ENVIRONMENTAL FOOTPRINT COMPARISON TOOL

A tool for understanding environmental decisions related to the pulp and paper industry

EFFECTS OF DECREASED GREENHOUSE GAS EMISSIONS

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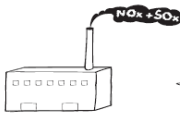

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OVERVIEW OF EFFECTS OF DECREASED GREENHOUSE GAS EMISSIONS

Introduction

The connections between the climate change issue and the forest products industry are more complex than for any other industry. The forests that supply the industry's raw material remove carbon dioxide from the atmosphere and store the carbon in the forest ecosystem and ultimately in forest products. Most of the industry's manufacturing facilities require fossil fuels, and these fuels generate greenhouse gases when burned. The industry obtains much of its energy, however, from biomass fuels, which are carbon neutral due to their short-term renewable life cycle. This characteristic contrasts with that of fossil fuels, which when burned undergo a one-way transfer to the atmosphere from geologic reserves. The forest products industry is a leader in using co-generation, also known as combined heat and power, which is far more efficient than conventional electricity generation; thus, smaller amounts of fuel are required and fewer greenhouse gases are emitted where this is employed. End of life management options for forest products, ranging from recycling to landfilling and burning for energy, have important but complex greenhouse gas and carbon implications. The World Business Council for Sustainable Development publication *Facts & trends: Forests, forest products, carbon and energy* (WBCSD 2012) provides an effective overview of these characteristics, from the global perspective.

Industry Performance

Greenhouse gases can be emitted from a number of places in the life cycle of a forest product. A recent study of the emissions from U.S. forest products sector, summarized in Figure G1, found that the largest single source is emissions related to energy use in manufacturing (NCASI 2008). Similar findings are presented in two other studies, on the Canadian and global forest products industries (NCASI 2007a, 2007b). These energy-related emissions come from the burning of fossil fuels and from power plants that produce the electricity purchased by the industry. Emissions of methane from municipal solid waste landfills attributable to the decay of discarded paper and wood products are also significant. These methane emissions are significant primarily because methane is 25 times more powerful than CO_2 as a greenhouse gas (a factor that is reflected in Figure G1 below).

