Annex B. Alternative Technologies

Preface

Marketing confusion and spin means that we have to start with definitions. What is being proposed by Bucks County Council (BCC) for Lower Greatmoor Farm (part of the Calvert site near Grendon Underwood) is a mass burn incinerator (MBI) at this single central location in Buckinghamshire. What SAVI is proposing, at several decentralised locations, is one of several advanced thermal technologies (ATTs) which include gasification, pyrolysis, and plasma/ ultraviolet gasification to dispose of the county's Municipal Solid waste (MSW). The two technologies are also often lumped together under the banner of incineration. Proponents of mass burn incineration take advantage of this confusion to claim the benefits of the more advanced techniques and apply them to mass burn incineration. This spinning of information has been effectively used to persuade individuals, not inside the waste industry, of the benefits of mass burn incineration. The reality is that there are substantial inefficiencies and faults with mass burn incineration that are admirably overcome by the more modern techniques but the lines are blurred and public opinion is not always evenly educated or informed to the differences, advantages and disadvantages. This paper aims to correct that.

Mass Burn Incineration

This is often referred to as EfW – Energy from Waste – but this is more spin because, as this paper will show, ATTs are much more efficient at generating energy from waste. Mass burn incineration involves burning waste in the presence of air at relatively low temperatures[1]. Steam for electrical generation is produced as well as substantial base and fly ash (both of which are officially classified as hazardous), carbon dioxide and particulate pollution.

Several **advantages** are claimed for mass burn incineration:

a) Proven with an established track record;
b) Cost efficient in that it is cheaper than landfill and avoids landfill tax and landfill accelerator tax (applicable to bio wastes), both of which are set to increase annually in the foreseeable future, and so has come to be viewed as a cheap disposal method;
c) One stop solution to a big problem and only one planning application is required while multiple smaller recycling and treatment plants will take longer to come online and may not be so reliable or financially sustainable in an economic downturn.

But there are also **disadvantages** using mass burn incineration:

a) Needs to be very big to achieve economies of scale and this means centralisation (ATTs on the other hand are generally smaller and thus avoid centralisation). Centralisation has implications for the generation, transport and supply of waste.
b) Is only one level above landfill as a waste disposal technique – land-filling is viewed as the least suitable method of waste disposal. The Scottish Green Party refers to MBI as "landfill in the sky" and the Scottish Parliament has now banned MBI.
c) Only reduces waste by 2/3rds – the technique does not eliminate waste. Under the present proposal for Lower Greatmoor Farm 100,000 tonnes of base and fly ash will need to be disposed of in landfill or reprocessed as a construction aggregate. Glass, stone, minerals and similar wastes can not be burned. Fly ash from mass burn techniques is unstable, highly toxic, and officially classified as hazardous. This means either:
    - That Calvert landfill needs to be licensed to accept such waste. Planning permission for this license has not been secured and the residents of the neighbouring villages have not been informed of this development. If the license is granted then the Calvert landfill site will almost certainly attract other countrywide hazardous wastes including power station base and

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[1] 850^{o} C is the legal minimum temperature for waste incineration. MBI is generally a bit above this, but generally not above 1100^{o}C. Problems of toxic emissions arise particularly when MBI is firing up or cooling down due to breakdown and maintenance, By contrast, ATTs burn at very much higher temperatures and as a consequence have lower toxic emissions, especially dioxins. Indeed, most ATTs don't even have a chimney, and emissions are only those from the exhaust gases from power generators.

fly ash (high mercury content). This will lead to increasing traffic incidence and increasing the threat to health.

