < 10 microns (PM-10)	112.7
PM < 2.5 microns (PM-2.5)	86.3
Sulfur dioxide	246.8
Volatile organic compounds	60.3
Lead	1.03
Hazardous air pollutants-Total	13.9

The permit application states: "Because the proposed biomass facility does not fall within one of the 28 listed source categories, the emission rate threshold for triggering PSD NSR is 250 TPY." As seen in Table N, Wiregrass Power's emissions are a shade below 250, making it a minor source for New Source Review. The plant escapes the requirements of a major source under the Clean Air Act's Prevention of Significant Deterioration (PSD) rules. This means that control technology review, source impact analysis, air quality analysis, source information, and additional impact analysis *are not required*. [Section 3.0][125]

Regarding sulfur dioxide, the application states: "There is no emission limit for SO2 for boilers burning wood." [Section 3.1.1] Therefore, the only requirement is that

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[124] Emissions data from Air Construction Permit Application, Table 12, "New Facility Emissions Summary," and Form 4.00 "Emission Information," Submitted to GEPD by Golder Associates Inc. for Wiregrass Power, LLC, December 2009, 093-90124

[125] Section numbers refer to the Air Construction Permit Application for Wiregrass Power, LLC, December 2009, 093-90124

the plant meet an opacity standard; i.e., the density of smoke seen to come from the stack. Also, the Wiregrass plant owners plan to buy sulfur dioxide allowances under the Acid Rain (Title IV) permit trading scheme, adding to the levels of SO2 emitted. [Section 3.1.3]

Again, regarding nitrogen oxides, the permit application: "Subpart Db contains NOx standards for fossil fuel firing. There are no specific standards for wood firing; however, when burning natural gas in combination with wood, the applicable standard for natural gas firing alone must be met. The applicable standard for natural gas-firing units is 0.30 lb/MMBtu. However, there is an exemption from this standard provided that fossil fuel firing does not exceed a 10-percent annual capacity factor for the unit." The Wiregrass application estimates that the "maximum natural gas firing" would be 500 hours per year, or 5.7%. Therefore, NOx emission New Source Performance Standards (NSPS) do not apply to the Wiregrass unit. [Section 3.1.1]

The Wiregrass plant is also permitted to emit the following hazardous air pollutants:

Table O. Hazardous Air Pollutants[126]

Hazardous air pollutant	Pounds per year
Sulfuric acid H_2SO_4	30200
Benzene*	3235
Arsenic	15
Carbon tetrachloride	112
Chlorine	1940
Formaldehyde*	2577
Hydrochloric acid (HCl)	16400
Styrene	260
Trichloroethylene	74
Xylene	62
Vinyl chloride	44

* These totals are calculated based on emission limits in the GEPD Air Permit, Section 2.15

Maximum achievable control standards are applied to air pollution sources which emit more than 10 tons per year of a specific HAP or more than 25 tons per year of all HAPs. Although the plant would emit 15 tons per year of hazardous sulfuric acid, it is not listed as a "HAP" under 40 CFR 63. The plant would emit hydrogen chloride, which is a listed HAP, but just over 8 tons per year. Therefore, the Wiregrass plant escapes NESHAP. [Section 3.1.2]

[126] Emissions data from Air Construction Permit Application, Tables 2-2 and 2-3, Submitted to GEPD by Golder Associates Inc. for Wiregrass Power, LLC, December 2009, 093-90124.

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