Effects of Decreased Greenhouse Gas Emissions

General Overview

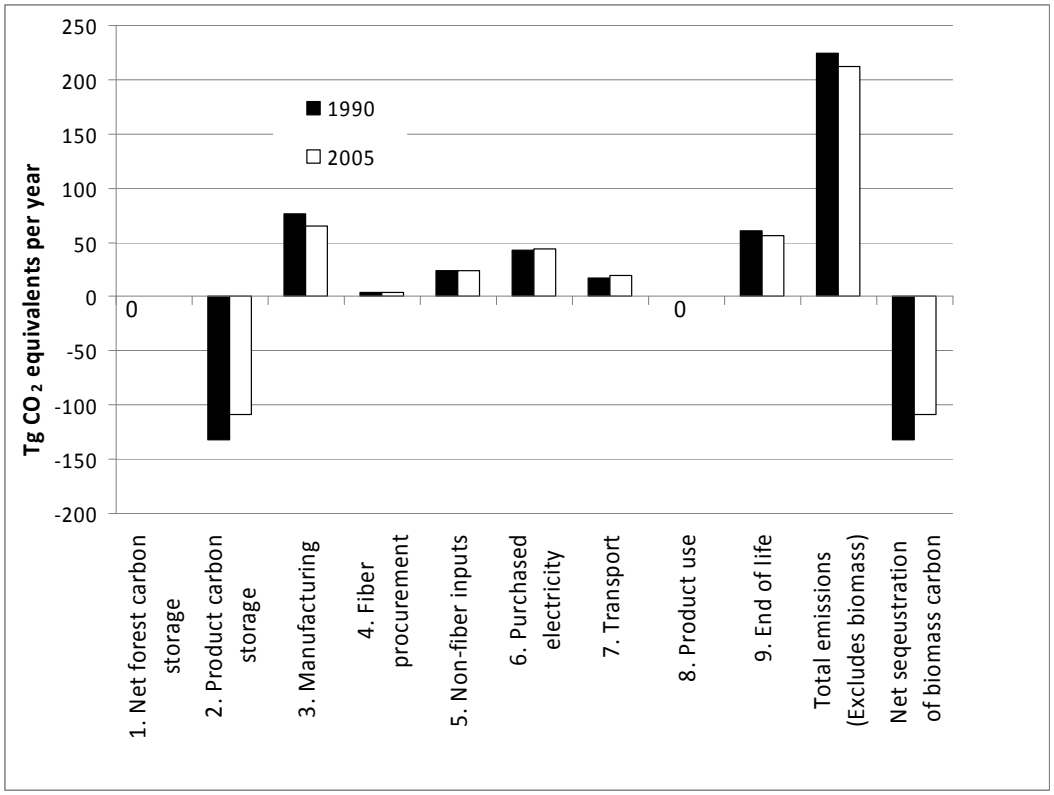

Figure G.1. Greenhouse Gas and Carbon Profile of the U.S. Forest Products Sector – 1990 and 2004/2005 (Source: NCASI 2008)

The life cycle of forest products also includes carbon sequestration and storage. The CO_2 removed from the atmosphere in the forest can remain stored in forests and forest products for periods ranging from days to centuries. For many forest products, the net removals of CO_2 from the atmosphere associated with this sequestration and storage are large enough to offset a significant fraction of the life cycle emissions, as shown for the U.S. industry in Figure G1.

Figure G2, below, shows energy use and biomass-based energy levels for the U.S. industry since the early 1970s.

