ELECTROWATT-EKONO
Jaakko Pöyry Group

ILEX ENERGY
CONSULTING

ELIGIBILITY OF ENERGY FROM WASTE – STUDY AND ANALYSIS

The options for, and implications of, amending the Renewables Obligation eligibility rules for energy recovery from mixed wastes

A final report to the
Department of Trade & Industry

March 2005

Disclaimer

The report contains projections that are based on assumptions that are subject to uncertainties and contingencies. Because of the subjective judgements and inherent uncertainties of projections, and because events frequently do not occur as expected, there can be no assurance that the projections contained herein will be realised and actual results may be different from projected results. Hence the projections supplied are not to be regarded as firm predictions of the future, but rather as illustrations of what might happen. Parties are advised to base their actions on an awareness of the range of such projections, and to note that the range necessarily broadens in the latter years of the projections.

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EXECUTIVE SUMMARY

This report presents the results of a study to assess the options for, and implications of, amending the Renewables Obligation eligibility rules for energy recovery from mixed wastes. At present, electricity generated from mixed wastes using the advanced conversion technologies of anaerobic digestion, gasification and pyrolysis is eligible for Renewable Obligation Certificates (ROCs). Any other form of generation from mixed wastes is not.

Waste policy will encourage energy recovery from wastes

UK and EU waste management policies are driving a radical change in the way municipal, commercial and industrial wastes are managed. The UK has traditionally disposed of the majority of wastes to landfill but this is not sustainable. A raft of policy instruments have been designed to reduce the volume of waste being created, to encourage recycling and to divert wastes from landfill. The key policy instruments in relation to municipal wastes are:

- an absolute cap on the amount of biodegradable municipal waste (BMW) that Local Authorities (LAs) can send to landfill – with options for trading landfill allowances but penalties of £150/tonne for breaching the cap;
- national targets for the recycling of household wastes, which rise to 25% in 2005, 30% in 2010 and 33% in 2015; and
- increases in the Landfill Tax which will rise to £35/tonne in the medium to long term.

The analysis presented in this report suggests that these policy instruments can only be met through substantial reductions in wastes – unlikely in our present culture of consumerism – or through significant investment in source-segregated recycling schemes and energy recovery from the residual mixed waste stream.

The role of recycling

Our analysis suggests that there will be a growth in new source-segregated recycling schemes, which divert recoverable and recyclable material to specialist materials recovery facilities (MRF), alongside the existing kerbside, deposit and composting schemes and will see recycling rise to levels in line with the 30% target. However, there are limits to recycling, particularly from mixed wastes streams, where contamination of materials limits the proportion of recoverable material and its value. As recycling grows the value of recovered material can fall, undermining the economics of recycling schemes. It is therefore unlikely that recycling more than 45% of the waste stream would be practical in the period to 2020 covered by this report.

Energy recovery as a waste management tool

The waste hierarchy sets out an order of preference for waste management policy – reduction, reuse, recovery, disposal. Where waste minimisation has reduced the waste stream to the extent practical, and recovered materials are reused or recycled, it may be preferable to recover energy from the residual mixed waste stream rather than to dispose of it. Our analysis of the waste management options available to Local Authorities to meet their waste diversion targets suggests a strong case for the use of energy recovery facilities for the management of municipal wastes, and potentially for commercial and industrial wastes too, due to the lack of economic alternatives.

Electricity generated from waste reduces the need to generate power from conventional sources, and Combined Heat and Power (CHP) facilities additionally displace gas or oil space heating, thereby reducing the use of fossil fuels, as well as methane emissions from landfill, a significant greenhouse gas. However, energy recovery is not a perfect solution. It reduces the requirement for landfill by approximately 90%, but residual ash from the process may still need to be landfilled. The net electrical energy recovered from these facilities may represent 17% to 21% of the energy contained in the waste stream – compared to 35% recovery for a coal-fired power station or up to 50% for gas-fired combined cycle (CCGT) power stations. CHP facilities, whether fuelled from waste or conventional sources enjoy considerably greater efficiencies. The operation of all energy-recovery from wastes is governed by the EU Wastes Incineration Directive[1] (WID), which imposes far stricter emission limits than apply to other forms of electricity generation, but emissions are still frequently cited as a barrier to planning consent.

Our analysis, based on a least-cost optimisation of the waste management options, suggests that the energy recovery technology most likely to be adopted will be Mechanical Treatment (MT) to pre-sort the mixed wastes stream to recover recyclates, with conventional energy recovery from the residual wastes. This technology (referred to as *MT+EfW* throughout this report) appears to offer the optimal economic balance between the desire to recover and recycle material, alongside energy recovery, against the additional costs of pre-sorting the waste stream.

In the longer-term we anticipate that simple energy recovery facilities (sometimes known as mass burn technologies) might also be built. Such plant (referred to as *EfW* throughout this report) may recover ferrous material from the bottom ash where this is economic, though such recovery does not qualify against recycling targets.

The preference for *MT+EfW* over *EfW* in the short to medium term may be due to the different treatment of metals recovered from these processes. With *MT+EfW*

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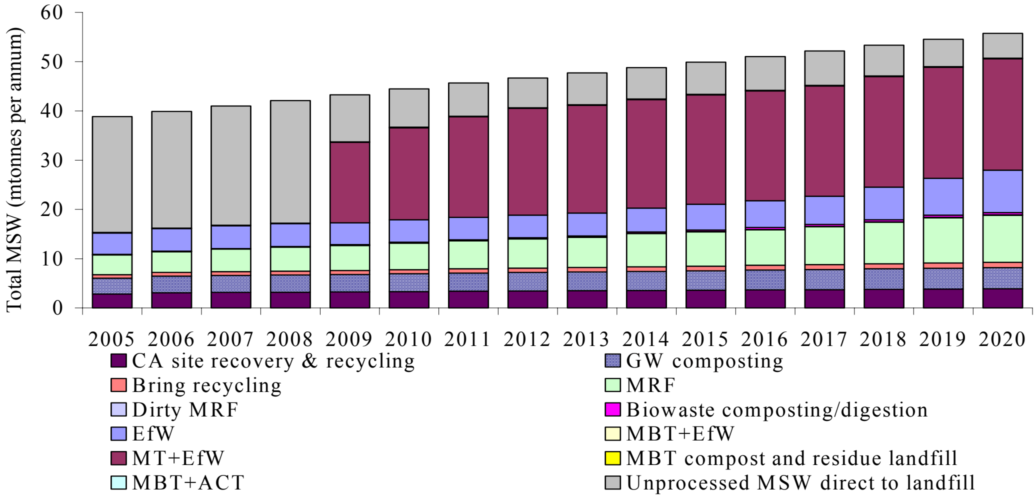
[1] Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste (WID).

metals recovered during pre-treatment count towards an LA's recycling targets, whilst for EfW, metals recovered from the bottom ash do not.

These are not the only energy recovery technologies we have considered. We have considered Mechanical Biological Treatment (MBT) with conventional energy recovery (*MBT+EfW*) and with Advanced Conversion Technologies (*MBT+ACT*). Based on our analysis of the economics, we consider that MBT will not be the most attractive option, as its costs are significantly greater than the alternatives and there are limited opportunities to make use of the additional composted material created. This problem may be compounded by the Environment Agency's proposal that composted material from the mixed waste steam used for land reclamation will continue to count towards a Local Authority's landfill allowance. That is not to say that no MBT plant will be built, as LAs may choose to use it to boost recycling levels, but our analysis suggests that MBT may not provide a major contribution to energy recovery.

Figure 1 – Total UK MSW by treatment process (assumes only ACT is RO eligible)



Source: ILEX

From our analysis of energy recovery technologies, three conclusions stand out.

