ENVIRONMENTAL FOOTPRINT COMPARISON TOOL

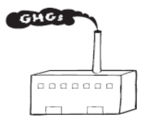
A tool for understanding environmental decisions related to the pulp and paper industry

EFFECTS OF DECREASED ENERGY CONSUMPTION

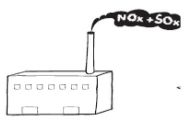
Table of Contents

General Overview

Water Use



Greenhouse Gases
- Thermal efficiency of steam generation
- Energy savings by reducing steam demand
- Energy savings by reducing electricity demand
- Combined heat and power (CHP) systems



Emissions to Air
- SOx
- NOx

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OVERVIEW OF EFFECTS OF DECREASED ENERGY CONSUMPTION

Introduction

Both pulp and paper and wood products manufacturing require significant energy in converting raw fiber into a finished product.

Pulp and paper making is energy intensive. There are two main reasons.

- First, a great deal of energy is required to separate solid wood into fibers. To this effect, recycled paper and paperboard mills are the indirect beneficiaries of the energy used by virgin mills to separate wood into fiber, which is why their energy requirements are usually lower.
- Second, the process of making paper and paperboard requires that fibers be transported and distributed into a thin sheet using water. The water that cannot be squeezed from this sheet must be evaporated, which requires a substantial amount of energy. All types of paper and paperboard mills need to apply this energy.

Smaller amounts of energy are required in many other places in pulping and paper making, but the energy requirements for pulping and for drying paper are the largest.

All mills require steam, which is generated by burning fossil fuels and biomass fuels, and most mills also purchase electricity. The amounts of electricity that are purchased are highly variable because many mills, and essentially all chemical pulp mills, generate large amounts of electricity. Mills usually generate electricity in combined heat and power (CHP) systems (also known as co-generation systems) which are far more efficient than the systems typically used by commercial electricity producers. In some cases, the amounts of electricity generated by a mill will exceed its needs and the mill will be able to sell electricity to the "grid."

The pulp and paper industry obtains much of its energy from renewable sources, particularly biomass. Most of this is produced from the parts of the tree that are not needed for paper and paperboard production. In specific, the industry relies heavily on bark fuels and energy-rich "pulping liquors" which contain those parts of the wood that are not used for making paper (primarily the lignin that holds fibers together in the tree).

Energy usage in wood products plants varies substantially by product type. For plants that receive wood in the form of logs, the single highest energy requirement is for heat energy to dry the wood to product specifications. Wood products presses also require heat. Electrical energy requirements are much lower than heat energy requirements at wood products mills.

Heat energy may be applied directly or indirectly though steam or thermal oil. With a few exceptions, wood products presses are heated by steam or thermal oil. Most wood products rotary dryers are directly heated and most conveyor dryers are indirectly heated with steam.

Like the pulp and paper industry, the wood products industry obtains much of its energy from renewable biomass, primarily wood residuals. Wood residuals may be broadly defined as all wood materials not incorporated into the final product. Wood residuals are the primary fuel at most wood products plants with natural gas a distant second. Very few wood products plants burn coal or oil.

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Industry Performance

Energy consumption in the North American pulp and paper industry has declined over the years, while the fraction of energy supplied by renewable fuels has increased. This is illustrated in Figures E1 and E2 for the U.S. pulp and paper industry[1] and Figures E3 and E4 for the Canadian pulp and paper industry. Between 1972 and 2010, there has been a 26% reduction in fenceline energy intensity in the U.S. pulp and paper industry. During this same time frame, the fraction of fenceline energy supplied by biomass and renewable energy like hydroelectric power has increased from 40% to 65%. It should be noted that there are various ways of expressing energy intensity such as fenceline energy intensity[2] used within this document, purchased energy intensity which is sensitive to marginal fuel choices and is the metric adopted by AF&PA in their energy sustainability goal[3], fuel energy intensity which considers the energy content of fuels used to generate steam and power at facilities, or useable energy intensity, which is based upon the energy content of steam and power used at facilities. When comparing energy intensity values from various sources, it is important to use the same energy intensity metric.