- Or that the waste is again transported to one of only 12 such sites in UK. This will anyway have to happen when Calvert landfill site is filled. This will result in more traffic movements.

d) Is a very inefficient method of electricity generation, only 15% efficient, i.e. 85% of the waste's energy value is lost.
e) Counters the UK council's directive of the 'proximity principle' (not carrying waste excessive distances from the point of generation to treatment/ disposal). 10% of all UK traffic movements are related to the waste industry.
f) Will militate against recycling because of the contractual requirement for minimum volume. More specifically this:
   - Will seriously reduce, perhaps even eliminate, the opportunity for the private sector to create recycling businesses within Buckinghamshire or the surrounding area.
   - Reduce access to recycled products such as garden mulch, wood chip or stone aggregate which will have to be transported in from further afield. Once again, this will further increase traffic movements.
   - May undermine existing recycling businesses' viability as waste producers may cease to separate waste.
   - Only ferrous metals will be recovered from the mass burn incineration process by magnets
   - Will counter Europe's and the UK's directives to salvage value through recycling
g) Will close off the opportunity for clean and efficient generation of electricity for in excess of a generation – a very substantial lost opportunity considering the predicted shortfall in electricity production.
h) Has hidden, increased and difficult to quantify health and transport costs.
i) Is unsustainable in that input quantities, costs and social costs are far greater than the benefits.

Finally, mass burn incineration has been verbally derided by representatives of WRG, one of the two "preferred bidders" to build the proposed incinerator, as inferior technology. It is BCC's waste strategy that is at fault.

Characteristics of the waste destined for the mass burn incinerator

The county local waste amounts to 140,000 tonnes per annum (and falling because of improved recycling at household level). The capacity and design load of the incinerator is 300,000 tonnes per annum. The result is that a minimum of 160,000 tonnes will have to be imported from outside the Buckinghamshire catchment.

According to WRG, 50% or prospectively 150,000 tonnes of the total is bio waste. The remainder is domestic black bag waste and commercial waste. One of the characteristics of commercial waste is that it is often more homogenous than domestic waste. It is therefore often easier to treat/ recycle as the waste's characteristics are narrowly defined.

BCC's tender parameters.

BCC tender document requests that thermal treatment is to be used for the treatment of MSW waste arising in the county. The extra 160,000 tonnes arising from outside the county is an opportunity taken by WRG and is not part of the BCC tender document.

We have said above that it is BCC's waste strategy that is at fault. Overall, this is true, but it should also be mentioned that BCC only specified thermal treatments for their own waste in 2005. At the time, mass burn incineration was the only practical thermal solution, partly because they were dealing with largely black bag waste. But now WRG have taken the opportunity to introduce large amounts of bio-waste to the incinerator (bio waste would attract the landfill accelerator tax if put into landfill), completely bypassing the recycling route.

BCC requests that the technology be bankable, i.e. Robust, Reliable, Proven, and Cost efficient. The argument put forward by BCC is that landfill is too expensive (because of fines imposed ultimately by the EC), the remaining space is at a premium and incineration is the only option. BBC also states that there is no track record that shows that gasification and plasma pyrolysis can handle the variability of MSW. BBC also states that the electricity produced from the incinerator adds to the overall argument for incineration.
So perhaps we should modify our statement that BCC's strategy is flawed. It's out of date and has been overtaken by events.

Alternative technologies for the treatment and disposal of Bucks' (and other) waste

a) Bio-wastes

Given the high proportion (50%) of bio-waste there is a clear opportunity to use several well understood and established methods to recycle or better still re-use bio-waste. Bio-waste covers: food waste; slurry and sewage; park and garden waste; wood waste; animal bi-products (manure and abattoir waste).

Bio-waste characteristics:

- One of the difficulties with processing food wastes is separating it from other wastes. There are successful technologies that can separate bio wastes from non bio waste streams.
- Park and garden wastes, animal bi- products and wood wastes are often separated at source and are therefore straightforward to recycle.
- Additionally bio-wastes are heavy/ bulky/ uneconomic to transport and the value derived from their reprocessing is generally not high.
- A high proportion of bio waste is water often up to 50% by weight. Therefore the most efficient location for treating bio waste is close to its point of origin.
- Note: there are some innovative companies such as Argent that manage to reprocess abattoir waste into biodiesel

b) Composting - open windrow

This is involves shredding park and garden waste so that carbon (in wood) and nitrogen (in leaves and grass mowings) combine with water and oxygen in the presence of bacteria to breakdown into a clean mulch. The waste is heaped into windrows and turned periodically to add oxygen.