- That energy recovery using *MT+EfW* and *EfW* technologies as the preferred waste management option is robust to a wide range of sensitivity analysis including the cost and structure of plants and power and ROC prices.
- That although the exact split between *MT+EfW* and *EfW* technologies may vary over time under these sensitivities, the total volume of eligible generation from energy recovery remains very similar – being primarily determined by the volume of BMW to be diverted from landfill.
- That we have been unable to identify any significant environmental advantage of one form of energy recovery technology over another. As all plant would be built to comply with the requirements of the WID, emissions would be similar. As such, there does not appear to be any clear environmental basis on which to differentiate ROC eligibility between energy recovery technologies

We have also considered the following energy recovery options but do not consider that they will be adopted in substantial number or that such uptake will materially impact on the results of this study.

- Provision of Refuse Derived Fuel (RDF) to conventional and biomass power stations:
  - requirements of the WID would apply to generation from RDF, which may make this viable only in conventional generation fitted with flue gas desulphurisation (FGD) and additional environmental protection measures.
- Co-location of energy recovery providing steam to conventional power stations:
  - limited opportunities due to the small number of sites with long-term coal-fired assets. Some potential alongside new-build gas-fired generators.
- Cement kilns:
  - potential route for some RDF, but would not be ROC eligible and would be competing with hazardous waste feedstocks which lack alternative routes.

The growth of energy recovery from mixed wastes

To meet the requirement to divert biodegradable municipal waste from landfill, it would be economic to recover energy from 26 million tonnes of mixed wastes per annum (58% of municipal waste) by 2010 and 35 million tonnes per annum by 2020. However, this economic capacity, which represents a five fold increase over present installed capacity, could not be developed by 2010. Planning and consenting for energy from waste facilities has proved difficult and time-consuming to date. Even if this capacity were to be rapidly consented, constraints in the supply chain with equipment supply, engineering, operational expertise and, potentially, access to capital funding could delay development.

In practice the deliverable capacity could be substantially less than this at first. It is not possible to determine with any certainty the rate at which energy recovery capacity might be delivered. For the purposes of this report we have assumed that delivered energy recovery capacity grows linearly up to the economic capacity over either 5 or 10 years from when initially viable. This phase-in of deliverable capacity implies that LAs will find it challenging to meet their landfill avoidance obligations and may incur penalties over a number of years. It must also be recognised that this economic capacity might never be achieved if planning restrictions force LAs to adopt more expensive alterative waste management options.

In addition to the municipal wastes diverted from landfill, there is also the potential in the longer-term for commercial and industrial wastes to also seek to use energy recovery, if the economics turn out to be more attractive than the costs of landfill.

Effect of extended eligibility on the development of energy recovery from mixed wastes

For most renewable technologies, the value of a Renewable Obligation Certificate (ROC), worth £55/MWh in 2003/4 (money of the day) will represent the single largest element of value and perhaps 60% of the income stream to the project. However, for energy from waste projects this may not be the case. By 2010, a £38/MWh ROC may typically equate to a gate fee equivalent of £9/tonne, compared to around £15/tonne of avoided landfill costs and up to £35/tonne of avoided Landfill Tax. Overshadowing all of this is the value of avoiding the LATS penalty, at £150/tonne. It follows that ROCs represent a significant but not substantial element of the income stream for energy recovery facilities.

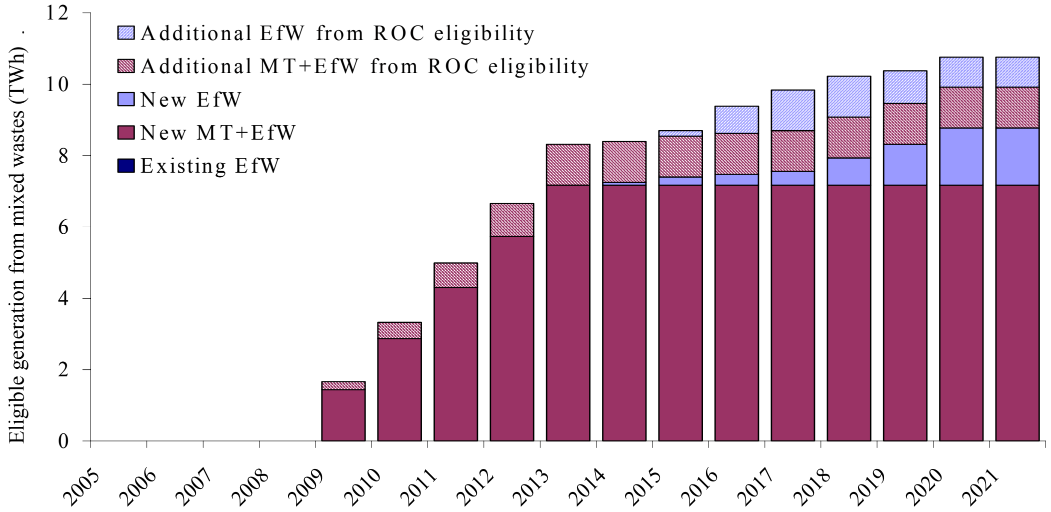
We have analysed the impact of extending ROC eligibility from the present ACT technologies to the biodegradable proportion of wastes from:

- mechanical biological treatment with conventional energy recovery (*MBT+EfW*) alone;
- mechanical biological treatment with conventional energy recovery (*MBT+EfW*) together with mechanical treatment with conventional energy recovery (*MT+EfW*);
- all new-build energy recovery facilities; and
- all existing and new-build energy recovery facilities.

The results of our analysis suggest that the choice of eligibility rules for mixed wastes will not affect the type of technology that it is economically optimal to build. Extending eligibility to *MT+EfW* and/or *EfW* will increase the take-up of energy recovery facilities by between 8% and 14%, and increase the economically viable capacity by two million tonnes per annum in 2010 and four million tonnes per annum in 2020. Figure 2 illustrates the potential deliverable generation from energy recovery and identifies that generation that could additionally be brought on from ROC eligibility. We do not believe it would be practical to target RO eligibility just at this additional element. It is unlikely that extending eligibility only to *MBT+EfW,* or retained just on ACT plant, would lead to a material increase in the number of energy recovery plant that would be built, beyond those already identified as likely to come on without RO support.

In practice we would not anticipate that the mix of technologies would be as clear cut as indicated from the economics. Local Authorities and developers may be influenced by additional factors. For example, there are a number of MBT plant being proposed at present that are likely to be developed, and which may or may not be retrofitted with energy recovery facilities or supply RDF to other facilities. Our analysis suggests, however, that there is insufficient value to warrant the additional costs incurred in segregating biodegradable material for composting from mixed wastes and disposing of residues (particularly if those residues count against the LATS). LAs seeking to recycle very high proportions of waste, beyond the statutory levels, may find MBT an attractive complement to source-segregated recycling. Such a choice is unlikely to significantly impact on the ROC eligible generation presented in this report, as it is likely to be a direct substitution for *MT+EfW* generation.

Figure 2 – Potential growth in RO eligible generation from energy recovery technologies with a five year phase-in



Source: ILEX

It should be appreciated that there is a great deal of uncertainty over the rate of growth of energy recovery facilities. We have identified a substantial demand for this waste management option driven by the need to divert municipal waste from landfill, but the actual rate of development remains very uncertain. It can be argued that ROC eligibility may not only improve the financial viability of some marginal projects relative to other waste management options, it may also assist in overcoming some of the consenting and planning barriers to their take up, by increasing the perceived legitimacy of such projects as renewable generation.