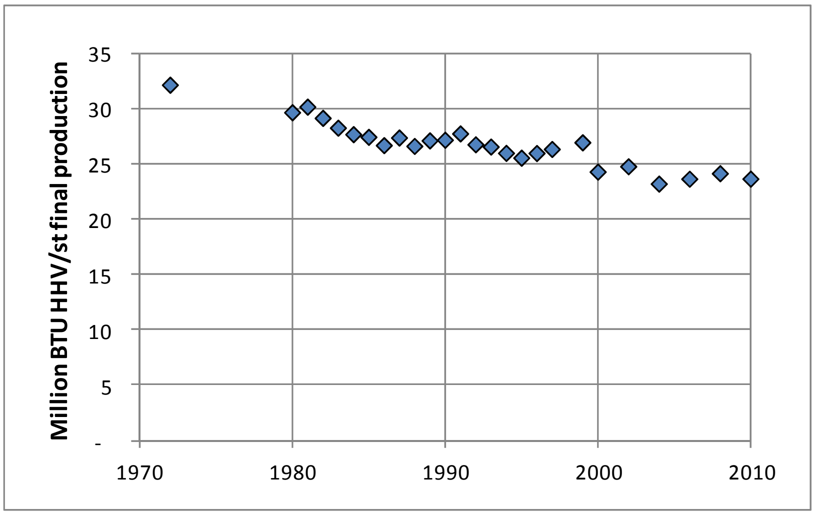

Figure E1. U.S. Pulp and Paper Industry Fenceline Energy Use Intensity since 1972 (Source: AF&PA 2012)

[1] Data represent American Forest & Paper Association (AF&PA) membership only.
[2] Fenceline energy is the energy content, on a high heating value basis, of all purchased and self-generated fuels and purchased electricity and steam, minus the energy content of any sold electricity and steam. Fenceline energy intensity is the fenceline energy divided by final production, which provides a measure of the amount of energy required to produce a fixed amount of paper, paperboard, or market pulp product.
[3] http://www.afandpa.org/sustainability/increase-energy-efficiency

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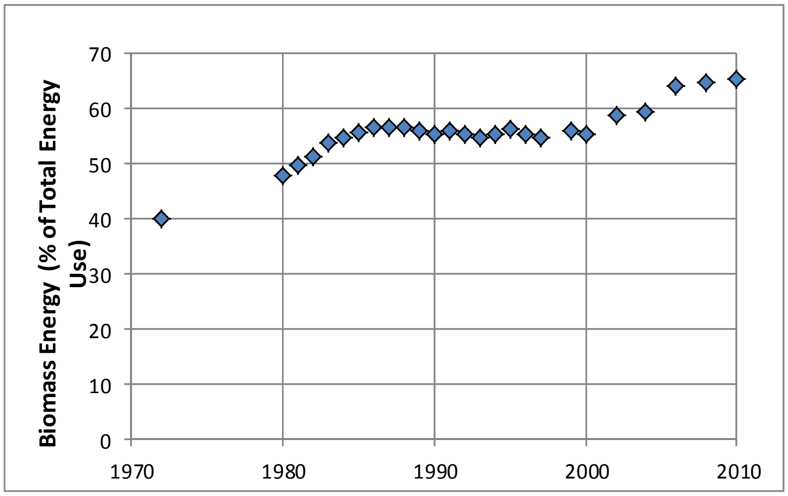

Figure E2. U.S. Pulp and Paper Industry Biomass and Renewable Energy as a Percent of Total Fenceline Energy Use (Source: AF&PA 2012)

Between 1990 and 2010 there has been a decrease of 27% in energy intensity in the Canadian pulp and paper industry, and the fraction of fenceline energy supplied by biomass has increased from 47% to 56%.