Effects of Decreased Greenhouse Gas Emissions

General Overview

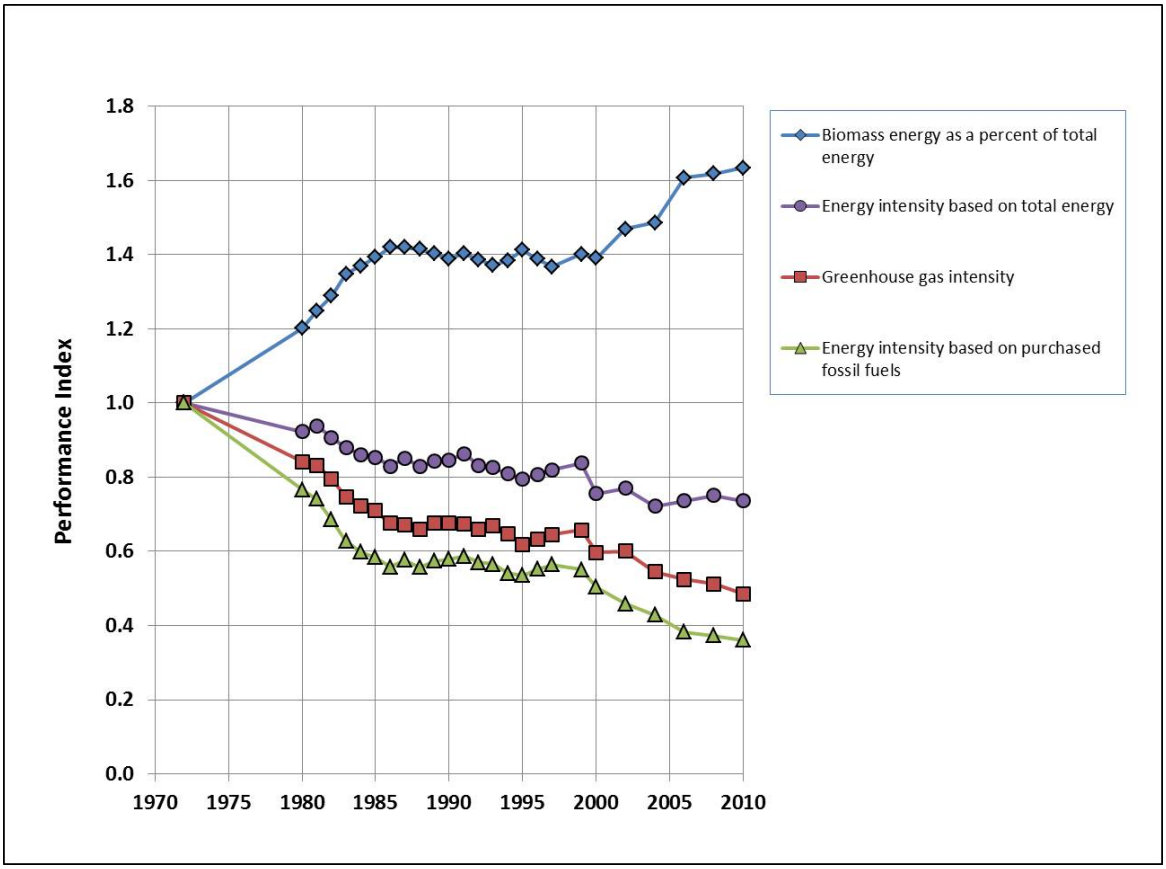

Figure G.2. U.S. Forest Products Industry Energy Use and Biomass-Based Energy Levels Since 1970 (Source: Data collected by AF&PA)

Biomass Carbon Neutrality

The carbon in trees started as carbon dioxide (CO_2) in the atmosphere. The trees removed this CO_2 from the atmosphere in the relatively recent past. When this carbon returns to the atmosphere as CO_2, as a result of decay or combustion, this merely completes a cycle. As long as this cycle is in balance, it neither adds carbon to, nor removes carbon from, the atmosphere. This is what is meant by carbon neutrality in the context of woody biomass. Because there is concern about keeping this cycle in balance, the amounts of carbon in national forests are monitored (typically by national governments) to ensure that that the amounts of biomass being removed from forests do not exceed the amounts being added to the forest as a result of photosynthesis, the process whereby trees remove CO_2 from the atmosphere and convert it into forest biomass.

Opportunities for Improvement

Figure G1 makes it clear that there are many places in the life cycle of forest products where there are opportunities for reducing greenhouse gas emissions. Not shown on the figure are the many opportunities to use forest products to reduce society's greenhouse gas emissions, for instance via the use of wood-based building materials in place of more greenhouse gas-intensive alternatives.

In this section of the Tool, we will focus on the opportunities to reduce the emissions shown in Figure G1 as they apply to the pulp, paper and paperboard industry, and to the wood products sector. The co-

benefits and trade-offs associated with pursuing these opportunities depend on many factors, many of which are highly site-specific and beyond this Tool's ability to explore. Nonetheless, we can explore some of the general issues you can expect to encounter if you attempt to reduce greenhouse gas emissions from various places in the life cycle of forest products.

By clicking on the parameters of interest, you can explore what happens to them when you attempt to reduce atmospheric levels of greenhouse gases via the following major sources and sinks in the life cycle of paper products.

1. increasing carbon storage in the forest
2. increasing carbon stored in paper, paperboard, and wood products
3. reducing emissions related to energy use in manufacturing facilities
4. reducing emissions from the end of life of paper and wood products
5. reducing emissions through practices that avoid emissions elsewhere in society, especially a) the burning of used paper and wood products that are not economically recycled and b) exports of "green" electricity from pulp and paper mills

Challenges to Further Greenhouse Gas Emission Reduction

Some circumstances beyond a mill's control (e.g., availability of natural gas or biomass fuels, or the design of municipal solid waste landfills) may contribute to higher than expected GHG emissions. Complex mills that produce a variety of product grades using a combination of manufacturing processes may have complex internal energy flows that can be difficult to compare to those of other facilities. Therefore, comparisons across facilities should be used with caution and an awareness of the potential limitations in their utility in seeking GHG emission reductions.

References

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ENVIRONMENTAL FOOTPRINT COMPARISON TOOL

A tool for understanding environmental decisions related to the pulp and paper industry

EFFECTS OF DECREASED GREENHOUSE GAS EMISSIONS ON WATER USE

Overview

The effects on water use that occur when greenhouse gas emissions are reduced depend on how the emissions are reduced. Click on the subject areas to the right to find out more about how each of these activities may affect water use.

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Carbon storage in the forest and in products

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EFFECTS OF DECREASED GREENHOUSE GAS EMISSIONS ON WATER USE

Carbon Storage in the Forest and in Products

Carbon stored in forests that supply wood to the forest products industry can be increased by changing management methods or by extending rotation times. Care is needed when assessing the effects of these practices on life cycle greenhouse gas emissions because some of these practices may increase carbon stored in the forest while increasing emissions elsewhere in the life cycle.