Depending on the assumed rate of growth of the deliverable capacity of energy recovery facilities we project that between 2.4TWh and 4.3TWh of ROCs could be sourced from energy recovery in 2011 if *MT+EFW* were eligible, rising to 3TWh to 5TWh if all new build were eligible. By 2021 the ROCs sourced from energy recovery could be 10.8TWh. By this time, not only may energy recovery be attractive for municipal wastes, but also for commercial and industrial wastes. Alternatively, if it does not become easier to obtain planning and environmental consent for these facilities, the economically viable capacity may never be built in full, and the number of ROCs generated could be substantially less.

Impact on the Renewables Obligation

Assessing the impact that extending the eligibility for energy recovery from mixed wastes could have on the Renewable Obligation (RO) is complex. In addition to the uncertainty over the build rate energy recovery facilities, described above, there is also uncertainty over the capacities of the other renewable technologies that will be developed under the RO. These two factors are of course interrelated, such that the possibility that large quantities of ROCs could be sourced from energy recovery could reduce investor confidence in the returns available to other technologies – thereby reducing their deployment.

To undertake this assessment we have considered as our starting point two alternative scenarios for the level of renewables development under the present RO[2]. The *Under Compliant* case lies towards the lower end of expectations for eligible generation from renewable technologies whilst the *Near Compliant* case, lies towards the upper end of expectations. We consider that both cases represent equally probable outcomes.

The *Under Compliant* case illustrates a moderate renewables build with not all proposed schemes being developed as or when proposed. Planning consent will not be granted for a substantial number of projects and transmission constraints will restrict onshore developments, particularly in Scotland. Developers would be cautious about developing new and offshore technologies. Under this scenario annual eligible generation is substantially below the level of the RO in all years, and ROC prices remain significantly above the Buyout Price, as the quantity of eligible generation is constrained by non-price issues.

In contrast, the *Near Compliant* case illustrates a relatively high renewables build, but still substantially less than the aggregate capacity of proposed projects. We assume that all developers act rationally to develop only projects that are economically viable given projections for the future value of their income stream. In consequence, renewable generation remains less than the RO in all years and ROC prices are above the Buyout level with the quantity of eligible generations being constrained by the new entry costs for each technology.

Amending the eligibility rules for energy from mixed wastes could substantially increase the available eligible generation. If the development of other renewables technologies were heavily constrained by non-price factors such and planning and transmission constraints, as in the *Under Compliant* case, then this growth might be accommodated with little impact on other developments. Average ROC prices could be depressed by £6/MWh, but probably not below the level that would significantly deter investment (the new entrant price).

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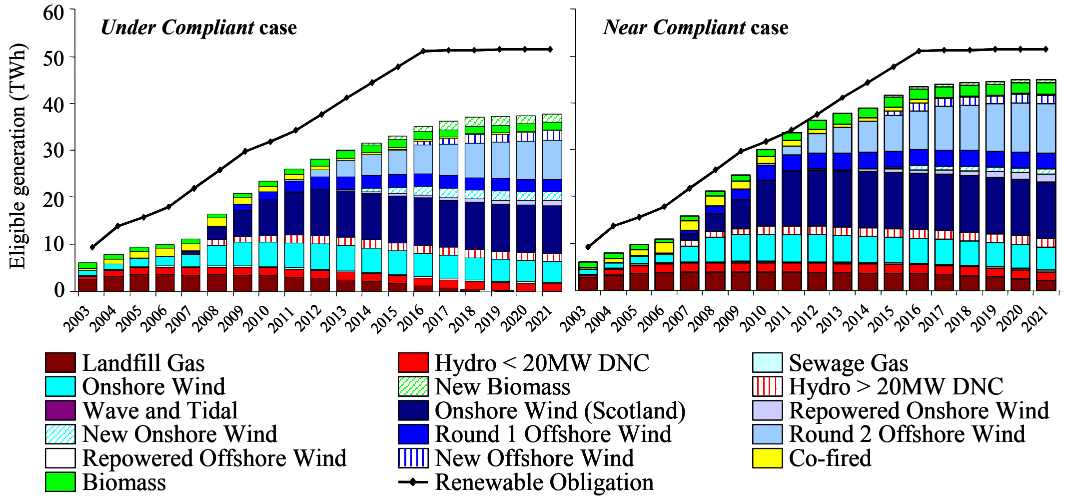
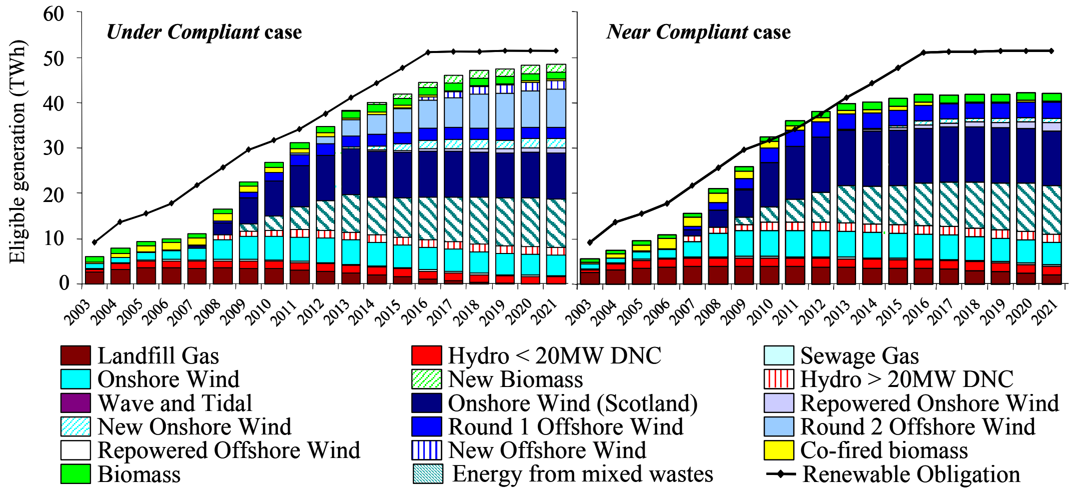
[2] We have assumed that the RO is raised to 15.4% in 2015/16 and incorporates the UK wide market, as envisaged in the draft Renewables Obligation Order 2005.

Figure 3 – *Under Compliant* and *Near Compliant* cases for current eligibility rules



Source: ILEX

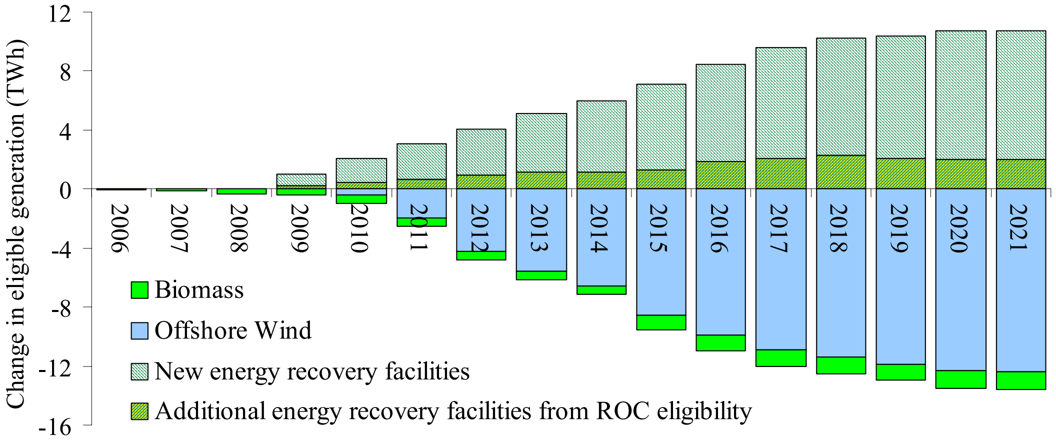
Figure 4 – *Under Compliant* and *Near Compliant* cases for extended eligibility for energy recovery from mixed wastes



Source: ILEX

However, if renewable development were likely to be more substantial, as represented by the *Near Compliant* case, the additional eligible generation from energy recovery facilities would largely be at the expense of generation from offshore wind and dedicated biomass and energy crop facilities. Generation from energy recovery facilities could depress ROC prices to the point that these renewable technologies might not be viable. As energy recovery may not require ROCs or would be less dependent on ROCs for their income than other renewables, they are more likely to be developed than offshore wind or biomass.