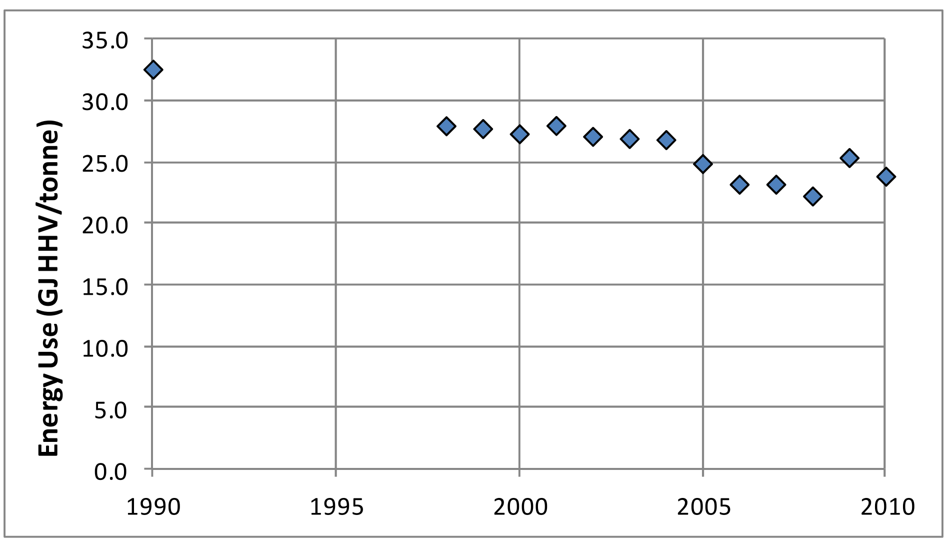

Figure E3. Canadian Pulp and Paper Industry Energy Use Intensity since 1990 (Source: CIEEDAC 2012)

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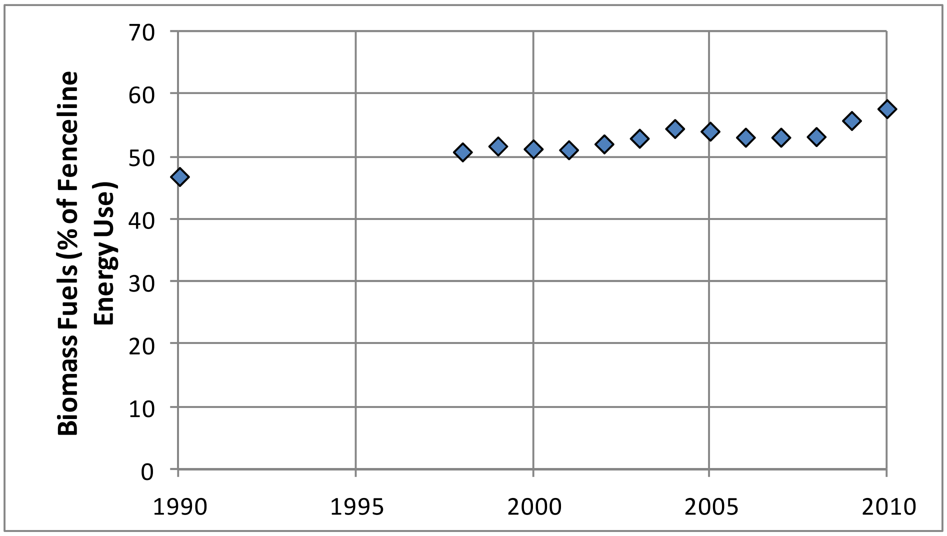

Figure E4. Canadian Pulp and Paper Industry Biomass Energy as a Percent of Total Fenceline Energy Use (Source: CIEEDAC 2012)

The energy intensity trend for the U.S. wood products sector from 2000 to 2010 is given in Figure E5. Underlying data in Figure E5 may be considered to have higher uncertainty than the U.S. pulp and paper energy data because the wood products sector energy data do not undergo equivalent quality assurance and quality control procedures. There has been an increase in energy intensity between 2000 and 2010 for the wood products sector. Contributing factors that may have adversely affected wood products results include a dramatic reduction in production represented by the data and a shift in production mix to more energy intense structural panel products from lumber products.