Forests, including working forests, are sources of much of the freshwater available in the U.S. and Canada (Wiegand et al. 2011). Almost two-thirds of freshwater runoff in the United States originates from forested watersheds (Stein and Butler 2004), even though forests cover only one-third of the nation. The quality of the water from forested land is higher than any other land use.

In general, increasing carbon storage in sustainably managed working forests will have relatively little effect on the amounts of water available from that forest.

The carbon stored in forest products can be important to their life cycle greenhouse gas profile. Wood products can be in use for over a hundred years. For paper products, however, the time that the product is in use provides relatively little carbon storage benefit. For wood products and some types of paper and paperboard, the amounts of carbon stored in landfills can be important, in some cases even matching the methane emissions from the fraction of the material that decomposes. Due to a number of other environmental and resource issues, however, increased landfilling is not likely to be seen as an option for reducing greenhouse gas emissions, even for wood products and those paper grades where landfilling results in a net sink of greenhouse gases.

This means there are few options for significantly increasing the carbon stored in forest products so the potential effects on water use are not relevant.

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EFFECTS OF DECREASED GREENHOUSE GAS EMISSIONS ON WATER USE

Emissions from Energy Use in Manufacturing

There are two primary ways in which energy-related emissions can be reduced: a) changing to less greenhouse gas-intensive fuels, and b) increasing energy efficiency so less fuel and purchased electricity is needed.

Reducing greenhouse gas emissions by changing fuels can have direct effects on water requirements at mills, although these would be comparatively small for pulp and paper facilities. Most notable, but still relatively insignificant, would be the potential for saving water by abandoning wet scrubbers in cases where natural gas displaces coal in mill power boilers (or in the opposite direction, adding wet scrubbers if converting from natural gas to biomass). There may also be indirect effects on water use because different fuels may require different amounts of water to produce. These effects would be expected to be relatively small, however, compared to the amounts of water used by most pulp and paper mills.

Water use may be impacted by efforts to reduce greenhouse gas emissions by increasing energy efficiency, but the effects are highly dependent on the specific energy efficiency measures implemented. In cases where energy is saved by finding ways to reuse warm water there may be a direct relationship between energy efficiency and water use. In many other cases, however, there will be no direct relationship between water use and energy efficiency.

Water use at wood products mills is very small compared to pulp and paper mills. Because of this, changes in fuel resulting in changes to wet control devices (scrubbers, biofilters, etc.) would be more significant in the wood products sector.

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EFFECTS OF DECREASED GREENHOUSE GAS EMISSIONS ON WATER USE

Emissions from End-of-Life of Forest Products

The vast majority of emissions associated with the end-of-life of wood, paper and paperboard products consists of methane released from landfills as the result of the decomposition of these products in landfills. These emissions are very product-specific; some products (e.g., uncoated copy paper) release large amounts of methane and others (e.g., newsprint, wood) release relatively little. Keeping products out of landfills is especially important for those grades which release larger quantities of methane. The effects on water use of recovering rather than landfilling used paper depend on the alternative use to which the use paper is put, but in most cases, the effect is small compared to the water use at the manufacturing facilities.

For all grades, an important option for reducing greenhouse gas emissions is improved capture and destruction of methane before it escapes from landfills to the atmosphere. Improved methane capture and destruction has very little impact on life cycle water use.

EFFECTS OF DECREASED GREENHOUSE GAS EMISSIONS ON WATER USE

Avoiding Emissions Elsewhere in Society

Reducing emissions through practices that avoid emissions elsewhere in society can be a co-benefit resulting from the manufacture of forest products, especially through a) the burning of used paper and wood products that are not economically recycled and b) exports of “green” electricity from pulp and paper mills.

Burning non-recyclable used wood, paper, and paperboard products as a source of biomass energy will not have a significant impact on life cycle water use. The water use co-benefits associated with exports of “green” power, however, may be more significant. This is because the electricity exported by a pulp and paper mill will often be produced in a biomass boiler using a combined heat and power (CHP) system. In these systems, steam is first used to produce electricity and then used in the mill for process heat. To produce the same electricity at a typical power company, the steam must be condensed with cooling water after it is used to produce electricity because there is no use for it. As a result, in many cases, one would expect a water use co-benefit when a mill exports CHP-derived electricity to the grid, displacing electricity from a conventional power plant. Wood products plants rarely operate CHP systems due to relatively small boiler sizes.