Figure 5 – Substitution of generation technologies in the *Near Compliant* case



Source: ILEX

The need for mitigation measures

As we cannot know at this time whether renewable deployment will follow the *Near Compliant* or *Under Compliant* cases we have to assume that to retain investor confidence in the RO, mitigation measures may need to be introduced to ensure that the levels of renewable generation anticipated under a *Near Compliant* case could still be developed after any change to the eligibility rules for energy recovery from mixed wastes. Failure to introduce mitigation measures after changes to eligibility would almost certainly ensure that generation from other renewables technologies does not exceed that in the *Under Compliant* case, as it would not be rational for investors in other renewables to develop these projects if there is the potential for substantial generation from mixed wastes.

The uncertainty over the level of generation from mixed wastes does not aid the development of mitigation measures. If investor confidence is to be maintained following a change to eligibility then it may be necessary to ensure that ROC prices even under optimistically higher levels of mixed waste generation are no less than that which would have arisen in a *Near Compliant* case without the change in eligibility.

Our consideration of possible mitigation measures has concluded that only an increase to the level of the RO would be sufficient to maintain investor confidence. If new build *MT+EfW* and *EfW* energy recovery plant become eligible, we estimate that the RO may need to be increased from 2008/9, rising to 11.7% in 2010/11, 18.4% in 2015/16 and 18.7% in 2020/21. The proposed UK RO is illustrated in Table 1, which also restates the present GB RO and its equivalent UK percentages for comparison.

If existing *EfW* plants were also to become eligible, the RO may have to be increased by 0.5% in each year – rising to 19.2% by 2020/21.

Table 1 – Proposed Obligation level to mitigate the extension of RO eligibility to all new energy recovery from mixed wastes

	2006	2007	2008	2009	2010	2011	2012	2013
Current GB RO	5.5%	6.7%	7.9%	9.1%	9.7%	10.4%	11.4%	12.4%
Equivalent UK RO	5.4%	6.6%	7.8%	8.9%	9.5%	10.2%	11.2%	12.2%
Proposed UK RO	5.4%	6.6%	7.8%	9.5%	10.6%	11.7%	13.3%	14.9%

	2014	2015	2016	2017	2018	2019	2020	2021
Current GB RO	13.4%	14.4%	15.4%	15.4%	15.4%	15.4%	15.4%	15.4%
Equivalent UK RO	13.2%	14.2%	15.1%	15.1%	15.1%	15.1%	15.1%	15.1%
Proposed UK RO	16.0%	17.1%	18.4%	18.5%	18.6%	18.6%	18.7%	18.7%

Note: The *Equivalent UK RO* values represent the current level of the Obligation including Northern Ireland, which takes effect from 1 April 2005

This proposed increase in the level of the RO may be necessary to accommodate the potential use of energy recovery from municipal mixed wastes. In the longer-term we consider that energy recovery may also become viable for commercial and industrial wastes. However, as these wastes are not subject to a cap on landfill, we would not anticipate that a significant volume of biodegradable material from such wastes would be diverted to energy recovery until such time as sufficient capacity has first been developed to recover energy from diverted municipal wastes (perhaps between 2015 and 2020). The timing and extent of this additional generation cannot be determined at this time, not least because there is no clear understanding of the biodegradable content of the residual element of these wastes. Further, we consider that it will be very difficult to differentiate between municipal and commercial and industrial wastes for the purposes of RO eligibility, and may not be desirable. It may therefore be necessary to review the potential for the development of energy recovery from commercial and industrial wastes in due course, to assess any additional mitigation measures which might be needed after 2015/16.

Costs to the consumer

The cost to the electricity consumer of the Renewables Obligation is principally driven by the level of the Buyout price and the annual Obligation level. It follows that an increase in the Obligation, in line with that proposed above, could lead to an increase in the cost to consumers of the order of £160m in 2010/11, £350m in 2015/16 and £400m in 2020/21 (in April 2004 money). If existing *EfW* plants were also to become eligible, the cost to consumers could increase by a further £100m.

Table 2 – Annual cost to consumers of the RO (£bn)

£bn	2010/11	2015/16	2020/21
15% UK RO in 2015/16	1.1	1.6	1.6
18.7% UK RO in 2019/20	1.2	1.9	2.0
19.2% UK RO in 2019/20	1.3	2.0	2.1

However, this increase in costs may lead to an increase in renewable generation. Expressing this cost per unit of eligible renewable generation produced in each year illustrates that unit costs might remain the same or fall. If renewable generation were towards the higher end of expectations (the *Near Compliant* case) the unit cost to consumers could remain unchanged at £32/MWh in 2010/11 and £36/MWh in 2020/21.

Table 3 – Cost to consumer per MWh of eligible renewable generation (£/MWh)

£/MWh	2010/11	2015/16	2020/21
Under Compliant - 15% RO	41	46	43
Under Compliant with EfW eligible - 18.7% RO	40	44	41
Under Compliant with EfW eligible - 19.2% RO	39	44	41
Near Compliant - 15% RO	32	37	36
Near Compliant with EfW eligible - 18.7% RO	32	37	36
Near Compliant with EfW eligible - 19.2% RO	32	37	36

If the volume of renewable generation were towards the lower end of expectations (the *Under Compliant* case), then the unit costs would be greater than in the above *Near Compliant* case but lower than under the present eligibility rules and level of Obligation. This is illustrated in Table 3.

These numbers assume that the volume of generation from mixed wastes is in line with the projections in this report. We have identified that there is considerable uncertainty over the capacity and timing of such developments. Whilst it may be necessary to increase the Obligation to ensure investor confidence is maintained, if the volume of generation from mixed wastes falls below that anticipated the unit cost to the consumer could be greater.

If suppliers are able to satisfy their Obligation through purchasing eligible generation at a price (net of the recycled Buyout Fund payments) below the Buyout Price then it is possible that, in a competitive supply market, that cost savings could be passed back to consumers, reducing the cost to consumers below the figures quoted above.

Additionality

However, in our discussions on the volume of generation we might expect from mixed wastes, we identified that the bulk of this generation from mixed wastes might be developed without ROC support. If we consider the cost to consumer per unit of *additional* generation brought on by RO support, we see that the unit costs might be considered to increase, as illustrated in Table 4.

Table 4 – Cost to consumer per MWh of additional renewable generation brought on through the support of the Renewables Obligation (£/MWh)

£/MWh	**2010/11**	**2015/16**	**2020/21**
Under Compliant - 15% RO	50	53	49
Under Compliant with EfW eligible - 18.7% RO	56	61	57
Under Compliant with EfW eligible - 19.2% RO	58	61	57
Near Compliant - 15% RO	37	42	40
Near Compliant with EfW eligible - 18.7% RO	42	48	48
Near Compliant with EfW eligible - 19.2% RO	44	50	49

Interaction with Council tax bills

Local Authorities' expenditure on waste management will increase substantially over the period to 2020, as alternatives to landfill are of considerably higher cost. Local Authorities may also incur fines under LATS for exceeding their cap on biodegradable municipal waste.

Other things being equal, this could lead to increases in Council Tax bills. ROC eligibility for energy recovery from mixed wastes could help to reduce the net cost of this form of waste management. We envisage that new waste management contracts signed by LAs would benefit from ROCs, as this would permit developers to reduce the residual gate-fee charged to LAs. It is not clear whether existing contracts would allow for the pass back of ROC incomes to LAs or whether this income would be retained by the operator of the waste contract and/or the energy recovery facility – but it is likely to vary on a site-by-site basis.

