Carbon Saint Or Carbuncle?

Following on from his article in the July issue, **Jerome Baddley**, Nottingham Energy Partnership's sustainable energy development manager, asks whether changing waste mix continues to have the same impact on EfW's carbon efficiency

Incineration and energy from waste (EfW) have been associated with Nottingham since the development of the first "destructor" technology by Manlove, Alliot and Fryer in 1887, which was exported worldwide from their Nottingham factory.

Nottingham's current plant has operated since 1975, providing heat and electricity for the UK's largest district heating network and is currently applying for permission to expand. Key to the current expansion in Nottingham is the city's desire to provide secure, low-carbon, low-cost, energy to local homes and businesses in the context of climate change, dwindling landfill capacity and increasing natural resource and energy costs.

There is a key question, however. Does EfW save carbon? In my previous article in July I raised the issue that EfW, at least in Nottingham for now, saves CO_2 emissions versus the equivalent gas and electricity from the mains. However, with a changing waste mix this may not always be the case. This is worth looking at in more detail…

A simple carbon intensity trend for the heat arising from the Nottingham incinerator can be derived from the total Environment Agency (EA) reported stack CO_2 emissions divided by the total energy export. This includes both biogenic (ie biomass derived) and fossil CO_2. While there are arguments for controlling both, it is the fossil derived CO_2 and other greenhouse gasses (GHGs) that controlled and targeted through climate change legislation.

Currently incinerators, while emitting considerable amounts of GHG and required to report emissions to the EA, are exempt from the EU Emissions Trading Scheme.

From Figure 1 it is clear the CO_2 emissions from incineration in Nottingham on an upward trend. A fairly consistent 155Kt of waste has been burnt each year. The most likely cause for the trend is the increasing amount of plastic or fossil derived waste in the fuel mix. The amount of energy exported annually has declined slightly, but by a far lower gradient.

To see whether EfW can save carbon versus gas and electricity, we need to know the "fossil carbon" emissions factor for heat arising from EfW.

Spot waste sampling has taken place to establish a *de minimis* biogenic heat fraction and renewables obligation allocation for the heat arising, however unless carbon-14 sampling is put in place, data on fossil CO_2 has to be estimated.[1] It is, however, possible to make a ranged estimate using the key variables.

Key variables	Range for Incinerator derived heat
% by weight of plastics and other fossil derived combustibles	Nominally estimated as 10%, With 40% of Nottingham's homes recycling, could be as high as 13.8%
Calorific value of Municipal Solid Waste (MSW)	The calorific value of MSW in Europe falls between 7.5Mj/kg and 10.5Mj/kg
GHG CO2 emitted per tonne of plastic	2,182kg (IPCC and low calorific value plastic) 2,750kg (EU ETS and CRC)
% waste from recycling homes	40% in Nottingham
Minor variables	
Incinerator heat harvest efficiency	From analysis in Nottingham 90-95%
Ferrous metal reclaim	
Fuel oil burnt at start up	

Table 1: key and minor variables for establishing carbon emissions in incinerator derived heat

MSW Calorific value	Energy generated from 1000 tonnes (MWh)	Kg GHG CO2 per tonne plastic	@ 10% plastic Kg CO_2	@ 13.8% plastic Kg CO_2	Incinerator heat harvest efficiency (thus, correction factor)	@10% plastic ($kgCO_2$ / kWh)	13.8% Plastic ($kgCO_2$ / kWh)
10.5Mj/kg (2.92kWh/kg)	2920	2182	218.2	301.1	95% (x1.04)	0.078	0.107
		2750	275	379.5	95% (x1.04)	0.098	0.135
		2182	218.2	301.1	90% (x1.11)	0.083	0.114
		2750	275	379.5	90% (x1.11)	0.105	0.144
7.5Mj/kg (2.08kWh/kg)	2080	2182	218.2	301.1	95% (x1.04)	0.109	0.151
		2750	275	379.5	95% (x1.04)	0.137	0.19
		2182	218.2	301.1	90% (x1.11)	0.116	0.161
		2750	275	379.5	90% (x1.11)	0.147	0.203

Table 2: carbon emissions factor for energy from waste derived heat based on the range analysis of key variables

The resulting emissions factor for EfW is then between 0.078kg/kWh and 0.203kg/kWh, or around 26-68 percent of the total average stack CO_2 emissions.

The actual average calorific value figure for Nottingham (including heat reclaim efficiency losses) from 2001-2010 was about 9.4MJ/kg (2.61kg/kWh). Assuming 13.8 percent plastics and the lower emissions factor for plastic, this could put the Nottingham factor at 0.115kg/kWh, though with the higher EU ETS plastics factor it would be 0.145kg/kWh.

