An Examination of the Justification For a Biomass Boiler

1 Synopsis

Linden Homes/Galliford Try argue that another 40 Luxury apartments are required to finance an 'Eco-friendly' wood chip boiler plant that will provide the heating needs for 132 apartments. This argument does not stand scrutiny in terms of cost justification and eco friendliness. Further it can be shown that this biomass burning boiler will, both directly and indirectly, create a significant amount of pollution.

2 Cost Justification Fallacy

If we assume the following:

- Heating for 131 apartments
- Wood chip usage at 4 tonnes (dry) per year per apartment (averaged for a two and three bedroom apartment mix) [1]
- £330/kW boiler capital cost [2]
- 1.84 kW/tonne boiler output [2]

Calculated Capital Cost will be:

131 x 4 x 330 x 1.84 = £318,173

This would most likely qualify for one or more of the energy savings capital allowances, such as the 'Bio-Energy' capital grant of 34% [2] or the 'The Enhanced Capital Allowance (ECA) scheme [4] which enables businesses to claim an "enhanced" 100% capital allowance on investments in energy-saving equipment, during the first tax year. Given that the proposed three bedroom penthouse apartments will probably sell for over £1 million, it will take only take one such apartment to pay for the boiler plant rather than the 40 extra apartments claimed. The management company could easily finance this separately through service charges as most bio-fuel plants have a 10-25 year payback period.

3 Eco Friendliness Fallacy

3.1 Emissions and Air Quality

Wood energy systems, when they replace fossil fuel systems, can significantly reduce carbon dioxide emissions, but like those fuelled by oil, gas, or coal emit dozens of exhaust components [6]. Those considered major or "criteria" pollutants are discussed below.

Key emission components:

- Particulates. These very fine solid and liquid particles are the emission from biomass combustion that is of greatest concern. Biomass particulate emissions are higher than those from oil or gas plants. For this reason, it is important to include a stack high enough to effectively disperse emissions into the air.
- Oxides. Compared to fuel oil, biomass systems have one sixth the emissions of sulphur dioxide, which causes acid rain. Wood and fuel oil combustion emit similar levels of nitrogen oxide, which causes ozone, smog, and respiratory problems. All fuel combustion produces carbon monoxide, which is a pollution concern primarily in urban areas with already high CO levels. Wood combustion produces more CO than oil, though tuning of the system reduces this.
- Volatile organic compounds. This large family of pollutants is emitted by both oil and wood combustion (and to a much lesser extent, by gas), in varying degrees.

It has been shown that biomass combustion can be a significant source of aerosol emissions and of emission of fine particles in the ambient air (PM-10, PM-2.5, PM-1) [8]. For this reason, several countries consider the reduction of aerosol emissions from biomass combustion as one of the priority research areas of bio-energy [8].

Particulate matter (PM) is a mixture of particles that can adversely effect human health, damage materials and form atmospheric haze that degrades visibility. PM is usually divided up into different classes based on size, ranging from total suspended matter (TSP) to PM-10 (particles less than 10 microns in aerodynamic diameter) to PM-2.5 (particles less than 2.5 microns). In general, the smallest particles pose the highest human health risks. PM exposure can affect breathing, aggravate existing respiratory and cardiovascular disease, alter the body's defence systems against foreign materials, and damage lung tissue, contributing to cancer and premature death. Individuals with chronic obstructive pulmonary or cardiovascular disease, asthmatics, the elderly and children are most sensitive to the effects of PM [12]. More than 40,000 Americans die each year from illnesses caused by breathing particulate matter (PM). As with the effects of carbon dioxide (CO_2) and nitrogen oxide (NOx), the elderly and children are most susceptible to illnesses as a result of exposure to PM [10].

3.2 Wood Chip Delivery Pollution Contribution

If we assume the following:

- 950 tonnes green wood chip per year (See Sec 3.3)
- 100 miles average distance for sourcing wood chip.
- 13 tonne tipper truck (maximum for London street access)

We can estimate the total delivery truck miles (round trip) as:

(950 / 13) x 2 x 100 = 14,615 miles

This is significant mileage, some of which will be in London and local streets. The additional pollution generated by diesel delivery trucks cannot be dismissed.