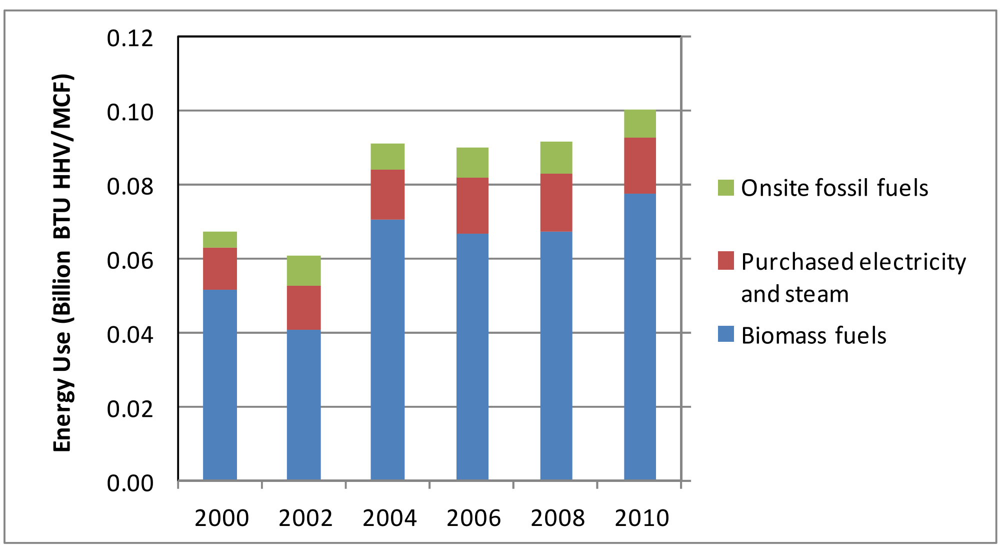

Figure E5. U.S. Wood Products Industry Energy Use Intensity since 2000 (Source: AF&PA 2012)

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Opportunities for Improvement and Challenges to Further Energy Use Reduction

One way to determine whether there are opportunities to further reduce energy use is to compare a facility's energy consumption to that of other facilities manufacturing the same products. If the energy consumption is greater than that of other facilities, there may be ways to reduce the facility's energy consumption and thereby reduce greenhouse gas (GHG) emissions. That said, comparison of a facility's energy consumption to reference values is limited due to the wide variation in mill configuration, which can make it very difficult to compare energy use of two similar facilities. For example, these comparisons do not specifically identify where opportunities for improvement may be found, and mill-specific circumstances may result in irrelevant comparisons (for example, some facilities may consume fuels in quantities higher than expected, but as a result are able to generate excess electrical power and steam for export to other users). Complex mills that produce a variety of product grades utilizing a combination of manufacturing processes may have complex internal energy flows that can be difficult to compare to those of other facilities. Therefore, these comparisons should be used with caution and an awareness of the potential limitations in their utility.

References

American Forest & Paper Association (AF&PA). 2012. *AF&PA environmental, health & safety verification program fuel and energy data*. Washington, DC: American Forest & Paper Association.

Canadian Industrial Energy End-Use Data and Analysis Centre (CIEEDAC). 2012. Energy use and related data: Canadian paper manufacturing industries 1990 to 2010. Canadian Industrial Energy End-Use Data and Analysis Centre. http://www2.cieedac.sfu.ca/media/publications/Pulp_Paper_Analysis_2011__2010__Final.pdf

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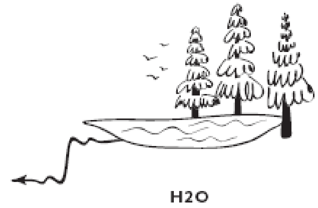

EFFECTS OF DECREASED ENERGY CONSUMPTION ON WATER USE

Overview

There are many ways to reduce energy consumption in forest products manufacturing facilities. Many of them have no effect on water use.

In some cases, a pulp and paper mill may save energy by replacing cool freshwater with recycled hot water to capture the heat energy. This will reduce water use and effluent flows. There are other energy conservation measures that tend to reduce water use, but the reductions accomplished are relatively small in most cases.

Water use at wood products facilities is substantially smaller than at pulp and paper facilities.

Few energy saving measures cause water use to increase.

