NCASI Fact Sheet
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Conversion of Higher Heating Values to Lower Heating Values for Various Fuels Used in the FPI

The **higher heating value** (HHV, or total heating value or gross heating value) is the heat of combustion ($-\Delta\hat{H}_c^o$) with $H_2O(l)$ as a combustion product, and the **lower heating value** (LHV, or net heating value) is the value based on $H_2O(v)$ as a product. Since $\Delta\hat{H}_c^o$ is always negative, the heating value is positive.

To calculate the LHV of a fuel from an HHV or vice versa, one must calculate the moles of water produced when a unit mass of the fuel is burned. If this quantity is designated n, then:

$$HHV = LHV + n\,\Delta\hat{H}_v\,(H_2O,\ 25°C) \qquad (1)$$

where $\Delta\hat{H}_v\,(H_2O, 25°C)$ is the heat of vaporization of water at 25°C = 44.013 kJ/mol or 18,934 Btu/lb-mole.

Example Calculation

- → Find the LHV of wet Douglas fir bark containing 5.9% H (dry basis), 50% moisture, and an HHV of 4,752 Btu/lb wet bark.
- → 1 lb of wet bark at 50% moisture has 0.5 lb of H_2O or 0.0278 lb-moles of H_2O (0.5/18).
- → 1 lb of wet bark has 0.5 lb of dry bark and thus 0.0295 lb of H (0.5 × 0.059), which will result in 0.01475 lb-moles of H_2O (0.0295/2).
- → Thus, combustion of 1 lb wet bark results in 0.0278 + 0.01475 = 0.04255 lb-moles of H_2O.
- → Using eq. 1, LHV = HHV − n $\Delta\hat{H}_v\,(H_2O, 25°C)$ = 4,752 – 0.04255 × 18,934 = 3,947 Btu/lb and the ratio of LHV to HHV is 3,947 / 4,752 = 0.83.
- → Table 1 estimates this ratio for several fuels that are typically used in the forest products industry.

Table 1. *Conversion of HHVs to LHVs for typical fuels burned in the FPI.*

Fuel Type	Typical % Moisture	Typical % H Dry Basis	Typical HHV, Btu/lb	Estimated LHV, Btu/lb	Ratio of LHV to HHV
Pittsburgh No. 8 bituminous coal[a]	5.2	5.1	12,540	12,028	0.96
Illinois No. 6 bituminous coal[a]	17.6	4.9	10,300	9,733	0.94
Anthracite coal[a]	7.7	1.9	11,890	11,643	0.98
North Dakota lignite coal[a]	33.3	4.5	7,090	6,456	0.91
Louisiana natural gas[a]	0.00	22.7	21,824	19,677	0.90
Distillate fuel oil (No. 2)[a]	0.05	12.9	19,460	18,239	0.94
Residual fuel oil (No. 6)[a]	0.10	10.8	18,200	17,178	0.94
Douglas fir bark[b]	50.0	5.9	4,755	3,950	0.83
Loblolly pine bark[b]	50.0	5.6	4,687	3,896	0.83
Dry wood fuel[b,c] (Douglas fir)	10.0	6.3	8,560	7,918	0.93
Wood chips/screenings (Douglas fir)[b]	50.0	6.3	4,530	3,705	0.82
Low solids black liquor (65% solids)[d]	35.0	3.3	3,900	3,329	0.85
High Solids black liquor (75% solids)[d]	25.0	3.3	4,500	4,003	0.89

[a] *moisture, % H, and HHV from:* Steam, Its Generation and Use. *40th ed. Babcock & Wilcox.*
[b] *% H and HHV from NCASI files*
[c] *Dry wood residues from wood products operations.*
[d] *%H from Adams, T.N., W.J. Frederic, T.M. Grace, M. Hupa, K. Iisa, A.K. Jones, and H. Tran. 1997.* Kraft Recovery Boilers. *Tappi Press.*

Based on Table 1, the following average ratios for LHV/HHV may be used:

- Bituminous coal: 0.95;
- Anthracite coal: 0.98;
- Natural gas: 0.90;
- No. 2 and No. 6 oil: 0.94;
- Bark: 0.83;
- Dry wood residues: 0.93;
- Wood chips/screenings: 0.82;
- Black liquor: 0.87.

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