Energy from Waste

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The Non-Fossil Fuel Obligation and the Scottish Renewables Obligation impose requirements on public electricity suppliers to pay premium prices, funded by the Fossil Fuel Levy, for electricity from renewable energy developers. Projects for generating electricity from waste continue to be awarded a significant number of the contracts resulting from these obligations. This paper provides an overview of alternative energy in the UK, with a focus on waste incineration and landfill gas.

Grahame Danby
Science and Environment Section

House of Commons Library

Summary

The recovery of energy from waste has been an important component of the UK's sustainable development strategy. In addition to managing waste more effectively, it contributes significantly to targets for generating electricity from renewable energy sources. The principal financial mechanism for supporting this latter aim is the Non-Fossil Fuel Obligation which imposes requirements on public electricity suppliers to contract for specified amounts of generating capacity. Above market prices are paid to the successful renewable energy developers for a specified period, funded by a Fossil Fuel Levy which is reflected in electricity bills.

This paper provides an overview of the current state of renewable energy in the UK, and summarises the policies of the three largest political parties. Well over half of the nation's renewable energy utilisation in 1995 came from waste. Details are provided on the technology, environmental impact and potential for the two most important waste to energy methods: municipal waste incineration and the collection of landfill gas. The paper ends with a brief summary of biogas from sewage sludge and animal wastes.

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I UK policy on waste and renewable energy

A. Waste

The Government's strategy for non-radioactive solid wastes and sludges was set out in the December 1995 white paper *Making Waste Work: A strategy for sustainable waste management in England and Wales* (Cm 3040). Three key objectives form the focus of the strategy:

- to reduce the amount of waste that society produces;
- to make best use of the waste that is produced; and
- to choose waste management practices which minimise the risks of immediate and future environmental pollution and harm to human health.

A "waste hierarchy" has been drawn up to help classify the different waste management options in general terms. From the environmental standpoint, reducing the quantity of waste produced in the first place is - other things being equal - the most desirable option. After waste reduction, re-use (such as refilling bottles) is considered the next best environmental option. The Government attaches broadly equal importance to the three methods of recovering value from materials which have entered the waste stream; these methods are recycling, composting, and energy. A focus of the present paper will be methods of obtaining energy from waste. The fourth and least desirable waste management option is considered to be disposal. Government waste strategy has accordingly been informed in part by the Royal Commission on Environmental Pollution's 17th Report which recommended that[1]:

> "wherever possible avoid creating waste, where wastes are unavoidable recycle them if possible and where wastes cannot be recycled ... recover energy from them"

It has been estimated that the UK produces 435 million tonnes of waste each year: 245 million tonnes of controlled[2] waste (household, industrial and commercial) and 190 million tonnes of other waste (mostly from agricultural, mining and quarrying activity). About 70% of all controlled waste in England and Wales is landfilled, some of which will have been pre-treated in incinerators; these can obtain a 90% reduction in the volume of waste requiring disposal. Most incinerators are currently engaged in the destruction of hazardous waste which is unsuitable for landfilling.[3]

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1 *Royal Commission on Environmental Pollution - 17th Report, Incineration of Waste* HMSO 1994
2 Environmental Protection Act 1990, section 75
3 Cm 3040, page 67

A full discussion of UK waste management has been given in *Landfill* (House of Commons Library Research Paper 96/103, 8 November 1996). Of great relevance to the potential development of energy from waste schemes are the two primary targets which the Government have already set for England and Wales in order to take forward their waste strategy. These targets have been termed "landfill diversion" and "recovery". The first target is to reduce the proportion of controlled waste going to landfill to 60% by 2005. This implies some increase in the amount of waste from which value is recovered. The second primary target is to recover 40% of municipal waste by 2005. Municipal waste includes all household waste, street cleaning waste and some commercial and trade waste.[4] About 20 million tonnes of household waste are generated annually in the UK.[5]

B. Renewable energy

Renewable energy is a term used to describe energy sources which, for all practical purposes, are continually replenished.[6] Examples include wind farms for generating electricity, solar panels for water heating, and biodiesel as a transport fuel. The renewable status of wood for heat and electricity will depend on whether new trees are planted to replace those burnt. Such a definition of renewable energy may seem to exclude energy from waste schemes, though much waste is biological in origin, and the sources of this could in principle be farmed sustainably.

On 31 March 1994, the former energy minister Mr Tim Eggar announced the publication of *New and Renewable Energy:Future Prospects in the UK* (Energy Paper 62). This was the Government's response to a report by the Renewable Energy Advisory Group, chaired by Dr Martin Holdgate.[7] Energy Paper 62 sets out a strategy to help establish a market foothold for key renewables, including wood coppice, energy from waste, wind turbines and solar. This is in line with government policy:

> "to stimulate the development of new and renewable energy sources wherever they have prospects of being economically attractive and environmentally acceptable in order to contribute to:
>
> - diverse, secure and sustainable energy supplies;
> - reduction in the emission of pollutants;
> - encouragement of internationally competitive industries.
>
> In doing this it will take account of those factors which influence business competitiveness and work towards 1,500 MW DNC of new electricity generating capacity from renewable sources for the UK by 2000."