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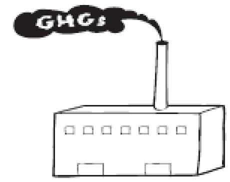

GREENHOUSE GASES

EFFECTS OF DECREASED ENERGY CONSUMPTION ON GREENHOUSE GAS EMISSIONS

Overview

The most important greenhouse gas (GHG) co-benefits from energy reduction occur when a mill reduces fossil fuel use without increasing use of other sources of energy (e.g., purchased electricity). Whether, or to what degree, this is possible depends on a number of factors. The effects may vary, for instance, depending on whether the reduced fuel use comes from reduced steam demand or reduced electricity demand. If steam demand is reduced, it also depends whether there is an effect on purchased electricity requirements. This, in turn, depends on whether the steam is generated in a combined heat and power (CHP) cogeneration system. See the links at the right for more information on these aspects of the co-benefits and tradeoffs.

Note that understanding the actual impacts of energy conservation on GHG emissions requires understanding the specific situation at the mill where the reductions are taking place.

More Information

Thermal efficiency of steam generation

Energy savings by reducing steam demand

Energy savings by reducing electricity demand

Combined heat and power (CMP) systems

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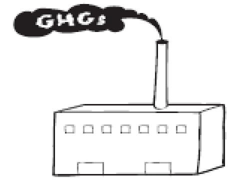

GREENHOUSE GASES

EFFECTS OF DECREASED ENERGY CONSUMPTION ON GREENHOUSE GAS EMISSIONS

Thermal Efficiency of Steam Generation

The forest products industry uses a number of different types of fossil fuels and biomass fuels for energy generation purposes. In 2010, over 65% of the total on-site energy generation needs within the United States pulp and paper industry were met by biomass and renewable fuels. Within the Canadian pulp and paper industry, 69% of the total onsite energy generation needs were met by biomass and renewable fuels in 2010. The parallel estimates for the North American wood products sector are even higher (at 80% in the U.S.). The amount of steam generation from fuels, thermal efficiency, can be defined as the ratio of energy available for steam generation to the total energy input into a boiler.

$$\eta = \frac{\text{Energy to generate steam}}{\text{Total energy input}}$$

The heat content of the fuel usually represents in excess of 90% of the total heat input into a boiler, with other heat inputs being the sensible heat of the incoming fuel, sensible heat of the combustion air and infiltration air, and external sootblowing. The efficiency of steam generation is dependent upon boiler losses that can be classified into two different categories: losses associated with the fuel choice such as moisture content and hydrogen content of the fuel, and losses associated with the combustion process such as radiation losses and flue gas losses.

Table E1shows typical thermal efficiencies for boilers firing different fuels. The total thermal efficiency is dependent upon where the boundary envelope is drawn, the exact definition of thermal efficiency, and whether the direct (measured) or indirect (energy balance calculation) method is used.

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Table E1. Literature with Published Thermal Efficiencies

Fuel	Efficiency	Reference
Spent Liquor Solids	61[a]	Adams et al. 1997
Spent Liquor Solids	68-69	AGRA Simons Ltd. 2001
Hogged Fuel	67	AGRA Simons Ltd. 2001
Natural Gas	83	AGRA Simons Ltd. 2001
Oil	87	AGRA Simons Ltd. 2001
Sludge	65	AGRA Simons Ltd. 2001
Spent Liquor Solids and Biomass	64[b]	Francis et al. 2006
Coal	85, 75[c]	CIBO 2003
Oil	80, 72[c]	CIBO 2003
Gas	75, 70[c]	CIBO 2003
Biomass	70, 60[c]	CIBO 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.

Hogged fuel and kraft recovery boilers tend to have higher moisture contents than fossil fuel boilers, which negatively impact their thermal efficiencies. Kraft recovery boilers have additional losses, particular to the kraft recovery process, that adversely impact the thermal efficiencies for these types of boilers. The two purposes of kraft recovery boilers are 1) energy generation and 2) efficient recovery of process chemicals. The recovery of process chemicals (primarily sodium carbonate and sodium sulfide) is specific to spent liquor solids combusted in kraft recovery boilers and negatively impacts the thermal efficiency of these boilers in two ways: 1) the energy required to reduce oxidized sulfur compounds to sulfides, and 2) the sensible heat loss of discharging a high temperature smelt stream.

