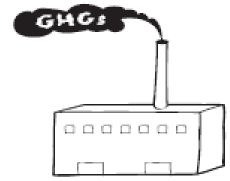

GREENHOUSE GASES

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.

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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