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4 Cm 3040, pp8-9

5 *Digest of Environmental Statistics* No. 18 1996, chapter 7

6 *Renewable Energy* House of Commons Library Research Paper 93/83, 29 July 1993

7 *Renewable Energy Advisory Group: Report to the President of the Board of Trade* (Energy Paper Number 60, November 1992)

The figure of 1,500 megawatts Declared Net Capacity is similar to the electricity generating capacity of a large conventional power station. Declared Net Capacity takes into account the intermittent nature of some renewable sources, such as wind farms, by reducing the maximum capacity (in megawatts) that the plant could maintain without sustaining damage.[8] For a wind farm, the DNC is considered to be 43% of the rated output whereas energy from waste plants have a DNC equal to the rated capacity. In other words, the same as conventional baseload power stations fired by fossil fuels (coal, gas, oil) or uranium.

The strategy for promoting renewables takes the form of a research, development, demonstration and dissemination (RDD&D) programme[9,10], and the Non-Fossil Fuel Obligation for those electricity generating technologies closest to being commercially competitive. There are several other programmes[11] of relevance to renewable energy, including the EC's JOULE[12] and THERMIE initiatives which provide funding for, respectively, research & development and demonstration projects[13]. The EC Commission has produced a green paper for a Community renewable energy strategy[14] which contains detailed national comparisons, and promises of a more detailed strategy and action plan by mid-1997. One EC response to the challenge of increasing the contribution of renewables has been ALTENER[15], a five year promotional programme ending this year, though there exists a proposal for an extension (ALTENER II).

C. Non-Fossil Fuel Obligations

Under section 32 of the *Electricity Act 1989*, the Secretary of State may require by order that public electricity suppliers arrange to have available to them generating capacity from non-fossil fuel sources. Thus the following fuels are excluded: coal, coal products, lignite, natural gas, crude liquid petroleum or petroleum products. The order may specify non-fossil generating stations of a particular description such as wind farms, different energy from waste technologies or nuclear power stations. A recent example of a non-fossil fuel obligation is the *Electricity (Non-Fossil Fuel Sources) (England and Wales) Order* SI 1997/248. This is the fourth renewables order (NFFO-4) for England and Wales, and like the other three its purpose is to support various renewable energy technologies by requiring the public electricity suppliers to contract for specified power capacity. A premium price (determined by a bidding process involving putative generators) is paid for electricity generated from these energy sources.

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8 *Renewable Energy: Power for a Sustainable Future* Open University 1996

9 *The Renewable Energy Research, Development and Demonstration Programme* National Audit Office 28 January 1994

10 *The Renewable Energy Research, Development and Demonstration Programme* Committee of Public Accounts HC 387 1993/94

11 http://www.etsu.com/DTIExportsGuide/programm.htm

12 *New Review* ETSU/DTI February 1997

13 *New Review* ETSU/DTI November 1996

14 *Energy for the Future: Renewable Sources of Energy* COM(96) 576, 20 November 1996

15 *European Environment* vol 5 1995, pp58-60

Details of the procedure have been summarised on page 127 of *The Energy Report* (DTI 1996, volume 1). Essentially four steps are involved in making a NFFO renewables order in England and Wales:

1. A DTI Minister makes an announcement of the basic policy proposals for a new NFFO Order, including its overall size (in megawatts) and the technology bands likely to be included. The DTI publishes further guidance to the 12 Regional Electricity Companies in the form of a *Renewable Energy Bulletin*[16].

2. Prospective NFFO generators prepare proposals to supply electricity, using technologies specified in the Bulletin, and submit these to the Non-Fossil Purchasing Agency which acts on behalf of the RECs. These proposals are scrutinised by the Office of Electricity Regulation (Offer) which applies to them a "will secure" test to assess their prospects of technical and economic feasibility[17]. Generators who pass the test can then submit formal bids to the NFPA.

3. After consulting Offer and the RECs, the Minister makes an Order setting an obligation on each REC for each technology band for each year of the Order. The NFPA signs sufficient contracts so that individual RECs will secure the specified capacity.

4. Before they can begin generating electricity, the contracted projects must obtain the necessary consents: planning permission and, in the case of waste incinerators, authorisations[18] under the *Environmental Protection Act 1990*. Operational projects sell their electricity to the RECs at an above market price, the difference being funded by the Fossil Fuel Levy.

Similar procedures exist in respect of a Scottish Renewables Obligation[19,20,21] (SRO) and a Northern Ireland Non-Fossil Fuel Obligation[22] (NI-NFFO).

The premium prices paid to renewable energy electricity generators are funded by a fossil fuel levy which is payable by all licensed suppliers, and passed on to consumers as a percentage of their electricity bills. Condition 3 of the PES licence, which sets out the restrictions on charges made by the public electricity supplier, makes provision for the fossil fuel levy.