There is considerable uncertainty concerning the revenues that could be passed back to LAs. In estimating these revenues we have only considered new contracts and that share of the total value of the ROC that a generator may receive. On this basis, a total of perhaps £140m might be passed back to LAs might in 2010/11, £290m in 2015/16 and £330m in 2020/21. This equates to approximately 80% of the cost to the electricity consumer. The residual is likely to be retained by electricity suppliers as the transaction costs of the ROC market.

As has been discussed above, if actual generation from mixed wastes were less than projected when the mitigation measures set a new RO, then the savings that may be made by LAs would be reduced proportionally. However, the cost to the electricity consumer is fixed by the level of the RO, and would be unaffected.

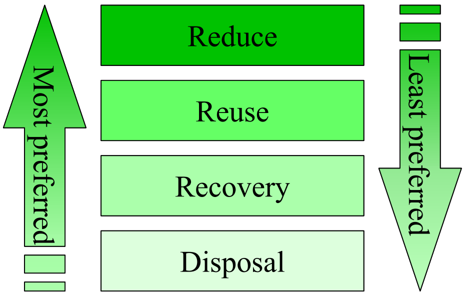
1. INTRODUCTION

1.1 ILEX Energy Consulting has been commissioned by the Department of Trade and Industry (DTI), to assess the options for, and implications of, amending the Renewables Obligation eligibility rules for energy from mixed wastes. This final report presents the results of the analysis undertaken.

Background

1.2 At present, electricity generated from mixed wastes using the advanced conversion technologies of anaerobic digestion, gasification and pyrolysis is eligible for Renewable Obligation Certificates (ROCs). Any other form of generation from mixed wastes is not. The DTI's rationale for restricting the definition to these particular technologies, at the time the Renewables Obligation Order was being drafted[3], was the potential for these technologies to play an important role in the future of electricity generation using energy crops, and the desire of the Government not to encourage energy recovery from waste to the detriment of measures to ensure waste reduction, re-use and recycling.

Figure 6 – Standard waste hierarchy



1.3 It is already apparent that the restricted eligibility of mixed wastes has not made significant progress towards assisting in the development of energy crops. At present, only two projects using advanced conversion technologies[4] have been accredited under the Renewables Obligation.

1.4 At the same time, the waste community is also facing challenges from a number of waste management regulations, including the EU Landfill Directive, the EU Waste Incineration Directive and the current review of the Packaging Waste Directive and national recycling targets.

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[3] The Renewables Obligation: Statutory Consultation. DTI. August 2001

[4] Holsworthy Biogas Company Project (1.56MW) and Compact Power Avonmouth Plant (0.225MW). Source: Ofgem's list of accredited generating stations released 13 January 2005.

1.5 The DTI are, therefore, considering whether other options for waste management have emerged in the market which are consistent with the Government's wider waste management goals. These options include those technologies which involve the creation of a Refuse Derived Fuel (RDF) which could potentially be used in new or existing plant. These technologies include the use of Mechanical Biological Treatment (MBT) and Mechanical Treatment (MT).

The project team

1.6 ILEX is a leading independent European energy markets consultancy specialising in the electricity, gas, carbon and renewables markets. ILEX has expertise in the development and assessment of renewable policy instruments, having advised renewable operators, developers and financiers on market rules and governments on the development of renewables policies. Along with ILEX, the project team has included Julian Scutter of Electrowatt-Ekono's Renewable Energy business area, a leading adviser on waste to energy plants across Europe, and Anton van Santen, a waste management specialist with AEA Technology Environment.

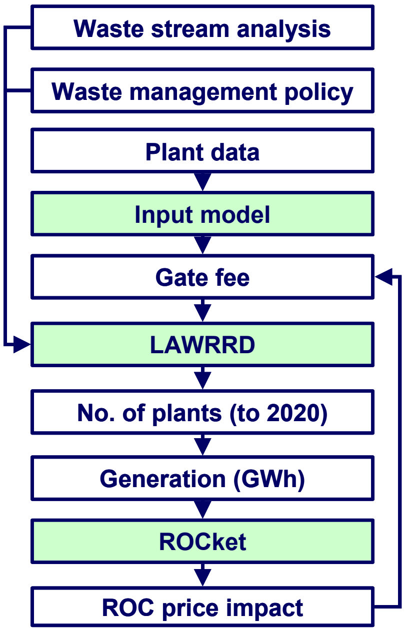
1.7 This study has utilised Defra's Local Authority Waste Recycling Recovery and Disposal (LAWRRD) model, developed by AEA Technology.

Our approach

1.8 Our approach to this study, summarised in Figure 7, is discussed throughout this report, and comprised the following key steps:

- Assessment of the resource available for energy recovery based on current waste management policy drivers and analysis of UK waste stream.
- Review of the economics of energy recovery for four generic process types at a range of scales.
- Optimisation of the take-up of waste management options using Defra's LAWRRD model. LAWRRD forecasts the waste management mix to be adopted through to 2020, taking into each Local Authorities requirements, recycling targets, landfill diversion and landfill tax rates etc.
- Assessment of the non-price sensitive barriers to the take-up of energy recovery, including planning approval and supply chain limitations, to determine the deliverable capacity of energy recovery plant.
- Calculation of the annual eligible generation from the energy recovery plant.
- Analysis of the impact on the ROC prices and the Renewables Obligation, using ILEX's ROC market model (ROCket).
- Determination of the mitigation measures that may be necessary to maintain investor confidence on the RO, were eligibility to be extended to a broader definition of energy recovery from mixed wastes.

Figure 7 – ILEX's approach to the study



Report structure

1.9 In Chapter 2, we describe the waste management policy drivers that underlie the growth in energy recovery from mixed wastes.

1.10 In Chapter 3, we set out the different energy recovery technologies we have considered and their economics and the effect that RO eligibility may have on their take up. We also discuss the uncertainties over the rate of growth of energy recovery from mixed wastes and potential issues relating to the co-firing of RDF.

1.11 In Chapter 4, we discuss impact that the envisaged growth of energy recovery from mixed wastes could have on the RO.

1.12 We discuss in Chapter 5 the mitigation measures that may need to be introduced to maintain investor confidence in the RO if eligibility were to be extended to energy recovery, and the associated costs to consumers.

1.13 Supporting information and our more detailed results are provided in the following Annexes:

- Annex A describes the LAWRRD model used to project the take up of waste management options;
- Annex B provides our assumed capital and operating costs for each of the generic energy recovery technologies we have considered in detail;
- Annex C sets out the detailed results from our modelling of waste management options under a number of scenarios; and

- Annex D provides further analysis on the potential impact that extending eligibility to energy recovery from mixed wastes may have on other renewable technologies.

Convention

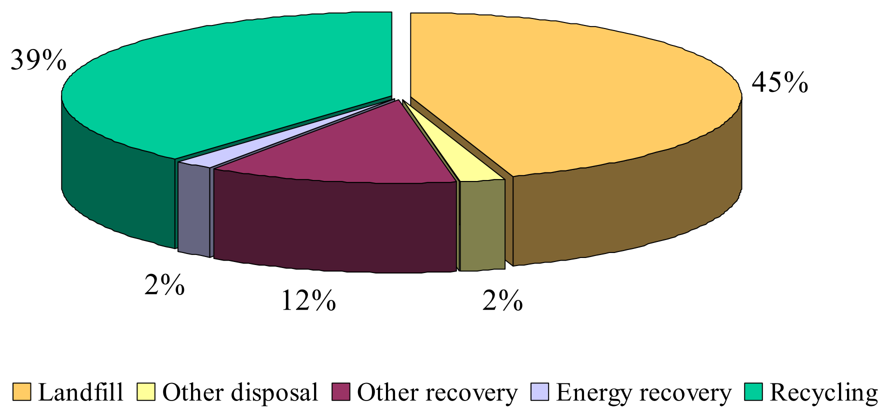
1.14 Unless stated otherwise, all prices and costs presented in this report are expressed in real terms in April 2004 money. References to years within this report relate to financial years ending 31 March. It follows that references to 2006, for example, relate to the period 1 April 2005 to 31 March 2006.

