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# PYROLYSIS IN WASTE TO ENERGY CONVERSION (WEC)

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## ABSTRACT

Solid waste (SW), mostly now wasted biomass, could fuel approximately ten times more of USA's increasing energy needs than it currently does. At the same time it would create good non-exportable jobs, and local industries. Twenty four examples of wasted or under-utilized solids that contain appreciable organic matter are listed. Estimates of their sustainable tonnage lead to a total SW exceeding 2 billion dry tons. Now usually disposal problems, most of these SW's, can be pyrolyzed into substitutes for or supplements to expensive natural gas. The large proportion of biomass (carbon dioxide neutral plant matter) in the list reduces Greenhouse problems. Pyrolysis converts such solid waste into a medium heating value gaseous fuel usually with a small energy expenditure. With advanced gas cleaning technologies the pyrogas can be used in high efficiency gas turbines or fuel cells systems. This approach has important environmental and efficiency advantages with respect to direct combustion in boilers and even air blown or oxygen blown partial combustion gasifiers. Since pyrolysis is still not a predictive science the CCTL has used an analytical semi-empirical model (ASEM) to organize experimental measurements of the yields of various product $\{C_aH_bO_c\}$ yields vs temperature (T) for r dry ash, nitrogen and sulfur free (DANSF) feedstock having various weight % of oxygen [O] and hydrogen [H]. With this ASEM each product is assigned 5 parameters (W, $T_0$, D, p, q) in a robust analytical Y(T) expression to represent yields vs. temperature of any specific product from any specified feedstock. Patterns in the dependence of these parameters upon [O], [H], a, b, and c suggest that there is some order in pyrolysis yields that might be useful in optimize the throughput of particular pyrolysis systems used for waste to energy conversion (WEC). An analytical cost estimation (ACE) model is used to calculate the cost of electricity (COE) vs the cost of fuel (COF) for a SW pyrogas fired combined cycle (CC) system for comparison with the COE vs COF for a natural gas fired CC system. It shows that high natural gas prices solid waste can be changed from a disposal cost item to a valuable asset. Comparing COEs when using other SW capable technologies are also facilitated by the ACE method. Implications of this work for programs that combine conservation with waste to energy conversion in efforts to reach Zero Waste are discussed.

## 1. WASTED SOLIDS AND SOLID WASTE

In 1940, when Britain was in deep trouble fighting a ruthless enemy that then appeared unstoppable, Winston Churchill offered only "Blood, Sweat and Tears" to unite Britain's political factions. At this time in our history we are excessively (60%) reliant on foreign sources for our liquid fuels and are increasingly importing our gaseous fuels (now>15%). Our country is now shedding Blood in its efforts to stabilize regions of the globe that supply these premium fuels. Yet the US is well endowed with solid fuels in the form of wasted solids as well as coal and oil shales. In this paper, in continuation of a long search for alternatives to oil [1-10], our focus is on converting our solid waste to energy by advanced thermal technologies (SWEATT). Table 1 is a list of US's abundant supply of wasted solids or solid waste whose organic matter can be made into liquid and gaseous fuels. With recent high natural gas prices and technical reasons that will become obvious this paper will concentrate on advanced thermal technologies (ATT) conversions of solid waste (SW) to gaseous fuels. ATT conversions to liquid fuels involve similar technical considerations but the oil back-out problem has the attention of many government, business and engineering personnel. SWEATT has the attention of only a few.

In the US most of the categories in Table 1 would now be called "biomass" in part because "solid waste" has a bad public image, bringing to mind old incinerators belching black smoke. However, advances in thermal technologies and gas clean-up systems now being successfully applied in Japan and the European Union (EU) [11] deserve a new image. SWEATT not only addresses US's very urgent need for alternative fuels, but could also mitigate air and water pollution problems. The large carbon dioxide neutral plant matter components in Table 1 can help in Greenhouse mitigation. The great diversity of physical and chemical characteristics in Table 1 implies that the world now needs an "omnivorous feedstock converter" (OFC) to change these solid fuels into much more usable liquid or gaseous fuels. Figure 1 is a conceptual illustration of an OFC adapted from a number of prior CCTL papers [8-10].

Figure 2 shows the subdivisions of the US total primary energy supply (TPES) in 2005. The data (in quadrillion British thermal units (Btu) or quads) is taken from the January to October 2005 monthly numbers given in US Energy Information Agency website [12] augmented with estimates of the November and December 2005 consumptions. Since the total consumption is now very close to 100 quads the numbers might also be considered as approximate percentages of US energy consumption. It is seen that over 40% of our energy consumption is in the form of oil that is mainly consumed in our transportation sector. Without doubt the biggest energy problem faced by the US today, as has been recognized for many years, is the need to find alternatives to oil [1-3]. In the 70's and early 80's the CCTL focus was on alternatives to oil in the utility sector. At this time, our focus is on the developing alternatives to natural gas for electricity generation