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16 *Renewable Energy Bulletin No 6: Fourth Round of Bidding - NFFO-4* DTI December 1995

17 *Fourth Renewables Order for England and Wales* Offer January 1997

18 *Processes subject to Integrated Pollution Control: Waste Incineration* IPC Guidance Note S2 5.01, Environment Agency, October 1996

19 HC Deb 13 March 1997 cc313-4W

20 *Outline Proposals for a Scottish Renewables Obligation* A discussion paper issued by the Energy Division of the Scottish Office Industry Department, May 1992

21 *Scottish Renewables Obligation: Bulletin.* Information about the Scottish Renewables Obligation for Generators of Electricity from Renewable Energy Sources (Scottish Office Industry Department, October 1993)

22 HC Deb 24 July 1996 cc474-5W

The levy rate for England and Wales is determined according to the prescription given in the *Fossil Fuel Levy Regulations* SI 1990/266 (as amended by SI 1996/1309). In Scotland, the relevant regulations are the *Fossil Fuel Levy (Scotland) Regulations* SI 1996/293 (as amended by SI 1996/1512). The Director General of Electricity Supply collects the levy, using the proceeds to reimburse the public electricity suppliers for the excess costs involved in purchasing renewable electricity from generators. Section 33 of the *Electricity Act 1989* provides the general terms of reference under which the levy operates. Though the *Electricity (Northern Ireland) Order* SI 1992/231 (NI 1) includes provisions for a levy to support the development of non-fossil fuel sources such as renewables, such a levy has not been introduced. Instead, Northern Ireland Electricity is obliged by the Office for Regulation of Electricity & Gas (OFREG) to meet its NI-NFFO obligations by the most economic means[23].

In England and Wales, the fossil fuel levy rate currently stands at 3.7% (applied to electricity bills), though this will be reduced to 2.2% on April 1 1997. This will finance renewable energy commitments and payments due to the non-privatised part of the nuclear industry[24]. The proportion of levy receipts going to renewables has steadily increased since 1990, reaching £99m in 1995/96, or 9% of the levy proceeds[25] (which at that time stood at 10% on electricity bills, to which VAT is then added[26]). From April 1, the levy rate for Scotland will rise 0.2% to 0.7%, to enable Scottish Power and Hydro-Electric to meet the additional costs of the Scottish Renewables Obligation[27].

D. Current status of renewables and prospects

Most present day UK renewable energy output is in the form of electricity (2% of UK electricity in 1995), with the national picture being dominated by large scale hydro and municipal solid waste combustion. Landfill gas and sewage sludge digestion together with other waste digestion or combustion make up most of the remaining renewable electricity supply. Wind turbines and small scale hydro contributed only 4% to the supply of renewable electricity (1995 figures), though they make a relatively greater contribution to replacing fossil fuel use. Detailed information is available from a number of sources, most particularly the *Digest of United Kingdom Energy Statistics 1996* (DTI/Government Statistical Service July 1996) and the Renewable energy statistics database[28].

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23 OFREG spokesman 21 March 1997

24 *Offer press release R67/96*, 20 December 1996

25 *New Review* February 1997. A lower figure of "some £94 million" was cited for 1995/96 in DTI press release P/97/116

26 In other words, one pays VAT on the levy. (source: Offer spokeswoman, 20 March 1997)

27 *Scottish Office press notice* AG120/96, 20 December 1996

28 http://www.etsu.com/Renewables/RESTATS/home.htm

The estimated total operational capacity of renewable-energy based electricity plant which was operational in the UK at the end of 1995 has been given in a written answer[29]:

large scale hydro	1,440 MW dnc[30]
other capacity outside non-fossil fuel obligations[31]	20 MW dnc
capacity supported by non-fossil fuel obligations	380 MW dnc

As noted earlier, the present Government's policy is to work towards 1,500 MW of new renewables-based capacity by 2000. Should this target be met, then the total renewables-based electricity generating capacity would come to about 3,000 MW dnc, equivalent to between 2 and 3 large thermal (e.g coal, nuclear) power stations.

Recent figures for renewable energy projects supported by non-fossil fuel obligations are given in the table below[32,33]:

obligation	number of **contracts**	capacity of contracted projects (MW)	number of projects **generating**	capacity of generating projects (MW)
NFFO-1[34]	75	152.11	63	141.82
NFFO-2[35]	122	472.23	82	179.79
NFFO-3[36]	141	626.91	30	79.48
NFFO-4[37,38]	195	843.1	-	-
SRO-1[39]	30	76.5	7	19.1
SRO-2[40,41]	26	112	-	-
NI-NFFO-1[42]	20	15.6	11	12.4
NI-NFFO-2[43]	10	16.27	1	0.75

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29 HC Deb 9 January 1996 cc10-11W

30 megawatts declared net capacity. A megawatt is a unit of power (not energy) which is equal to 1,000 kilowatts. Declared net capacity is a correction factor to take into account the intermittent nature of some renewable energy sources.