It is notable that in the Government's SAP figures the emissions factor for heat from EfW is set at 0.047kg/kW.[2] This was based on BRE calculations using the BEAT tool, assuming high calorific RDF with only a 10 percent plastic content.[3] Clearly this is wrong in the case of a MSW incinerator like Nottingham's and probably most other sites. The factor will also become increasingly wrong, as the waste mix changes.

The Carbon Reduction Commitment (CRC) guidance on EfW uses the EU ETS factor of 2750 kg CO_2 per tonne for plastic and the 10 percent composition estimate, which in Nottingham would lead to an emissions factor of 0.105kg/kWh, still more than double the Government's SAP guidance.[4]

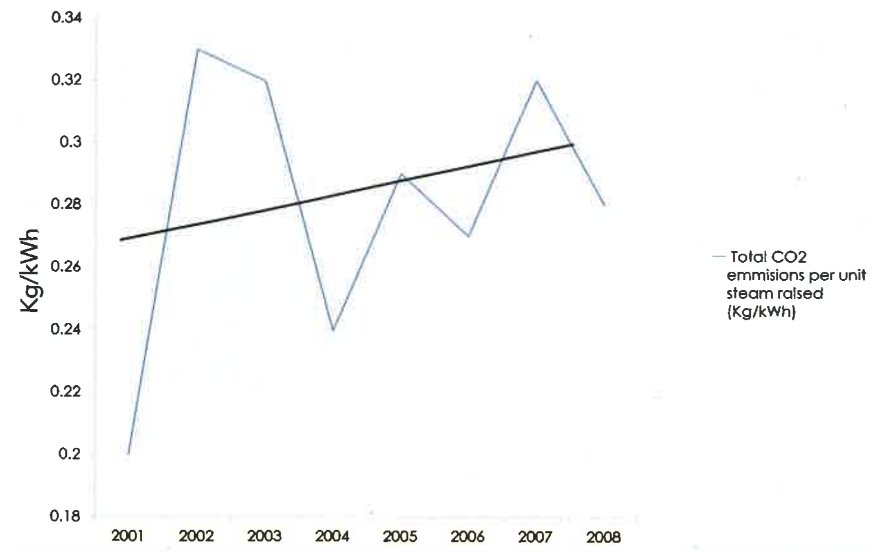

Figure 1: total stack CO_2 emissions per unit steam raised (Kg/kWh)

Heat And Power

INCREASINGLY CONSUMERS, developers and public bodies are looking for low carbon energy solutions. While incineration certainly has a role in waste management, can EfW provide this or not, and how low carbon is the heat: is it better than grid gas and electricity? These are critical questions.

Using the Nottingham calculations in Table 2, the Nottingham incinerator could be emitting 47-58Kt fossil CO_2 per annum. The CHP energy centre turns out typically around 183 GWH of energy; 49GWh electricity for export and private wire and 134GWh heat for DH.

58Kt/183GWh=0.316kg/kWh
47Kt/183GWh=0.256Kg/KWh

By comparison, heat derived from gas has a delivered factor of 0.248kg per kWh, and grid electricity at 0.594kg per kWh.[5,6]

There are no rules on weighting of carbon between heat and power in private networks. One approach would be to weight exported electricity the same as grid (0.594kg per kWh) – the heat in Nottingham could then be given a factor of 0.134-0.216kg per kWh. Even including 10 percent distribution losses, heat would be lower carbon than gas but, at the upper range, not by much.

Only a factor at the lower end of the range (40 percent less than gas) would really be sufficient to drive the expansion of an EfW district heating scheme in local planning, or be attractive to developers looking to connect low carbon buildings. This said, heat and power supplied from the network is zero carbon for the purposes of CRC, as all the carbon is a responsibility of the heat network operator.

To see if it can save carbon versus gas and electricity, we need to know the 'fossil carbon' emissions factor for heat arising from EfW

In fact there is no onus on district heating operators to use accurate figures at all. The figure used for the heat arriving from an incinerator can be rated as 0.047kg per kWh, from the SAP guidance. In Nottingham's case both this and the CRC could justify the networks claim to zero carbon heat and zero carbon private wire electricity, even accounting for further CO_2 from gas CHP.

In my last article I suggested a renewable obligation for incinerators to ensure a minimum biomass fraction, so that the heat networks they feed remain low carbon and valuable biomass is burnt where it is of most use. Of course this only makes sense if we use real figures for the carbon emissions from EfW in the first place.

At a time when EfW is making a resurgence there is an urgent need for clear, honest and consistent rules for associated heat and power networks on energy and carbon accounting. The monitoring technology is readily available in the form of carbon-14 flue gas sampling; this also allows more accurate claims for biogenic heat generation for the Renewable Heat Incentive and Renewables Obligation subsidy schemes and could potentially save some operators money on CRC carbon costs.[7,8] Alternatively we may simply be ushering in an era of municipal plastics fired power stations, while 10 percent of the world's biomass is burnt at plants like Drax.[9] CIWM

A full set of references are available on request from ben.wood@ciwm.co.uk