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EFFECTS OF DECREASED GREENHOUSE GAS EMISSIONS ON ENERGY USE

Overview

The effects on energy consumption that occur when greenhouse gas emissions are reduced depend on how the emissions are reduced. Click on the subject areas to the right to find out more about how each of these activities may affect energy consumption.

More information

Carbon storage in the forest and in products

Emissions from energy use in manufacturing

Emissions from end of life of paper products

Avoiding emissions elsewhere in society

EFFECTS OF DECREASED GREENHOUSE GAS EMISSIONS ON ENERGY USE

Carbon Storage in the Forest and in Products

Increasing carbon in the forest will normally have little direct effect on energy consumption in the forest products value chain. Indirect effects are possible if, for instance, carbon is retained in the forest via practices that result in fewer products being manufactured that would have displaced more (or less) energy-intensive products in commerce. These effects, however, can only be understood by focusing on particular products.

Increasing the carbon stored in products is not expected to significantly affect the energy consumption in the forest products value chain. The one potential direct effect worth noting is the opportunity for generating energy from used forest products at the end of life because this potential will be related, in part, to the amounts of carbon stored in products. As is the case with forest carbon, indirect effects are also possible if the increased carbon storage is accomplished by producing more products that are less (or more) greenhouse gas intensive than the products they displace.

EFFECTS OF DECREASED GREENHOUSE GAS EMISSIONS ON ENERGY USE

Emissions from Energy Use in Manufacturing

Reducing energy-related greenhouse gas emissions by fuel switching can affect energy consumption. The amounts of usable energy obtained from fuels are more or less inversely related to the fuel's greenhouse gas emissions, as shown in Table G2. Therefore, a change, for instance, from coal to bark will accomplish a very large reduction in greenhouse gas emissions but will require more total energy consumption because more bark is required to produce the same amount of usable energy.

Table G2. Representative Greenhouse Gas Emissions for Fuel Sources (Source: IPCC 2006)

Fuel	Greenhouse Gas Emission Factor for Combustion, kg CO2 eq./GJ (HHV)
Bark and wood waste (biomass)	1.84
Pulping liquors (biomass)	0.64
Coal (bituminous)	90.32
Residual oil	73.77
Natural gas	50.54

Table G3. Boiler Thermal Efficiencies

Fuel	Efficiency	Reference
Spent Liquor Solids	61[a]	Adams et al. 1997
Spent Liquor Solids	68-69	AGRA Simons Ltd.
Hogged Fuel	67	AGRA Simons Ltd.
Natural Gas	83	AGRA Simons Ltd.
Oil	87	AGRA Simons Ltd.
Sludge	65	AGRA Simons Ltd.
Spent Liquor Solids and Biomass	64[b]	Francis et al. 2006
Coal	85, 75[c]	Council of Industrial Boilers 2003
Oil	80, 72[c]	Council of Industrial Boilers 2003
Gas	75, 70[c]	Council of Industrial Boilers 2003
Biomass	70, 60[c]	Council of Industrial Boilers 2003

[a] Includes sootblowing 3.4% and boiler blowdown 0.85%.
[b] Canadian average.
[c] Second number is low load efficiency, numbers are for relatively new unit.

Switching to less GHG-intensive fuels seldom reduces total energy consumption, although it can significantly reduce non-renewable energy consumption if the change involves switching from a fossil fuel to biomass.

It is also important to consider whether fuel switching is accompanied by a change in combustion technology because this can have major impacts on total energy consumption. For instance, although coal-fired boilers are generally more efficient than gas-fired boilers, this difference is small compared to the increase in efficiency associated with replacing a coal-fired condensing turbine power plant with a natural gas-fired combined cycle co-generation facility. In addition to fuel switching, it is possible to reduce energy-related greenhouse gas emissions by reducing energy consumption. There are, of course, always strong co-benefits to energy use when greenhouse gases are reduced by reducing energy consumption.