31 NFFO/SRO/NI-NFFO

32 *Fourth Renewables Order for England and Wales* Offer January 1997

33 Northern Ireland Office, Belfast (21 March 1997)

34 SI 1990/1859

35 SI 1991/2490

36 SI 1994/3259, amended by SI 1995/68

37 SI 1997/248

38 *DTI press notice* P/97/116, 6 February 1997

39 SI 1994/3275

40 SI 1997/799

41 HC Deb 13 March 1997 cc313-4W

42 SR 132 (1994)

The projects awarded contracts in the most recent England and Wales order (NFFO-4) have an average[44] electricity price of 3.46 pence per kilowatt-hour, which compares with the 4.35 pence achieved in NFFO-3.[45] The size of a fifth order, currently planned for 1998, is expected to take into account progress made in the earlier orders covering periods beyond that year (NFFO-3, NFFO-4).

Prospects for the further development of renewable energy will depend to some extent on the outcome of the forthcoming general election. At the time of writing, the election manifestos of the larger parties were unavailable, but the use of non-fossil fuel obligations by the present Government will reflect Conservative Party opinion.

The Labour Party has published a report of its policy commission on the environment called *In trust for tomorrow* (1994), which includes a chapter on a sustainable energy policy. Continued use of the fossil fuel levy is proposed to help meet a Labour Government's targets of 10% of electricity demand to be met by renewables by 2010, and 20% by 2025. This general policy aim was reiterated by Mr John Battle at a renewables conference in March 1996. A report in *Renew* contained further details of Mr Battle's contribution[46]:

> He added "Because our support for renewables is so low, Britain is being held back from establishing a competitive renewables industry. We are being held back from the future industries of the next century. Already we have lost ground by failing to encourage a UK wind turbine industry early on in the expansion of the industry." He concluded "What's lacking is a strong framework of support to ensure that renewables, wind, biomass, wave and solar, can move out of the margins and have a positive future as part of a diverse and sustainable long term energy supply" and proposed that the NFFO, the bulk of which has gone to support nuclear power, be converted into a 'Cleaner Energy levy' to support renewables.

Liberal Democrat policy on renewables is summarised on one of that Party's web pages[47]:

> The UK should use the 'window' provided by plentiful supplies of cheap gas over the next 10–15 years to invest in energy efficiency improvements and to develop renewable energy sources to meet 20% of electricity demand within 15 years. We would encourage renewables by:
>
> Extending the current Non-Fossil Fuel Obligation.
> Increasing financial support for renewables through the Fossil Fuel Levy.
> Increasing spending on research and development.

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43 SR 407 (1996)

44 weighted according to their capacity

45 *DTI press notice* P/97/116, 6 February 1997

46 http://eeru-www.open.ac.uk/NATTA/RENEW96(4).html, extracts from RENEW Issue 101

47 http://www.libdems.org.uk/libdems/cgi-bin/show.pl?english+uk&../english/documents/uk/poli00429447.txt

The Non-Fossil Fuel Obligation has provided a significant impetus to the development of renewable energy sources, and a similar competitive support mechanism is now being set up in France. The competitive element, has driven down prices to the extent that the average price paid for renewables in NFFO-3 was 4.35 pence per unit (kilowatt-hour), which compares favourably with the 6.5 pence per unit for NFFO-1 projects. The ongoing fall in prices (in terms of money of the day) owes much to the longer contract lengths offered in the later renewables rounds, giving developers up to 15 years of premium prices with which to provide investors with the required rate of return. This is particularly important given the relatively high capital cost of renewable energy technologies, in comparison with their running costs.

The Non-Fossil Fuel Obligation mechanism has been criticised, on account of the wastefulness involved in its oversubscription (in the NFFO-3 round, only 27% of bids were awarded contracts), and its lack of coordination with the planning system. Dr Catherine Mitchell of Sussex University's Science Policy Research Unit has written on this, and recommended a range of additional measures including green taxes and further incentives for renewable energy development[48].

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[48] *Science & Public Affairs* Winter 1996; *Energy Policy* vol 23, no 12, 1995

II Waste incineration

A. Resource

In terms of electricity generation, combustion of municipal solid waste (MSW) is the most important resource, accounting for 298.8 thousand tonnes of oil equivalent in 1995[49]. This is broadly equivalent to the amount of oil which would have to be burned in a typical oil-fired station to generate the same amount of electricity. Though tonnes of oil equivalent may seem a rather strange way of measuring electrical energy, it is chosen largely by convention and facilitates comparisons between different fuel types. Additional contributions come from the incineration of specialised wastes such as poultry litter[50] and old tyres[51,52], but these will not be discussed in this paper.

Although MSW combustion is relatively important from the standpoint of electricity supply, only a small proportion is incinerated, the bulk going to landfill sites. The term MSW includes all household wastes, together with wastes deposited at civic amenity sites, and a proportion of the waste from industry and commerce: a total of some 30 million tonnes per year in the UK[53]. A further 20 million tonnes of General Industrial and Commercial Wastes (GIW) are also produced, consisting of items such as paper, cardboard, wood and plastics. GIW tends to have a higher calorific value (energy content) than MSW, though energy recovery from it has mostly been for providing heat rather than electricity.