Advantages: well understood; low cost; clean and proven; produces a local organic natural fertilizer/ soil conditioner that can displace artificial fertilizers; high recovery value; kills weed seeds, pests and diseases; natural process.

Disadvantages: space hungry; time consuming (3 month turn around); low value final product that can be difficult to dispose of as it is produced seasonally; large waste wood fraction takes years to decompose.

c) In vessel composting

Similar to open windrow composting but 'in vessel' means that the process takes place in a building. This often enables food waste and animal bi-products to be safely composted in highly controlled environments. A higher value end product is achieved.

Advantages: accepts a more diverse and dangerous bio waste stream than open windrow composting (includes animal bi products and food waste); higher value end product; fewer bio-aerosols and can therefore be located near domestic houses/ industrial parks; faster process than composting; highly controllable.

Disadvantages: higher start up cost can limit capacity; planning permission is more difficult to achieve; more time consuming than thermal treatments.

d) Anaerobic digestion

Popular throughout the developed and developing world at both industrial and micro scale for the production of combustible methane gas from organic hydrocarbon based feedstocks (bio-wastes). Process involves shredding bio-wastes and then adding water and heat in the absence of oxygen. Methane is given off as the feedstock degrades and this gas is either used as a fuel on-site or sold to the highest bidder.

Methane is a versatile fuel that can be used in internal combustion engines, or fuel cells for the production of heat or electricity.

Advantages: diverts harmful greenhouse gases to produce a valuable fuel; small footprint; valuable by-product (soil conditioner/ combustible fuel); well understood process; provides an economic bridge between waste management and power production; provides locally produced variable load electric power; wide scope for power production and waste disposal of agricultural wastes are considered. Note AD plant under construction in Bedfordshire.

Disadvantages: high feedstock collection costs; fibrous end product destination can be an issue at certain times of the year.

e) Non bio-waste fractions

The mantra 'Reduce, Re-use, Recycle' (3Rs) is ignored by mass burn incineration (except for ferrous metals). The objective of the landfill tax and the 3Rs is to preserve scarce resources and reduce greenhouse gas emissions from landfill sites.

Recycling – there is increasing evidence that a proportion of the 140,000 tonnes of waste that arises could be recycled – cheaply, profitably and easily. In the north of the county there is no green waste collection, food waste collection or clothing waste collection. Green waste collections represent 30% of the domestic waste stream by weight. Currrently a householder without a compost heap in the north of the county would have to drive to a collection centre to recycle green waste. There are recycling points for clothes at supermarkets but the rate of recovery by using this method of collection is far lower than the kerbside collection technique.

As an example, the schools in Swanbourne employ over 150 people at the 4 schools and educate in excess of 700 pupils. Yet there are no recycling facilities for clothes, food or green waste at this obvious hub. The same is true for Stewkley which is one of the most highly populated villages in the county. When AVDC were contacted about providing extra bins at 'bring sites' or recreation grounds we were told that that there were no plans for a green waste, clothing or food waste collection service – only the possibility of a cardboard bin at some point in the future – but nothing was decided as the price of cardboard had fallen.

Mass burn incineration ducks under the landfill tax and landfill accelerator tax radar and destroys any value that might be recovered. There are many directives local, UK-wide and European that encourage authorities to recover what can be recycled economically. Recovering marginal amounts of recyclable material is progressively expensive and after a certain point is not worth the effort and resources to collect marginal recyclable material. In the midst of the recession it can also be the case that the prices of recycled commodities can fall to below the cost of collection. A collection authority will only undertake a recycling drive if it is worthwhile financially – or the resulting fines (e.g. for landfill) make it a financial necessity.

