THE FUEL COMPOSITION-CONVERSION DIAGRAM

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All fuels contain **carbon ('C), hydrogen (H) and oxygen (O)** as the principle energy elements. Their various compositions can be represented on a triangular diagram.* The composition of fuels is determined by a "proximate analysis" of the fuel and is necessary for any scientist or engineer designing conversion for the fuel to heat, power, or other fuels.

I first developed this diagram in 1979 while preparing the "Encyclopedia of Thermal Conversion" (BEF press) in order to explain the composition and conversion processes for biomass. It makes the relationships of hydrocarbon, biomass and all other fuels clear. The arrows show the directions for possible conversion of biomass to other fuels or heat with the arrows indicating the composition change for addition of oxygen or air, steam, hydrogen, and fast or slow pyrolysis. Similar arrows would indicate conversion for all the other fuels.

The diagram is based on the molecular, not the weight composition and so gives similar weight to carbon and hydrogen as fuel components. Note the happy coincidence that products of combustion, CO_2 and H_2O, and the products of gasification, CO and H_2, lie on parallel vertical lines.

Data points are shown for a selection of biomass compositions, chars and various coals. Biomass is a mixture of ~50% cellulose, 25% hemicellulose and 25% lignin, so has no "exact formula". Neither does "oil" or "coal", so for detailed calculations you will need an ultimate analysis. However, generic formulas are sufficient for many calculations. Here are my "generic formulas, sufficient for many calculations:

Natural gas	CH_4
Hydrocarbons	CH_2
Coal (and aromatic HCs)	CH
Biomass	$CH_{1.4}O_{0.6}$
Carbohydrates (sugar, cellulose, …)	CH_2O

In the real world fuels often contain water, ash and varying amounts of nitrogen, sulfur and other elements. The analyses shown here are normalized to only the C, H and O composition. One can think about many other uses for the diagram. One can overlay the energy contents of the various fuels as parallel lines starting from carbon (the highest energy content on a molar basis and proceeding across the diagram to zero at the CO_2-H_2O line.

I hope this diagram helps others as much as it has helped me.

Diagram of the Composition and Conversion Routes of Fuels