B. Technology

For the purposes of the third renewables order in England and Wales (NFFO-3), an eligible waste incinerator is one which is fuelled wholly or partially by municipal and/or industrial waste and/or fuel derived from this waste[54]. One can use untreated MSW delivered by waste carrying vehicles, as in the Edmonton incinerator supported by NFFO-1. Alternatively, one may first process the waste, mechanically separating non-combustibles such as metal and glass, and then producing pellets of the remaining organic matter. The resulting product is known as coarse RDF (refuse derived fuel). Densified refuse-derived fuel, d-RDF, is more highly processed, pulverised, compressed and dried, and has 60% of the energy content, per cubic metre, of coal[55].

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49 *Digest of United Kingdom Energy Statistics 1996* (DTI/Government Statistical Service)
50 "Poultry Litter as a Fuel in the UK" *CADDET Renewable Energy Newsletter* July 1993
51 "Scrap Tyres as a Fuel in the UK" *CADDET Renewable Energy Newsletter* January 1994
52 *Making Waste Work* Cm 3040 December 1995
53 *Renewable Energy: A Commercial Opportunity* ETSU/DTI 1994
54 *Renewable Energy Bulletin No 5* DTI October 1993
55 *Renewable Energy: Power for a Sustainable Future* Open University 1996

Because RDF has a much higher energy content for a given volume, it is cheaper to transport than untreated waste. Furthermore, the reduced ash content of RDF and d-RDF means that they can be burned in conventional power stations along with coal[56]. The design of furnaces or boilers for burning waste alone will have to take a number of factors into account, including the relatively greater proportion (compared to coal) of volatile matter in waste. One clearly wants this to burn in the furnace rather than escape up the chimney. The boiler is used to heat water, producing steam which drives the electricity generating turbines. At the SELCHP plant in south east London, gases and particulates (fine particles of soot, smoke and dust) emerging from the incinerator are cleaned to remove dioxins and heavy metals, neutralise acids, and filtered to collect the dust. Finally, ferrous metals can be separated for recycling from the residual ash using magnets. SELCHP was the first large-scale mass-burn[57] incinerator to be built under the non-fossil fuel obligation (NFFO-2), and its design incorporated a combined heat and power element. If and when this element becomes operational, waste heat from the steam will be channelled to provide useful heating for buildings rather than being lost[58].

Recently, explicit provision has been made for combined heat and power schemes to receive fossil fuel levy support. The powers to do this are contained within schedule 22, paragraph 38 of the *Environment Act 1995*. In *Renewable Energy Bulletin No 6* (DTI, December 1995) one of the technology bands identified as being eligible for support under the fourth (England and Wales) round of bidding (NFFO-4) was "municipal and industrial waste with combined heat and power". NFFO-4 allows up to ten per cent[59] of the incinerator fuel mix to consist of sewage.

Though the NFFO mechanism can only provide, by virtue of the Electricity Act, a premium price for the electrical output, the technology band has been defined in such a way as to require an annual heat output and "reasonable prospects" of obtaining contracts for its supply for specified purposes. It is arguable whether one needed legislation to allow this support for CHP, though the 1995 Act certainly ended any doubt.

In addition to the CHP technology band mentioned above, NFFO-4 also specified "municipal and industrial waste by fluidised bed combustion". Fluidised bed furnaces are of a relatively simple design, have high combustion efficiencies, and result in lower emissions of nitrogen oxides (which contribute to acid rain). They work by injecting the fuel into a "bed" of ash or sand which is supported and agitated by air flowing up through the base of the furnace[60,61].

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56 *Cofiring of coal and waste* IEA Coal Research, August 1996

57 mass-burn means burning the waste as collected.

58 *CADDET Renewable Energy Newsletter* June 1994

59 on a "dry-weight" basis.

60 *Processes subject to Integrated Pollution Control: Waste Incineration* Environment Agency October 1996

61 *McGraw-Hill Encyclopedia of Engineering* second edition

C. Environmental factors

On 1 December 1996, an EC Municipal Waste Incineration Directive[62] came into force, imposing more stringent emission standards which resulted in the closure of several existing plants[63]. To operate, municipal waste incinerators need to meet emission requirements which are enforced by means of authorisations granted by the Environment Agency. The Agency has issued a guidance note[64] on waste incineration which is a process prescribed for Integrated Pollution Control in regulations[65] made under section 2 of the *Environmental Protection Act 1990*. Page 11 of the Environment Agency's guidance summarises the standards and obligations imposed by EC municipal waste directives, as implemented in the UK. Limits are placed on emissions of dust, hydrogen chloride, carbon monoxide, hydrogen fluoride, sulphur dioxide, various heavy metals, and volatile organic compounds. A further EC directive has been drafted for the incineration of non-hazardous waste which would impose still stricter limits[66].