2. THE WASTE MANAGEMENT DRIVERS FOR ENERGY RECOVERY

The waste stream

2.1 Each year, the UK produces over 100 million tonnes of municipal[5], commercial and industrial waste[6], of which municipal only makes up about 30% of the total. Figure 8 illustrates how the UK's waste is presently managed.

Figure 8 – UK waste by management method



Source: Taken from the Headline Indicators of Sustainable Development for the UK – H15 Waste

2.2 Just under half of municipal, commercial and industrial waste is landfilled, whilst the remainder is split between recycling, energy recovery, other recovery and other disposal methods. Of the 45% that is landfilled, municipal waste contributes 60% of this portion. Waste generation is, and is likely to remain (at least in the medium-term), coupled to economic growth. This implies that the waste stream will continue to grow, which has important implications for the way waste will be managed and the approach used to meet a number of EU targets.

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[5] Municipal waste is defined in Article 2(b) of the EC Landfill Directive as: "waste from households, as well as waste which, because of its nature and composition, is similar to waste from households". In the UK, municipal waste is waste which comes under the control of waste disposal, waste collection and unitary authorities. 89% of municipal waste comes from households but it also includes some commercial waste and, where appropriate, some industrial waste.

[6] This does not cover arisings from construction and demolition wastes, agricultural wastes, mining wastes, sewage sludge and dredged spoils. If these wastes were included, the total waste production in the UK totals over 400 million tonnes per year.

Waste management issues

2.3 There are a number of existing regulations which control the amount of municipal, industrial and commercial waste that can be sent to landfill. These include the Landfill Tax, Packaging Regulations and national recycling and recovery targets.

2.4 The Landfill Tax, introduced in October 1996, is designed to stimulate reductions in the levels of waste going to landfill and encourage the development of more sustainable waste management practices. During the Budget 2003, it was announced that the standard rate for the Landfill Tax, which will be £18/tonne from April 2005, would be raised by an additional £3/tonne in each subsequent year towards a medium to long-term goal of £35/tonne[7]. The money raised from the increases in the Land Fill Tax will be redistribution to LAs through the EPCS block of Revenue Support Grant. For the purposes of our modelling, we have assumed that these increases in the level of the Landfill Tax go ahead as planned (see Chapter 3 for further detail).

2.5 The Packaging Regulations[8] sets targets for recovery and recycling of packaging waste to be met by obligated businesses each year so that the UK can meet EC Directive targets[9] by the specified deadline. In 2001, the overall recovery targets were set at 50%-65% whilst the overall recycling targets were set at 25%-45%. Energy recovery from packaging waste can be set against the recovery targets, so long as it does not upset the waste hierarchy. The EU is currently reviewing these targets, and is proposing to increase these targets to 60%-75% and 55%-75% for recovery and recycling, respectively[10].

2.6 The Government has also set a number of recycling and recovery targets for municipal waste[11]. These include:

- to recycle or compost at least 25% of household waste by 2005 and recover value from 40% of municipal waste by 2005;
- to recycle or compost at least 30% of household waste by 2010 and to recover value from 45% of municipal waste by 2010; and
- to recycle or compost at least 33% of household waste by 2015 and to recover value from 67% of municipal waste by 2015.

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[7] "£284M landfill tax recycled to help businesses make the most out of their waste". Defra Press Release. 22 November 2004.

[8] The Producer Responsibility Obligations (Packaging Waste) Regulations 1997.

[9] EC Directive on Packaging and Packaging Waste 94/62/EC.

[10] "Frequently asked questions". Packaging and Packaging Waste. Defra. http://www.defra.gov.uk/environment/waste/topics/packaging/faq.htm

[11] Waste Strategy 2000: England and Wales (Part 1). DETR. May 2000.

2.7 There are also a number of impending challenges resulting from recent EU legislation, which are described in further detail below. These include:

- the Waste and Emissions Trading Act 2003, put in place to assist the UK in meeting its obligations under the EU Landfill Directive[12]; and
- the Waste Incineration Regulations which transposes the EU Waste Incineration Directive[13].

The Waste and Emissions Trading Act 2003

2.8 The EU Landfill Directive requires the diversion of biological municipal waste (BMW) from landfill, and is implemented through the Waste and Emissions Trading Act 2003. These reductions are to be achieved through the use of targets, which for the UK are as follows:

- to reduce the volume of BMW sent to landfill to 75% of the total weight of BMW produced in 1995 by 2010;
- to 50% of the 1995 figure by 2013; and
- to 35% of the 1995 figure by 2020[14].

2.9 In terms of total UK BMW tonnage, these targets have been interpreted as shown in Table 5. Each devolved government within the UK has set out maximum levels for each year leading up to the 2010 target year.

Table 5 – Maximum amount of BMW to be landfilled in each of the target years

ktonnes	**England**	**Scotland**	**Wales**	**Northern Ireland**	**UK**
2010	11,200	1,320	710	470	13,700
2013	7,460	880	470	320	9,130
2020	5,220	620	330	220	6,390

Source: The Landfill (Scheme Year and Maximum Landfill Amount) Regulations 2004

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[12] Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste.

[13] Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste.

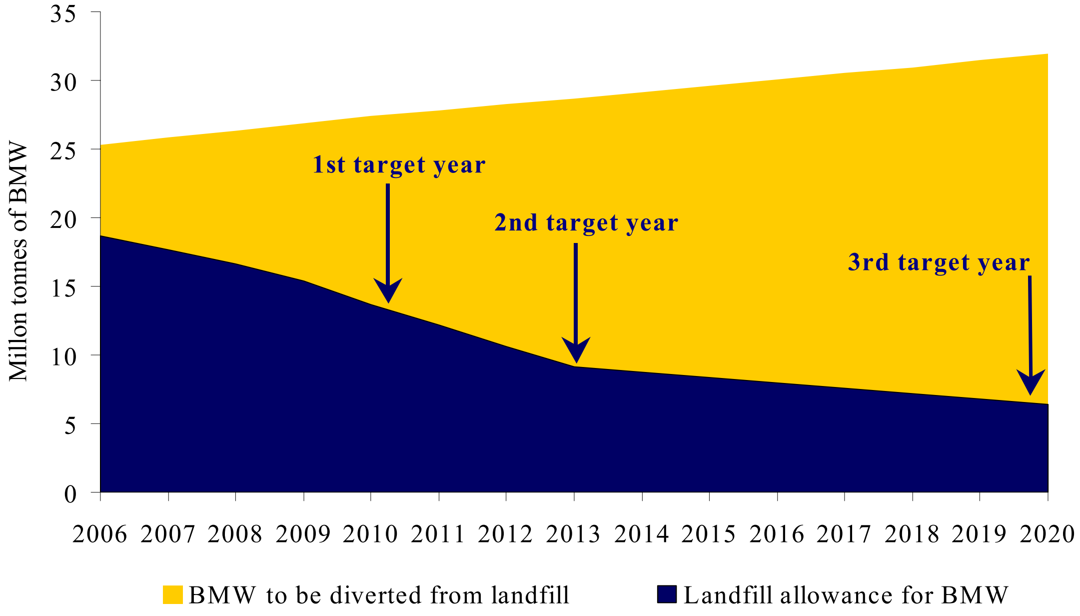
[14] A derogation of four years from the target years, as set out in the EU Landfill Directive, was given to the UK.