It is important to recognize the fuel specific and process specific impacts to thermal boiler efficiencies when comparing fuels for combustion purposes.

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Adams, T.N., W.J. Frederick, T.M. Grace, M. Hupa, K. Iisa, A.K. Jones, and H. Tran. 1997. *Kraft recovery boilers*. Atlanta, GA: Tappi Press.

AGRA Simons Limited. 2001. *A guide to energy savings opportunities in the kraft pulp industry*. Report prepared for The Pulp and Paper Technical Association of Canada (PAPTAC) by AGRA Simons Limited, Vancouver, BC.

Francis, B., M. Towers, and T. Browne. 2006. Benchmarking energy use in pulp and paper operations. In *Proceedings, 92nd PAPTAC Annual Meeting*, A55-A61. Montréal, QC.

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Council of Industrial Boiler Owners (CIBO). 2003. *Energy efficiency & industrial boiler efficiency: An industry perspective*. http://www.docstoc.com/docs/36692511/ENERGY-EFFICIENCY-and-INDUSTRIAL-BOILER-EFFICIENCY-An-Industry

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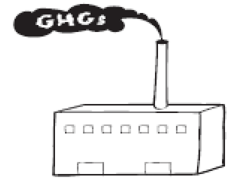

GREENHOUSE GASES

EFFECTS OF DECREASED ENERGY CONSUMPTION ON GREENHOUSE GAS EMISSIONS

Energy Savings by Reducing Steam Demand

Much of the energy required by mills is supplied by steam generated by burning fuels in boilers. A 2006 report to the U.S. Department of Energy indicates that steam supplies 67% of the energy used in pulp and paper mills. (See Table 4.5 in the 2006 *Pulp and Paper Industry Energy Bandwidth Study*, available at http://www1.eere.energy.gov/manufacturing/resources/forest/pdfs/doe_bandwidth.pdf). It is not surprising, therefore, that reducing steam demand is a major focus of mill efforts to reduce energy use.

In many mills, most of the steam is generated in combined heat and power (CHP) systems. In these systems, the steam is generated in a boiler at high pressure, passed through a turbine where electricity is generated as the steam pressure is reduced, and then the lower pressure steam is used in the mill. These CHP systems are usually sized to meet the mill's steam demand (see link in this section of the Tool to CHP systems).

Mills do not want to generate more steam than they need because this is expensive. Generating less steam, however, means that the mill can generate less electricity so more electricity must be purchased from the grid. This means that the overall effect of reduced steam consumption depends on a) how much fuel is saved at the mill, b) what type of fuel it is, c) how much more electricity has to be purchased from the grid, and d) the emissions released in generating this additional purchased electricity.

In most cases, reductions in steam demand are accompanied by reductions in greenhouse gas emissions. The relationship is not direct, however, and in some cases, it is possible for reductions in steam demand to increase greenhouse gas emissions, as explained below.

If the fuel used to produce steam at the mill is biomass, the overall emissions may increase when steam demand is reduced because reducing the consumption of biomass fuels has little effect on greenhouse gas emissions whereas increasing the purchases of electricity will usually be associated with increased indirect emissions (from the power plant producing the electricity). This effect can be reduced by either producing excess steam (not always economical) or by reducing electricity demand (not always possible).

This trade-off may exist even if steam is being generated from fossil fuels. This is because a mill's CHP system produces electricity far more efficiently than the systems used by most electric power companies. In addition, the fossil fuel used at the mill may be less greenhouse gas-intensive than the fuel used by the power company.

Where energy is saved by reduced steam demand, therefore, one needs to examine the effects on greenhouse gas emissions based on the specific situation involved.

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Steam usage varies substantially by mill type in the wood products industry. Further, although most mills do use some form of indirect heat, some do not use steam, but rather thermal oil. In general, oriented strand board (OSB) and particleboard mills use steam or thermal oil only to heat presses. Their primary use of heat is direct heat applied to the dryers. Plywood mills commonly use steam to heat both their dryers and presses. Medium density fiberboard (MDF) mills use steam or thermal oil to heat their presses, but may use either direct or indirect heat for their tube dryers.