The Department of the Environment's booklet, *Energy from Waste* (November 1996), acknowledges public concern about incinerator emission, but points to the new controls by way of reassurance. The booklet points to an Environment Agency report[67] as having demonstrated that dioxin emissions from waste incinerators operating under the new standards will not pose a health risk to people living near them. It is unlikely that this will entirely reassure environmental groups like Friends of the Earth who have campaigned against new incinerators, favouring instead waste minimisation and recycling[68]. One advantage of recovering energy from municipal waste is that it could displace the use of fossil fuels, thereby preserving non-renewable resources and slowing the build up of atmospheric carbon dioxide which has been implicated in global warming. Incineration greatly reduces the volume of the waste, leaving a relatively inert residue which can be sent to a landfill site.

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62 89/429/EEC (89/369/EEC applies to new waste incineration plants)

63 *ENDS Report* November 1996

64 *Processes subject to Integrated Pollution Control: Waste Incineration* IPC Guidance Note S2 5.01, Environment Agency October 1996

65 *The Environmental Protection (Prescribed Processes and Substances) Regulations* SI 1991/472 (as amended)

66 "Energy from waste - progress to date and the barriers faced" *Wastes Management* May 1996

67 *Risk Assessment of Dioxin Releases from Municipal Waste Incineration Processes* DOE report HMIP/CPR2/41/1/181 1996

68 http://www.foe.co.uk/camps/indpoll/index.html

D. Current status and prospects

The table below shows how the price, in pence per kilowatt-hour, of electricity from waste combustion has fallen, in the context of the Non-Fossil Fuel Obligation in England and Wales. Data is given for successful bids for NFFO contracts[69,70].

	number of projects	capacity (MW)	bid price (p/kWh)
NFFO-1	4	40.63	5.06 - 6.00
NFFO-2	10	271.48	5.50 - 6.55
NFFO-3	20	241.87	3.48 - 4.00
NFFO-4	16	241.3	2.66 - 3.4

The table clearly indicates that developers of incineration plants with energy recovery have been able to bid progressively lower prices for their electricity, the newer bids approaching the market price for electricity sold on the national grid. What the table does not show is the number of plants which were unable to take up their contracts due to the length of time it took to obtain planning permission. Only two of the NFFO-2 incinerators were operational as at December 1996, the remaining eight projects having been cancelled. While earlier renewables rounds could only offer premium prices up to the year 1998, NFFO-3 introduced 15-year contracts with a five year take-up period. Notwithstanding the new emission controls, it is anticipated that a result of this will be an expansion of incineration capacity coming online. The December 1996 figure for operational NFFO-supported electricity from waste incineration plants was about 100MW, enough for about 100,000 homes[71].

E. Planning

In 1993 the Department of the Environment and the Welsh Office published *Planning Policy Guidance Note: Renewable Energy*, which was supplemented in October 1994 by annexes covering energy from waste combustion, landfill gas, anaerobic digestion, hydro power, wood fuel, and active solar systems. Also of relevance is *Planning Policy Guidance Note 23* (July 1994) which deals with planning and pollution control.

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69 *DTI press release P/97/116*, 6 February 1997

70 *Fourth Renewables Order for England and Wales* Offer, January 1997

71 *Energy from Waste* DOE November 1996

In order to identify the main planning and environmental issues associated with the development of alternative energy sources, *An Assessment of the Potential Renewable Energy Resource in Scotland* was published in December 1993. The study was carried out by Scottish Hydro-Electric, Scottish Power, the Department of Trade and Industry, the Scottish Office, Scottish Enterprise and Highlands and Islands Enterprise, with support from the Convention of Scottish Local Authorities. By way of putting renewable energy in the context of the planning system, chapter 3 states:

> "The land use planning system is intended to promote the sustainable use of land resources and to strike a balance between development and preservation of the environment. Planning permission will be required for most renewable energy projects. Areas or sites that are technically suitable for renewable energy exploitation may not be acceptable to the planning authority; the planning system will therefore influence the distribution of renewable energy exploitation across Scotland."

The above study was followed, in August 1994, by two Scottish Office publications: *National Planning Policy Guideline NPPG 6* (Renewable Energy) and *Planning Advice Note PAN 45* (Renewable Energy Technologies). The former provides a statement of Government policy while the latter is designed to provide advice on good practice and other relevant information. NPPG 6 attempts to reconcile the Government's stated policy to promote renewable energy for global environmental reasons with the protection of local environments and Scotland's own natural heritage. Paragraph 25 of the guidance is reproduced below:

> Accordingly, in relation to renewable energy developments, planning authorities should seek through their policies and decisions:
>
> - to provide positively for renewable energy developments, where this can be achieved in an environmentally acceptable manner;
> - to safeguard sites with potential for renewable energy projects against sterilisation by types of development that would prevent or hinder such projects and could be accommodated elsewhere;
> - to protect areas of important natural and built heritage from inappropriate forms of development;
> - to achieve acceptable operating standards during the working life of any project and the early restoration of sites, once operation has permanently ceased.