So there is always a proportion of the waste stream that will not be composted or recycled. The question of how best to deal with this MSW fraction is paramount. Landfill and incineration have been two common methods but both are now frowned upon for sound and established scientific and social reasons.

f) Landfill

Landfill sites (LS) are unhealthy, unsightly, dangerous and open to extreme abuse. LSs produce large quantities of greenhouse gas in the form of methane. Methane can be harvested for electricity generation once a cell has been capped. The problem is that most of the methane escapes to the atmosphere whilst the LS is being filled and before it is capped and collected. Even when the cell is capped, a proportion of the methane always escapes. The amount of methane generated by LSs reduces over time making its collection uneconomic – methane collection is often abandoned at this point but the harmful methane greenhouse gas continues to be produced and released to the atmosphere almost indefinitely.

Additionally LSs are open to intentional and unintentional abuse. The waste business is difficult to monitor or police, and is often corrupt. Thus hazardous materials get into LSs that are not licensed to take hazardous wastes – nuclear waste, animal carcasses, pesticides and heavy metals are all dumped in LSs illegally. Furthermore, the linings on LSs are pierced from time to time and this leads to soil and groundwater contamination, even in heavy clay areas such as Calvert. Groundwater eventually ends up in drinking water or in the sea. Remediation work is prohibitively expensive.

Following recent penalty fines by the EC on UK, landfill is currently taxed by central government at £40/t., a figure that is set to rise by £8/t annually up to 2013 when it will be £72/t. Clearly BCC must try to avoid this potential £10 million tax. Although the last thing the EC intended was to trigger a rush by UK county councils to MBI, this is actually what seems to have happened in many cases, including the BCC. Seemingly as a consequence of this over-reaction, the Scottish Parliament has recently banned MBI[2]. And the Irish Government is now considering an incineration tax to balance the landfill tax[3]. BCC's planned MBI of 300,000t will produce about 100,000t of bottom and fly ash. All the fly ash is classified as hazardous and must be disposed of at a designated hazardous landfill site[4]. A proportion of the bottom ash must also go to landfill. So MBI will not completely avoid landfill, it will only reduce it. ATT, by contrast, delivers no residue that has to go to landfill.

LSs do have one important advantage over mass burn incineration. The value of the waste is not destroyed and it is possible to store and mine high value products such as aluminium, iron and batteries in LSs if the economics improve. In Japan and the USA, mining rare earth metals for lithium battery production has been common practice for years.

So on a local and global basis LSs represent a solution that can accept almost anything but there are many potentially catastrophic downsides.

So is there a bankable reliable silver bullet, given the characteristics of the waste, the problems of the disposal, and the recycling and recovery technologies?

It follows from the discussion above that the optimal solution is one that:

1. recovers recyclable waste fractions
2. disposes of the non recyclable fraction with no dangerous residue
3. produces high efficiency electricity output or combustible gas

It is increasingly evident that the present and future route of the waste industry will be partly defined by its ability to mesh with the electrical generation industry and produce power. Indeed in several countries waste and energy are combined under one government ministry. That is not the case in UK, but government is showing its encouragement by awarding double Renewable Obligation Certificates to the most efficient disposal techniques that can produce electricity. Presently the waste industry has not made significant inroads into the power market and vice versa. The mass burn incinerator is being viewed almost solely as a disposal technique for the county's and London's waste. Its power generation efficiency levels are so low that it is almost laughable to view it (as it likes to be known) as an Energy from Waste facility.

The reality is that the possibility exists for the chosen operator and the BCC to derive substantial revenue streams if the correct strategy is put in place and the correct technologies are then contracted to implement that strategy.

So there **is** a silver bullet to this waste problem. As well as (1) recovering the recyclable waste fractions, the technology can satisfy (2) and (3) in a reliable, efficient, inexpensive (and indeed profitable) manner.

The technique of disposing of waste and recovering gas/electrical power is encompassed under the heading of Advanced Thermal Treatment (ATT). ATT involves heating waste until the waste breaks into synthetic gases (syn gases). The syn gases are hydrogen and carbon monoxide. Each of these gases can be combusted separately to create electricity and /or heat or drive an engine/ fuel cell. Alternatively the gases can be collected stored and sold to the highest bidder.