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EFFECTS OF DECREASED GREENHOUSE GAS EMISSIONS ON ENERGY USE

Emissions from End of Life of Forest Products

The most likely way to reduce the end-of-life emissions associated with forest products is by reducing methane emissions associated with their degradation in landfills. There are several ways to accomplish this, however, and the implications for energy consumption vary among them.

Methane emissions can be reduced by increasing the use of landfill capping systems that capture and burn methane before it is released to the atmosphere. The energy-related impacts of this are small unless the methane that is captured is used for energy, in which case the value chain can be credited with this "energy production" activity.

Methane emissions can also be reduced by keeping degradable materials out of landfills. The energy impacts of diverting paper from landfills depend on how the diverted paper is used. If the paper is recycled into more paper, the overall effect may be to reduce total energy use because it often takes less total energy to produce paper from recovered fiber than from virgin fiber (although the impacts are highly grade-specific and the impacts on non-renewable energy consumption may be the exact opposite). More information on the energy-related impacts of recycling is available in the section on Effects of Recycled Fiber Use on Energy Use.

If paper that was destined for landfills is diverted and burned for energy, there is a co-benefit with having supplied biomass-based energy.

Like for paper, methane emissions can be reduced by keeping degradable wood products out of landfills. Demolition debris from structures containing wood can be segregated as combustible wood materials, saving landfill space and reducing methane emissions. Programs to collect and burn "urban wood," which includes demolition debris and woody debris from other urban sources (e.g., tree limbs from power line clearance), are increasing with the demand for biomass.

EFFECTS OF DECREASED GREENHOUSE GAS EMISSIONS ON ENERGY USE

Avoiding Emissions Elsewhere in Society

Societal greenhouse gas (GHG) emissions can be reduced by burning non-recyclable wood, used paper and paperboard products, or methane from landfills, in place of fossil fuels. In all three cases, the practice results in the forest products value chain producing biomass-based energy for society. Reducing societal GHG emissions by displacing high GHG-intensity electricity from the grid with low GHG-intensity power will increase the energy consumption at the mill producing the electricity. Societal energy consumption may increase or decrease depending on how efficiently the "new" fuel and the "displaced" fuel are used to produce electricity.

References

Intergovernmental Panel on Climate Change (IPCC). 2006. Stationary combustion. Chapter 2 in *Energy*. Volume 2 in 2006 IPCC guidelines for national greenhouse gas inventories. http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

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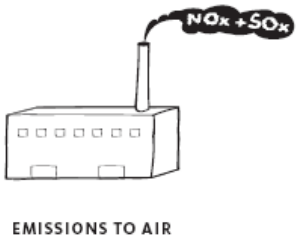

EFFECTS OF DECREASED GREENHOUSE GAS EMISSIONS ON EMISSIONS TO AIR

Overview

The effects on emissions of various air pollutants that occur when you reduce greenhouse gas emissions depend on how the emissions are reduced. Switching from using coal or fuel oil to using either natural gas or biomass would be expected to reduce SO_2 emissions. Reducing greenhouse gas emissions by selecting low GHG-intensity fuels can affect particulate emissions, with the effect ranging from strong co-benefits to strong trade-offs. Increasing carbon storage, either in the forest or in products, is not expected to impact sulfur dioxide (SO_2), nitrogen oxides (NO_x), or particulate emissions.

More information

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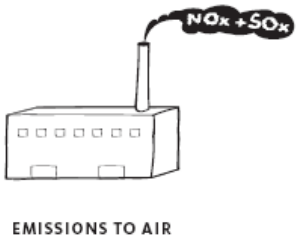

EFFECTS OF DECREASED GREENHOUSE GAS EMISSIONS ON EMISSIONS TO AIR

Emissions from Energy Use in Manufacturing

There are two primary ways that energy-related emissions can be reduced: a) changing to less greenhouse gas-intensive fuels, and b) increasing energy efficiency so less fuel and purchased electricity is needed.

Reducing greenhouse gas emissions by changing fuels can have significant effects on SO_2, NO_x, and particulate emissions. The fossil fuels that tend to have the highest sulfur contents (coal and fuel oil) are also the most greenhouse gas intensive. Therefore, switching from these fuels to natural gas or biomass would be expected to reduce SO_2 emissions. Some general information on the greenhouse gas intensity and SO_2 emissions associated with different fuels is shown in Table G1.