Since most of the heat energy at wood products plants is from renewable biomass, a 10% reduction in steam demand may only result in a 0 to 2% reduction in greenhouse gas emissions.

CHP systems are rare at wood products mills as the boilers are much smaller than pulp and paper boilers.

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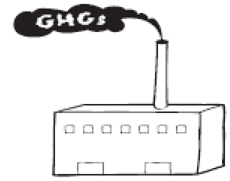

GREENHOUSE GASES

EFFECTS OF DECREASED ENERGY CONSUMPTION ON GREENHOUSE GAS EMISSIONS

Energy Savings by Reducing Electricity Demand

Most mill systems for generating electricity are sized to meet the mill's demand for steam. As a result, reduced electricity demand usually will not affect the amount of electricity generated by the mill but will instead reduce the electricity purchases (or allow increased sales of excess electricity). In either event, it is likely to result in an overall reduction in greenhouse gas emissions.

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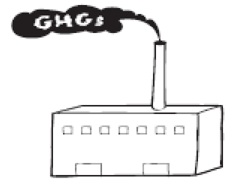

GREENHOUSE GASES

EFFECTS OF DECREASED ENERGY CONSUMPTION ON GREENHOUSE GAS EMISSIONS

Combined Heat and Power (CHP) Systems

In general, a CHP system is one that uses a single energy input to generate, in sequence, both heat (usually steam) and electricity. The most common systems in the forest products industry take high pressure steam from a boiler, pass it through a steam turbine where electricity is generated as the steam pressure is reduced, and then send the lower pressure steam to mill processes.

In a conventional fossil fuel-fired power plant, steam is generated and passed through turbines to produce electricity but the remaining heat energy in the low pressure steam is lost. Figure E3 illustrates the efficiency benefits of CHP systems. In a typical pulp and paper mill, all of the electricity and steam produced by the CHP unit would be consumed by the mill, but this is not always the case, and there are many examples of companies sending CHP-derived electricity to the grid.