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[2] http://www.newdesignworld.com/press/Society/Greens_win_Holyrood_Vote_against_Landfill_in_the_Sky/
[3] http://www.mrw.co.uk/page.cfm/Action=Archive/ContentID=1/EntryID=5436.
[4] Incidentally, if the Calvert/Lower Greatmoor Farm site is re-designated as a hazardous landfill site, this is likely to attract hazardous materials (and associated traffic) from outside the county as there are only 12 hazardous landfill sites in England.

There are many variations on the ATT process:
At one end of the scale, gasification involves heating in the presence of air, and burning the resulting gas to produce electricity and at the other end, plasma pyrolysis takes place in the absence of oxygen and in the presence of very powerful plasma or ultra violet light. Presently there is increasing interest shown in gasification techniques in the UK. The Isle of Wight has bought a system made by Energos that will gasify all 30,000 tonnes of the island's MSW. There are many further operational or planned projects in the UK and around the world. Gasification plants are scalable and can be tailored to fit the particular needs of an area – they are more efficient, smaller, safer and cheaper than MBIs.

Incidentally, research carried out by Energos has shown that the need for multiple transfer stations dramatically reduces if well placed gasification plants are installed as the need to bulk up waste reduces as the distances needed to travel from waste arising to disposal reduces.

The further towards the plasma pyrolysis end of the scale the technology is, the higher the temperature and the more efficient and safe the process. Plasma pyrolysis has been used for 50 years for the combustion of hydrocarbons and it is well understood. More recently plasma pyrolysis has been used for the treatment and extraction of value for waste streams. In Japan the Utashinai waste-to- energy facility has been producing electricity from MSW waste since 2003. During that time the plant's downtime is equal to only 5%, a very low value in the waste industry. This plant processes 55,000 tonnes each year and an equivalent plant would cost £40-50 million compared to an estimated £127 million for BCC's planned 300,000t MBI installation. The residue left by the pyrolysis process is 1% of the original and the residue far from being toxic is inert and harmless. The residue is known as plasma rock that can be used as a construction aggregate. There are zero atmospheric gas emissions and minimal particulate emissions from the technology. In all these respects, the benefits of plasma pyrolysis substantially exceed the benefits that MBI can deliver. The same technology is available in the UK developed by Westinghouse and sold by Waste2tricity.

So why is gasification and plasma pyrolysis not being more widely used?

a) The ATT technology used on MSW has a track record that is shorter than the record of MBI. However, the Utashinai plant has been running reliably, robustly and cost effectively for 6 years.

b) The waste and recycling industry is notoriously conservative and views MBI as cutting edge despite the technology being in use for more than 30 years and despite the disadvantages. The industry also claims that MBI has improved during that time. A BCC planner claimed that comparing MBI of 30 years ago was "like comparing a Model T Ford to a Rolls Royce". That may be so, but the point he missed is that both cars use the same basic technology (and inefficiencies) of the internal combustion engine. MBI and ATTs use fundamentally different technologies.

c) The reason given by Bucks County Council is that there is no other mass disposal method that is 'bankable'. When recently pressed on the meaning of bankable, the planning staff expanded the meaning to include: Proven, Reliable, Robust, Cost effective. BCC further clarified what it means by this in a letter to SAVI dated 20 June '09. It says that "bankable" is based on two premises: i) a lengthy proven track record that would convince a bank to lend for such a project; and ii) comparative projected long term gate fee per tonne of MSW. SAVI believes it can convince BCC on both these grounds that its interim conclusions may need adjusting. Regarding BCC's first point, SAVI points out that there are currently 10 plasma pyrolysis plants operational in the UK, with a further 10 that have funding, (and for these at least it is clear that funding is not the issue). Regarding BCC's second point, projected gate fees for ATT are **about half** of MBI gate fees **before** taking into account economic or social costs. Moreover, the back end of the ATT process - the cleaning, cooling and combustion of the gases - is an industrial process that can be bought off the shelf.