2.10 These levels have been apportioned to each Local Authority (LAs), using allowances, and it is up to the LA as to how they achieve their individual targets through the use of:

- own reduction and diversion;
- a penalty payment of £150 for every tonne that exceeds their assigned cap; or
- where permitted, LAs may trade allowances with other LAs (i.e. through the Landfill Allowance Trading Scheme (LATS), available to LAs in England).

2.11 Since the quantity of BMW is likely to continue growing, these tightening landfill targets imply rapidly increasing amounts of BMW that will need to be diverted away from landfill. Figure 9 provides some indication of the projected volume of BMW that will need to be diverted.

Figure 9 – Projected level of BMW in the UK and the corresponding landfill targets



Sources: ILEX analysis: assumes UK growth in BMW of 2% per annum to 2010 and 1.5% thereafter. Note: this may be conservative – historical average for England is 2.97%. The Landfill (Scheme Year and Maximum Landfill Amount) Regulations 2004, and Waste Strategies of England Wales, Scotland and Northern Ireland.

Waste Incineration Regulations

2.12 The Waste Incineration Regulations, to apply from 28 December 2005, transposed the EU Waste Incineration Directive (WID), and covers those plant that recover energy from waste or are co-fired with waste or refuse derived fuel (RDF). These regulations introduce stringent operating conditions and sets minimum technical requirements, with the aim of preventing and limiting negative environmental effects by emissions into air, soil, surface and groundwater, and the resulting risks to human health.

2.13 Although any new energy recovery from waste plant will be built to these requirements set down in the WID, these regulations will also apply to conventional generating plant which decide to co-fire with fuel derived from mixed wastes. In Chapter 3 we discuss the potential regulatory risks surrounding the issue of co-firing with this particular fuel, but it is questionable as to whether a conventional generating plant would be willing to incur further capital and operating costs in order to meet these requirements. Particularly in view of other environmental requirements applying to conventional generators from regulations including the EU Emissions Trading Scheme (EU ETS) and the Large Combustion Plant Directive (LCPD).

Possible solutions to waste management issues

2.14 Although much of the LAs current emphasis is on prevention and recycling, LAs urgently need to find alternatives to landfill for residual wastes, if they are to meet their assigned allowances and comply with the forthcoming regulations. It is recognised that significant additional treatment through recovery processes will be required if landfill and recycling targets are to be met. In Chapter 3, we discuss what options are available to the LAs, but in summary they include:

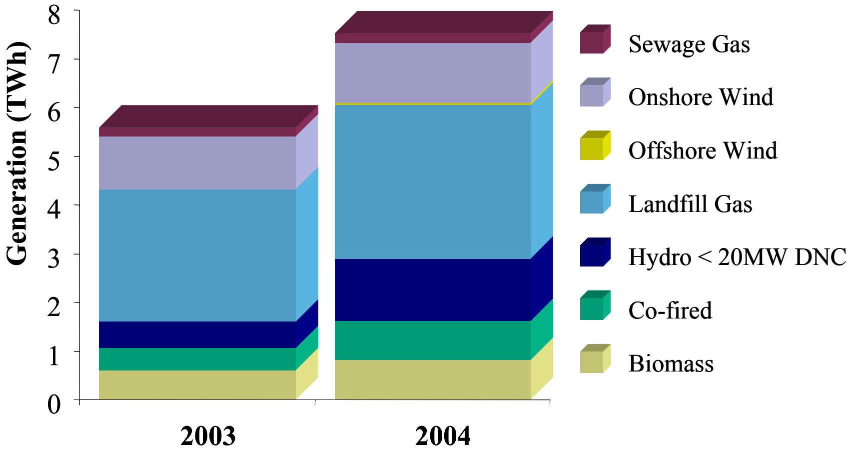
- recovery of materials from source segregated collection systems;
- recovery through production of compost from source segregated green wastes;
- recovery of materials through processing of mixed wastes;
- potential stabilisation of residual BMW from mixed wastes using biological treatment processes (e.g. MBT); and
- energy recovery from waste.

Current contribution towards RO from mixed wastes

2.15 Under the current rules of the Renewables Obligation, only energy from pyrolysis, anaerobic digestion and gasification of mixed wastes are eligible to receive ROCs.

2.16 Figure 10 illustrates that the present contribution that these different technologies, termed in the charts as “biomass and waste” make towards the total RO eligible generation is less than 1% for the first two RO compliance years, 2002/3 and 2003/4.

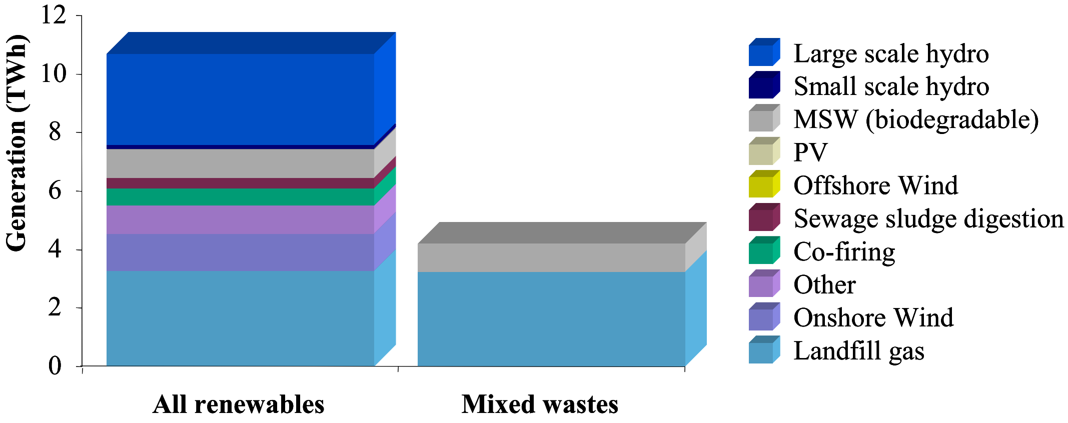
Figure 10 – Annual RO eligible renewable generation



Source: Ofgem ROC register and ILEX analysis

2.17 Under the EU Renewables Directive wider definition of biomass, which is the biodegradable fraction of industrial and municipal waste, the present contribution of electricity generation from mixed wastes would be around 9% of total renewable generation. This is illustrated in Figure 11. It demonstrates that there is potential for significant volumes of renewable generation to contribute to the Renewables Obligation if eligibility was extended to this particular area. Chapter 3 looks at whether this is probable given other constraints whilst Chapter 4 considers the potential impact extending eligibility could have on the Renewables Obligation and certain renewable technologies.

Figure 11 – Annual renewable generation in 2004 by DUKES technology/fuel type



Source: DUKES 2004.

Note – MSW (biodegradable) relates to all waste generation (fossil and biomass origin)

UK and European energy recovery capacity

2.18 Table 6 provides an indication of the current, developing a proposed capacity for energy recovery from waste facilities in the UK.

Table 6 – UK energy recovery capacity

	Capacity (kt MSW/year)	Net generating capacity (MW)	Qualifying LEC capacity (MW)
Operational	3341	272	118
Under construction	721	57	-
Planning granted	992	81	-
Subject to planning	1490	151	-

Source: ESA/Ofgem

2.19 Looking at the situation across Europe, almost every country has energy recovery facilities. In general, there are two important uses for the energy recovered, heat and electricity. Other European countries use a high percentage of the recovered energy to produce hot water for district heating, particularly in Scandinavia.

2.20 From research carried out by the International Solid Waste Association[15], Denmark currently ranks the highest with just under 600kg/year/capita of energy recovery capacity, followed by the Netherlands and Belgium. The UK, however, languishes somewhere near the bottom, with less than 25kg/year/capita.