Installations for the disposal of industrial and domestic waste, and industrial installations for the production of electricity, steam and heat are included in Schedule 2 of the *Environmental Assessment (Scotland) Regulations* SI 1988/1221 (as amended). This means that an environmental assessment is required if the projects are likely to have significant environmental effects on account of their nature, size and location. Environmental assessments are likely to be needed for all the municipal waste incinerators under construction (in England and Wales), given that the capacity of each exceeds an indicative criterion of 75,000 tonnes per annum.

III Landfill gas

A. Resource

The Department of the Environment's *Energy from waste* booklet states, in the context of the bulk of municipal solid waste:

> "For much of this waste, it will be more sustainable to recover value from it at an energy from waste plant rather than to dispose of it by landfilling ...
>
> ... Energy can also be generated less directly from municipal solid waste from the methane gas produced at landfill sites. However, while this approach has merit, it produces only one-fifth of the energy per tonne from municipal solid waste compared with an energy from waste [incinerator] plant, and has other disadvantages associated with it. It cannot therefore be seen as a substitute for the approach described here."

As already noted, the bulk of municipal waste goes to landfill sites, a consequence of the historically large number of suitable sites and the wide variety of wastes which can be disposed of conveniently in this way. Despite the much greater volume of landfill waste compared to that sent to incinerators, less electricity is generated by burning the gas given off: a UK total of 185.5 thousand tonnes of oil equivalent in 1995[72].

B. Technology

The disposal of municipal solid wastes in deep landfills, such as former quarry sites, provides suitable conditions for anaerobic digestion[73]. This is the process whereby a mixed population of bacteria, which are ordinarily present, breaks down the organic matter in the refuse to produce a mixture of gases, mostly comprising methane and carbon dioxide. Historically, this landfill gas was burned off to minimise the risk of fire or explosion. Since the 1970s attention has focused on how to exploit this product for its energy value.

Developing a landfill site for energy recovery involves covering the waste with a layer of impervious clay to encourage anaerobic digestion which, as the name implies, takes place in the absence of air. A network of interconnected perforated pipes is buried at depths of up to 20 metres to collect the gas which is then burned in gas engines or turbines to drive electricity generators. A large modern landfill site can produce useful amounts of gas for over 15 years[74].

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72 *Digest of United Kingdom Energy Statistics 1996*

73 *Renewable Energy: Power for a Sustainable Future* Open University 1996

74 *New and Renewable Energy: Future Prospects in the UK,* DTI March 1994

C. Environmental factors

The emission of methane gas from a landfill site provides a notable environmental detriment in that it contributes to the atmospheric greenhouse effect responsible for global warming. Leakage of the methane gas from the landfill site into buildings also poses an explosion hazard, though the risk could be minimised by careful engineering of the site and/or the controlled extraction of methane gas for heating or electricity generation. Burning the landfill gas destroys methane which is a highly potent greenhouse gas, replacing it with carbon dioxide which is less so. Traffic movements relating to the transportation of waste to the landfill site, and the associated vehicle emissions, may also be a cause for concern in the local community. Landfill gas plants also raise questions relating to visual intrusion, mostly due to the on-site equipment and gas flares.

In addition to planning permission for the use of the land, a landfill site requires a waste management licence under Part II of the *Environment Protection Act 1990*. The Environment Agency, as the waste regulation authority, has responsibility for monitoring a site once it has closed and for issuing a completion certificate. The development of a landfill site should ordinarily involve the preparation of an environmental assessment. Whether this applies to the subsequent development of an associated electricity generating plant will largely depend on its installed capacity[75].

D. Current status and prospects

The table below shows the range of prices bid by successful landfill gas developers under different rounds of the England and Wales renewables orders[76,77]. The data displayed is analogous to that in section II D above.

	number of projects	capacity (MW)	bid price (p/kWh)
NFFO-1	25	35.5	3.6 - 6.4
NFFO-2	28	48.45	3.96 - 5.7
NFFO-3	42	82.07	3.29 - 4.00
NFFO-4	70	173.7	2.8 - 3.2

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75 *Renewable Energy Technologies* PAN45, Scottish Office, August 1994
76 *DTI press release P/97/116*, 6 February 1997
77 *Fourth Renewables Order for England and Wales* Offer, January 1997

At the end of November 1996, 67 NFFO landfill gas projects were generating electricity, with a total capacity of 116 megawatts. Another 60 MW is expected to come on stream over the next three years[78].

Consistent with its policy of encouraging incineration of waste for energy recovery, the Department of the Environment's *Energy from Waste* booklet notes:

> "Increasingly high environmental standards for landfill sites, reductions in the available capacity and the introduction of the landfill tax will all add to the cost of landfill, making energy from waste more attractive. Despite these factors, the cost gap in unlikely to close completely in the near future. However, under the Environmental Protection Act 1990, local authorities, in their role as waste disposal authorities, are not required to accept the lowest tender for their contracts where an alternative offers environmental benefits (as set out in DOE Circular 8/91)."