Examples of ATT installations from UK and the rest of the world
Plasma gasification plants are running successfully in Faringdon and Swindon, also in Wales and Japan. The Japanese deployment of the ATT technology is detailed and peer reviewed by an independent third party (Juniper). A summary of the track record of the ATT technologies in operation in Japan can be found at http://www.alternrg.ca/project_development/commercial_projects/utashinai

Summary of ATT technology
Advantages: a) small footprint, considerably smaller than a mass burn incinerator; b) reliable; c) efficient (60% efficiency rating in the production of electricity); d) minimal inert residue (1%); e) negligible particulate emissions; f) low set-up costs, £40-50 million to process 55,000 tonnes p.a. compared to £125 million for a 300,000 t/yr Mass Burn Incinerator; g) has lower running costs largely because of more efficient power output and therefore commonly accepts a much lower MSW gate fee[5], thus offering a higher value for money option to BCC and rate payers; g) can be deployed in urban locations; h) reduces transport footprint compared to mass burn incineration because of the avoidance of centralisation and the need for very large volumes of waste; and large scale transfer stations) produces combustible, storable gas rather than steam.

Disadvantages: there are none, but the perceptions that ATT is not bankable, and that ATT is not scalable (though an ATT plant under construction in St Lucie County in Florida will be capable of taking 1000 tonnes per day) still persist. BCC's claim that ATT is experimental and not bankable is refuted by the many commercial ATT installations now operating worldwide.

National Significance and Opportunity
The small physical footprint of ATT technology coupled with near zero emissions enables towns and cities to adopt this technology, locating in industrial parks and drawing in only local waste whilst providing local employment and energy. (As an example of the strategic opportunities offered by ATT, the Royal Navy recently installed on one of its big ships a pyrolysis and gasification plant that reduces waste by 95%, and produces energy[6]. Going back to the Buckinghamshire situation, this small footprint obviates the need for centralisation, and this has a huge knock-on effect on overall transport requirements.

As a background note it is important to know that the UK is critically short of gas storage capacity and in addition, we source over 50% of our natural gas from Russia and the Middle East. Strategically, the UK has an insecure gas supply and as a consequence we tend to overpay for our gas contracts. ATT produces combustible gas with similar properties to natural gas.

Studies in the USA suggest that 4-5% of US electricity could be met from ATT technologies. It would be reasonable to assume similar figures in the UK. The significance of this is easy to ascertain if the outputs of other technologies and power stations are considered: for example, Drax, the UK's largest power station produces 7% of the UK's electricity; the national total contribution from wind energy is 5%; and nuclear and hydroelectricity contribute 7% each.

It is also reasonable to suggest that wastes from agriculture and human sewage could be disposed of effectively using ATT or anaerobic digestion (AD). Agriculture worldwide is responsible for 16% of carbon dioxide emissions; much of this comes from methane from crop and animal wastes as they decompose. Locally placed ATT and AD facilities could capture a proportion of that fuel resource.

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[5] Financial comparisons are of course site specific, but an industry manager indicates a contract gate tariff for MSW of £120/t for MBI compared to £70/t for ATT. These straight financial figures don't take account of economic costs (aka social costs) of health, traffic, environment and impact on rural businesses and property values. All of these would favour ATT over MBI and make the difference even greater. The principal reason for the big difference in gate tariffs for MSW is the comparison of energy generation – 20% efficiency for MBI, and 55% efficency for advanced plasma pyrolysis. Added to that, there is the cost of landfill for ash from MBI which will rise annually up to 2013 And power prices are projected to also rise steeply, thus further favouring ATT over MBI. Moreover, some pundits in the ATT business foresee a time when MSW will have a price, not a cost, because of ATTs vastly superior power generation capability. Thus it is expected that the gap between MBI and ATT costs and prices to widen in the coming years.

[6] http://www.mrw.co.uk/page.cfm/Action=Archive/ContentID=1/EntryID=815

Looking further into the future, it is conceivable that the ecological threat of landfill sites could be neutralised if they are mined for their MSW contents in the pursuit of locally produced electricity. Technically this is achievable and profitable.