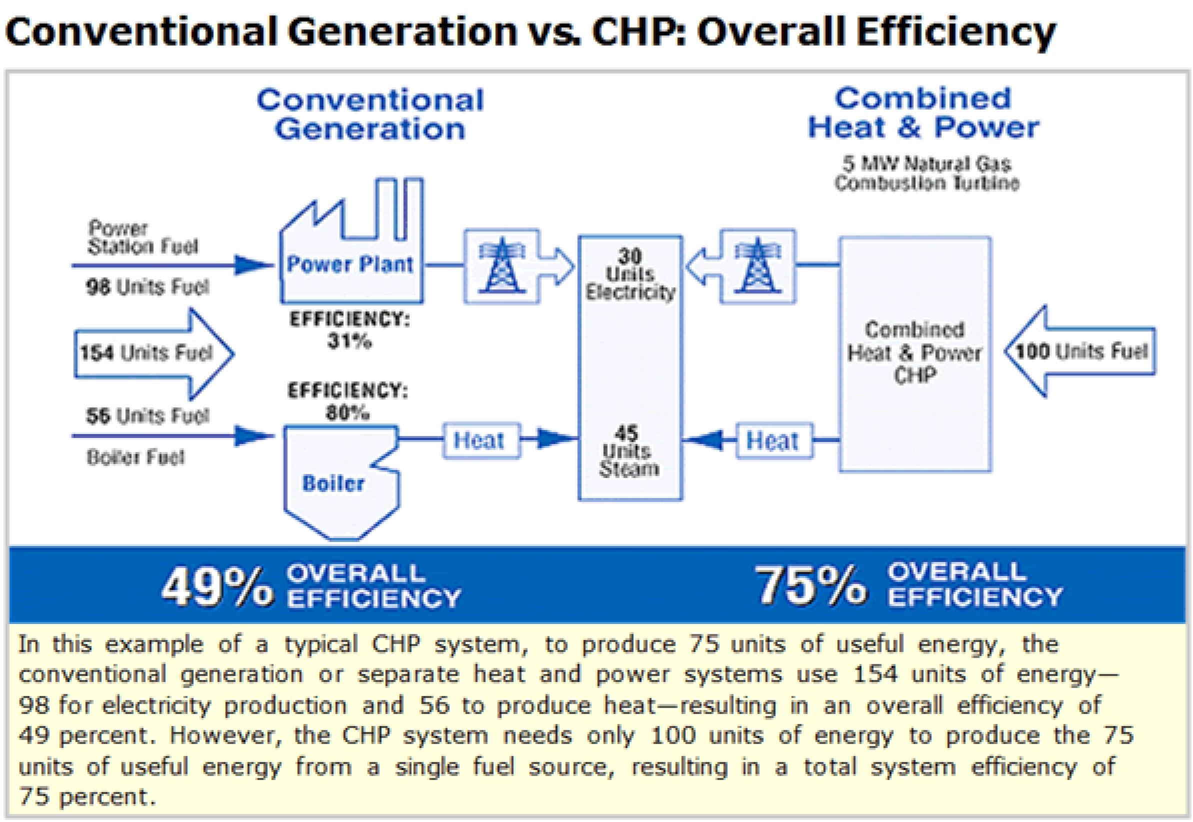

Figure E3. Efficiency of Conventional Energy Generation vs. CHP Energy Generation (Source: http://www.epa.gov/chp/)

CHP systems are rare at wood products mills as the boilers are much smaller than pulp and paper boilers.

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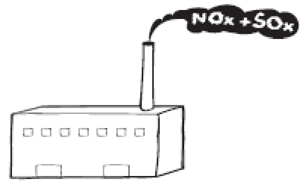

EMISSIONS TO AIR

EFFECTS OF DECREASED ENERGY CONSUMPTION ON EMISSIONS TO AIR

Overview

Fuel combustion is responsible for most of the sulfur dioxide and nitrogen oxides released from pulp and paper mills. In almost all cases, when you reduce energy consumption, you lower fuel use. The fuel savings may be at the mill or elsewhere (at the power plant from which the mill buys electricity, for instance). All other things being equal, the amount of SO_2 released from the burning of fuels is directly proportional to the amounts of fuel burned. NO_X emissions are usually more related to combustion conditions, and thus, unless combustion conditions become more favorable to NO_X formation as fuel use is decreased (unlikely), NO_X emissions should remain constant or decrease as fuel use decreases.

More information

SO_x

NO_x

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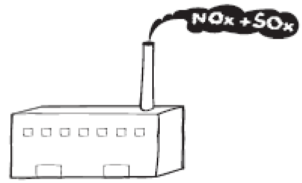

EFFECTS OF DECREASED ENERGY CONSUMPTION ON EMISSIONS TO AIR

SOx

Typically, all other things being equal, the amount of SO_2 released during the burning of fuels is directly related to the amounts of fuel burned. Therefore, in almost all cases, when you reduce energy consumption you lower fuel use. There are a few situations where reductions in energy use may increase SO_2 emissions. One of note involves switching from wood fuel or natural gas to higher sulfur oil or coal. Oil and coal generally burn more efficiently than wood or natural gas so less fuel is needed, even though more SO_2 may be emitted.

Understanding the actual impacts of energy conservation on SO_2 emissions requires understanding the specific situation at the mill where the reductions are taking place. More information on SO_x can be found in the SO_x and NO_x section.

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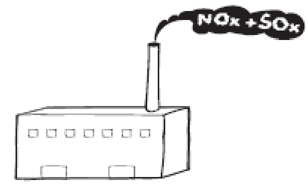
A tool for understanding environmental decisions related to the pulp and paper industry



EFFECTS OF DECREASED ENERGY CONSUMPTION ON EMISSIONS TO AIR

NOx

NO_X can be formed from the nitrogen in fuel or from nitrogen in the air during the combustion process. Other things being equal, therefore, emissions of NO_X may increase as the amounts of fuel increase. Research has shown, however, that NO_X emissions are usually more related to combustion conditions; thus, unless combustion conditions become more favorable to NO_X formation as fuel use is decreased (which is unlikely), NO_X emissions should remain constant or decrease as fuel use decreases.

Understanding the actual impacts of energy conservation on NO_X emissions requires understanding the specific situation at the mill where the reductions are taking place. More information on NO_x can be found in the SO_x and NO_x tab of this website.

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