Which is the best environmental option will depend on local factors and the assumptions made in any formal "life cycle assessment", which measures the total environmental impact of products over their entire life cycle[79]. Library Research Paper 96/103 contains further information on landfill gas, and the impact of the landfill tax. The European Commission has proposed a new version of the Landfill Directive, one provision of which would reduce the landfilling of organic waste - a move which would lessen the potential of landfill gas as an energy resource[80]. Landfill gas could supply 1.8% of current UK electricity demand, based on a price of 5p per kilowatt-hour and a 15% real required rate of return. These figures should be taken only as indicative, partly because the accessible resource will depend on the relative proportions of waste being incinerated and landfilled. An ETSU publication[81] provides information on the contributions which different renewables could make under different assumptions of cost and discount rates.

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78 *DTI press notice P/96/879* 27 November 1996

79 "The Application of Extended Life Cycle Assessment to Recycling and Waste Management" *Global Environmental Change Programme Briefings* no. 11, March 1997

80 *Croner Waste Management Briefing* 3 December 1996

81 *An Assessment of Renewable Energy for the UK*, ETSU 1994 (HMSO)

IV Sewage gas and animal wastes

So far this paper has focused on energy recovery from municipal waste, either in incinerators or by tapping the gas emitted by landfill sites. Other forms of waste which can serve as sources of energy include forestry residues, surplus straw, sewage, and animal wastes. We end with brief discussions of sewage gas and animal waste.

A. Sewage gas

The bacterial digestion of sewage sludge produces methane which can be burned to produce heat and electricity. Sewage sludge is a by-product of sewage works and it consists of a thick, putrescible, odorous liquid with about 4% solid matter. Thirty five million tonnes (wet weight) are produced annually. A significant proportion of the energy recovery is in the form of heat used, for example, to maintain optimum temperatures for anaerobic digestion. However, annual (UK) electricity generation from sewage gas amounts to some 120.2 thousand tonnes of oil equivalent (1995 figures[82]).

Sewage gas schemes received support under the first two renewables rounds in England and Wales (NFFO-1, NFFO-2): a total of 26 projects with a capacity of 33.31 megawatts, and a 100% commissioning rate[83].

B. Animal waste

Some animal waste, such as chicken litter, can be burned to provide heat and electricity. NFFO-4 includes, as one of its technology bands, the anaerobic digestion of agricultural wastes. Six projects have been awarded contracts with a capacity of 6.6 megawatts, at an average price of 5.17 pence per kilowatt-hour[84]. The exclusion of purpose-built plants for the anaerobic digestion of municipal waste has been criticised on the grounds of its economic potential; several local authorities have already ordered large scale plants[85].

One example of an operating plant, which received NFFO-1 support, is given in chapter 4 of *Renewable Energy: Power for a sustainable future* (Open University 1996). A 750 cubic metre plant at Piddlehinton in Dorset can handle over 20,000 gallons of pig slurry a day. The biogas, mainly methane, which is produced is burned to produce roughly 750,000 kilowatt-hours annually for the National Grid. Purpose-built digesters such as this one have a variety of environmental benefits. They reduce odours, destroy pathogens, displace fossil fuels, reduce methane emissions, and the residue can be used as a compost or fertiliser[86].

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82 *Digest of United Kingdom Energy Statistics 1996* (DTI)
83 *Fourth Renewables Order for England and Wales* Offer January 1997
84 *DTI press release P/97/116*, 6 February 1997
85 *ENDS Report* November 1995
86 *CADDET Renewable Energy Newsletter* March 1996

V Further reading

- *Energy from Waste: Getting more value from municipal waste* Department of the Environment, November 1996

  A summary of Government waste policy, which concentrates on incineration for energy recovery from waste.

- *RE View*, DTI August 1994

  A special issue which summarises the Government's strategy for new and renewable energy

- *Energy for the Future: Renewable Sources of Energy* Communication from the Commission COM(96) 576 final, 20 November 1996

  This Green Paper for a Community Strategy includes a comparison of renewable energy production in each member state.

- *The Energy Report (volume 1): Change and Opportunity* DTI 1996

  Together with a companion volume dealing with oil and gas resources, *The Energy Report* provides an annual overview of the energy industry in the UK. Chapter 10 covers new and renewable energy.

- http://www.etsu.com/

  The internet address of the ETSU home page. Formerly known as the Energy Technology Support Unit, ETSU is the Governments executive agency for energy technologies.

- http://eeru-www.open.ac.uk/NATTA/r.o.l.html

  An edited version of the news sections of *Renew*, the journal of NATTA, the independent national UK 'Network for Alternative Technology and Technology Assessment'.

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96/103	Landfill	08.11.96
95/85	Global warming: Environmental and Economic Effects	07.07.95
95/86	Global warming: Policy responses	14.07.95
95/50	The Environment Bill (HL) (Bill 85 1994/95)	12.04.95
93/83	Renewable Energy	29.07.93