Table G1. Representative Fuel Sulfur and Nitrogen Content and GHG Emission Factor

Fuel	Nitrogen, %	Sulfur, %[a]	GHG Emissions[b] kg CO_2 eq./GJ (HHV)
Natural Gas	Insignificant	Insignificant	50.54
Residual Oil	0.1 to 1.0	0.3 to 3.0	73.77
Coal	0.5 to 2.0	0.4 to 4.0	90.32
Bark and Wood Residue	0.1 to 0.4	0.2 or less	1.84

[a] USEPA 1998.
[b] IPCC 2006.

The effects of fuel selection on NO_x emissions are more complex because NO_x emissions are affected not only by fuel type but also by the combustion conditions. Though a significant portion of the fuel nitrogen can be converted to NO_x during combustion, the amount of nitrogen available in the fuel is relatively small compared with the amount of nitrogen available for conversion in the combustion air. Peak combustion temperatures influence the magnitude of that conversion. More information on the factors that affect NO_x emissions is available under the SOx and NOx Tab of the navigation menu in this Tool.

Reducing greenhouse gas emissions by selecting low GHG-intensity fuels can affect particulate emissions, with the effect ranging from strong co-benefits to strong trade-offs. Although in general, solid fuels are associated with higher particulate emissions than liquid and gaseous fuels, the emissions are also highly dependent on the type and efficiency of the device used to control particulate emissions. In the U.S., the two solid fuels used most by the industry, coal and wood-derived biomass fuels, are at the opposite end of the range of greenhouse gas emission factors. Therefore, fuel switching from coal to biomass, which would greatly reduce greenhouse gas emissions, may not significantly affect particulate emissions. Switching from coal to natural gas would accomplish reductions in both particulate emissions and greenhouse gases. And at the other end of the spectrum, switching from natural gas to solid biomass would significantly reduce greenhouse gas emissions, but in all likelihood, significantly increase particulate emissions.

Where greenhouse gas emissions are reduced by reducing energy consumption, emissions of SO_2, NO_x, and particulates will usually also decline, reflecting the reduction in fuel consumption.

Few wood products mills use coal or oil. SO_x emissions are very low at most wood products plants as the only source of sulfur is the small amount of sulfur in wood. NO_x emissions can be significant and, as

discussed previously, are a function of both nitrogen from fuel and nitrogen from the atmosphere. Wood products mills that use urea-formaldehyde resins (primarily particleboard and MDF mills) generate higher NO_x emissions than mills using other resins, as urea is a nitrogen rich compound.

References

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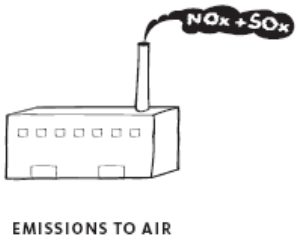

EFFECTS OF DECREASED GREENHOUSE GAS EMISSIONS ON EMISSIONS TO AIR

Avoiding Emissions Elsewhere in Society

Reducing greenhouse gas emissions associated with the end of life of forest products will normally have little effect on SO_2, NOx, and particulate emissions unless the used product, or the gas collected from landfills, is used as a source of energy, displacing fossil fuels. Burning non-recyclable used paper and paperboard products, wood, or methane from landfills, in place of fossil fuels can reduce societal greenhouse gas (GHG) emissions. The associated effects on SO_2, NOx, and particulate emissions will depend on the specific fuel substitution involved. These fuel substitution effects are discussed in the section Energy Used in Manufacturing.

Likewise, societal GHG emissions can be reduced by displacing high GHG-intensity electricity from the grid with low GHG-intensity power. The effects on SO_2, NOx and particulate emissions will depend on the types and amounts of fuels used to produce the "green" power and the grid power. Generally, the direction of the impact (co-benefit or trade-off) will be the same as presented in the section Energy Used in Manufacturing.

References

Intergovernmental Panel on Climate Change (IPCC). 2006. Stationary combustion. Chapter 2 in *Energy*. Volume 2 in 2006 IPCC guidelines for national greenhouse gas inventories. http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

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