heat, process steam and, via co-generation, electricity as well. It can be gasified to provide a fuel gas to replace oil and natural gas. It can be converted to methanol via synthesis after gasification, or to ethanol via fermentation. Finally, by means of slow heating under pressure, it can be converted to oil.

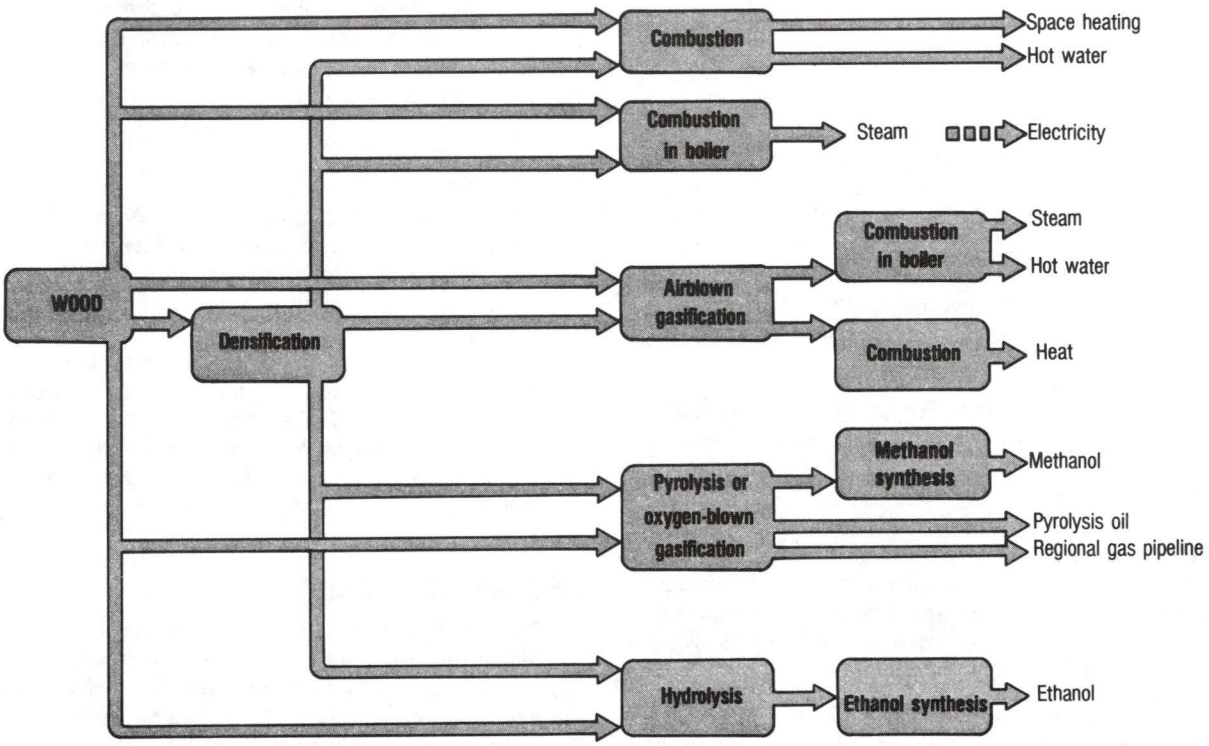
A. DIRECT COMBUSTION OF WOOD AND DENSIFIED BIOMASS FUEL (DBF)

Wood can be burned directly for residential use or for industrial purposes but certain conditions have to be met to maintain a positive net energy balance in exploiting this resource. The energy contained in wood justifies its cutting, handling and transportation for up to 40 to 60 miles depending on the region; however, further processing or transportation means that more energy may be spent in delivering the fuel to the user than is provided during combustion. It does not make good *energy* sense to spend more energy in providing a fuel than is contained in the fuel itself (although such use may be justified in the short term if the wood substitutes for oil). The use of unprocessed wood should remain local then and, fortunately, the wide dispersion of the wood resource very often allows this condition to be met.

Wood tissue is comprised primarily of cellulose, hemicellulose, lignin and water in varying concentrations. Biomass typically has a low *mass* energy density (MED) or low amount of energy which can be delivered per unit of mass. Similarly, biomass has a low *volume* energy density (VED). This is unfortunate as fuels with a high MED (or VED) are preferable to those with a low MED (or VED) because the former type is more efficient to store, ship and burn. Thus the large resources of wood in areas far from population centres or resource utilization locations are not economically exploitable unless they are upgraded or converted to fuels which have a high MED (or VED) before shipping. The prime energy commodities which can be derived from wood and wood waste are densified wood and, as described elsewhere, the alcohols methanol and ethanol. An increase in MED and VED is most desirable because combustion efficiency increases with increasing energy density and low moisture content; the efficiency of boiler heat exchange is a function of the quantity of gas produced from a given volume or mass of wood and the water content of the fuel.

Mass energy density and volume energy density values for raw wood and densified wood are shown in

Figure 6-7: CONVERSION PROCESSES FOR WOOD



Source: United States, Office of Technology Assessment, 1980a, p. 64.