Diesel fuel contains more than 40 toxic air pollutants (as listed by the US EPA), many of which are known human carcinogens. In the United States alone, diesel particulate pollution is responsible for causing over 100,000 cases of cancer. (From: "Health Effects of Diesel", Clean Air Network, May 2000) Also, diesel emits approximately 62% more NOx than CNG. [10]

“Pollution from diesel engines is one of the most critical air pollution problems in the United States. You know that a vehicle is using diesel when you see black, sooty exhaust being spouted from a vehicle’s tailpipe. Although only 2% of all vehicles in the U.S. run on diesel, they cause 27% of the smog-forming pollution and 66% of the soot produced by all of the nation’s motor vehicles. Since most vehicles that use diesel are heavy duty (trucks, buses), the harmful emissions from diesel are produced in huge amounts. Big trucks and buses are responsible for more than 15% of the transportation-related emissions of CO2 and this proportion is growing faster than CO2 emissions from other sources. One diesel truck can emit as much pollution as 100 cars. Diesel-powered vehicles account for nearly half of all NOx emissions and more than two-thirds of all particulate matter (PM) from US transportation sources.” (From: Union of Concerned Scientists, "Diesel Engines and Public Health") [10]. Particulate matter (PM) released by fossil fuel combustion is of extreme concern to human health [10].

3.3 Wood Chip Delivery Carbon Contribution

For bio-fuels to be truly green, it is necessary for them to be produced and transported with zero CO_2 emissions. Hence the supply of wood chip should be as local as possible, so reducing the amount of diesel used to deliver the wood fuel. We can estimate the amount of CO_2 produced, and use this to gauge how green the boiler plant is overall.

If we assume the following:

- Heating for 131 apartments
- Wood chip usage at 4 tonnes (dry) per year / apartment (averaged for a two and three bedroom apartment mix) [5]
- Wood chip is delivered green (moisture content assumed at 45%).
- Heavy duty truck ~ 80 ton-miles per US gallon of diesel fuel [9]
- Each litre of diesel fuel produces 2,730 grams of CO_2 [10]
- 1 litre = 0.26 US gallons
- 100 miles average distance for sourcing wood chip (assume trucks empty on return)

Weight Green Wood Chip required per year:

4 * (100/(100-45)) * 131 = 950 tonnes green wood chip per year

Amount of Diesel Fuel required:

(950 * 100)/80/0.26 = 4567 litres

Amount of CO_2 Produced:

4567 * 2730 /1,000,000 = 12.47 metric tons CO_2

From this we can see that the wood chip burner is not green overall due to the CO_2 contribution by diesel delivery trucks. Biomass fuels only make environmental sense when fuel can be sourced locally.

4 References

1 Addendum 5 - Typical UK House Heat Demand

2 www.wood-fuel.org.uk/resources/bmbc_biomass_cabinet_report_may04.doc

3 http://www.lowcarbonbuildings.org.uk/about/grants

4 http://www.woodenergyltd.co.uk/

5 http://www.cep.org.uk/downloads/8_-_wood_fuel.pdf

6 http://www.biomasscenter.org/information/emissions.html

7 http://www.fosterwheeler.com/publications/tech_papers/files/InitialOperatingExperienceThreeNewHighEfficiencyBiomassPlantsGer.pdf

8 http://www.ieabcc.nl/publications/Task%2032%20end-of-task%20report.pdf

9 Sources: FHWA's *Highway Statistics* and the Association of American Railroads' *Rail Facts*, both as reported by the Bureau of Transportation Statistics

10 http://www.nyc.gov/html/dot/html/motorist/alternativefuel.html

11 Ambient Elemental Signatures of Diesel and Automotive Particulate Matter by Size, Time, and Composition. DELTA Group, University of California, Davis,

12 http://www.scorecard.org/env-releases/cap/pollutant-desc.tcl

5 Addendum - Typical UK House Heat Demand

Typical house heat demand (space and hot water) and wood fuel requirements							
	Terraced 2 Bed						
	11500	kWh					
	41400	MJ					
	70%	efficiency					
	3.3	tonnes - dry					
	0.3	ha					
	3 Bed Semi						
	15500	kWh					
	55800	MJ					
	70%	efficiency					
	4.4	tonnes -dry					
	0.4	ha					
	4 Bed Detached						
	23000	kWh					
	82800	MJ					
	70%	efficiency					
	6.6	tonnes -dry					
	0.7	ha					
assuming 18 GJ/tonne dry matter and 10 tonnes/ha yield							

Table 1.0 Typical UK House Heat Demand