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[15] "Status of WTE in Europe". Waste Management World. International Solid Waste Association. May-June 2002.

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3. PROJECTING THE GROWTH OF ENERGY RECOVERY FROM MIXED WASTES

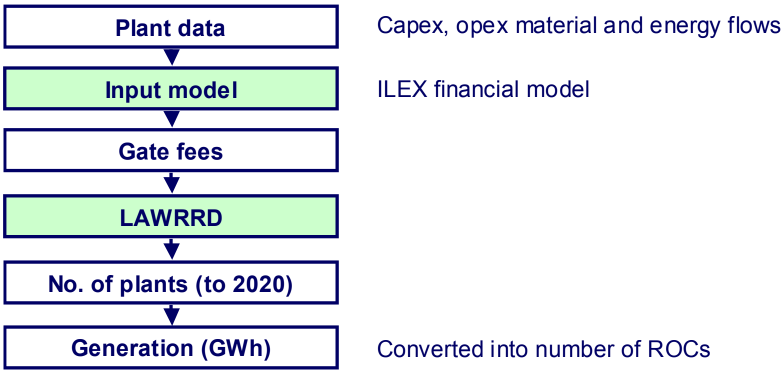
3.1 In this chapter we assess the waste management options that will be adopted over the period to 2020 and quantify the potential growth in energy recovery from mixed wastes, both with and without eligibility for ROCs. We set out the different options we have considered for energy recovery and describe the high level revenue and cost streams under each technology type.

Methodology

3.2 Figure 12 illustrates the methodology used for determining the potential level of renewable generation that could come about if RO eligibility was awarded to energy recovery facilities. This has included the combination of:

- a proprietary financial model converting capital and operating cost assumptions for various EfW technologies into the implied gate fee that each plant type would need to charge per tonne of MSW input in order to make a specified return; and
- LAWRRD, a model developed by AEA Technology for Defra to model waste management in England.

Figure 12 – Modelling process



Technology options modelled

3.3 Three generic processes for energy recovery from mixed wastes have been analysed in detail.

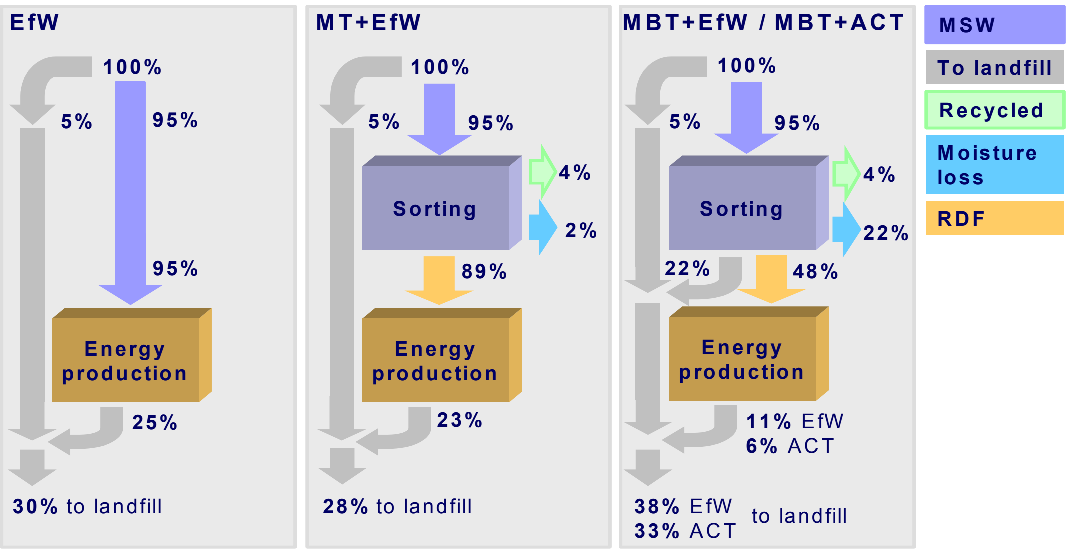
- Mechanical Biological Treatment with conventional energy recovery (*MBT+EfW*);
  - mechanical sorting of mixed wastes to recover materials and segregate biodegradable material;

  - biological composting of segregated biodegradable waste;
  - conventional energy recovery of residual wastes;
- Mechanical Treatment with conventional energy recovery (*MT+EfW*);
  - mechanical sorting of mixed wastes to recover materials;
  - conventional energy recovery of residual wastes;
- Conventional energy recovery (*EfW*);
  - conventional energy recovery from mixed waste stream.

3.4 All of the plant types were assumed to operate as integrated plant at four scales: a rated MSW input capacity of 50, 100, 200 or 400 kilo tonnes per year. Typical capital and operating costs were calculated for all sixteen plant options (four plant types at four scales), and then used to calculate the gate fee required by each. Details of the capital and operating cost assumptions for each plant type and scale are provided in Annex B. Plants with more sophisticated pre-treatment generally had higher costs than their simpler counterparts, but all plant types benefited from substantial economies of scale.

3.5 Figure 13 illustrates the material flows for each of three generic processes, whilst Figure 14 illustrates the corresponding energy balances.

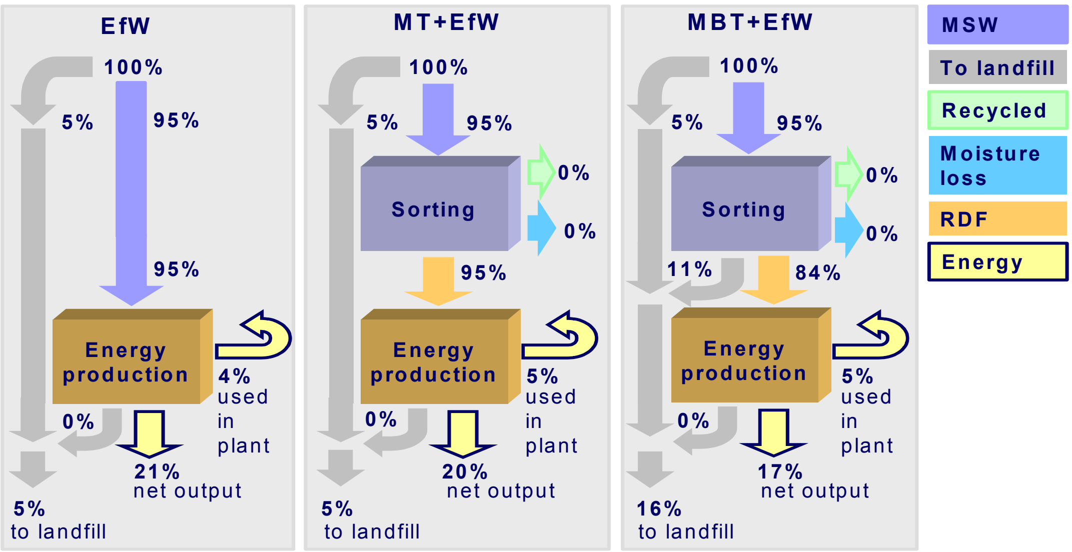
Figure 13 – Material flows for technology options modelled



Source: Electrowatt-Ekono / ILEX

3.6 Each of these options reduces the volume of waste to landfill by approximately 90%. However, there remains a requirement to landfill between 28% and 38% of the processed wastes by mass, representing: diversion during outage (5%), residues segregated during pre-treatment (up to 22%) and bottom ash from the incineration process.

Figure 14 – Energy flows for technology options modelled



Source: Electrowatt-Ekono / ILEX

3.7 In practice, there is considerable flexibility around the outputs from these plant. Notably, MBT processes can be tuned to produce a variety of outputs and the energy recovery facility may not be integrated with pre-treatment plants. However, the particular technologies chosen, and the process and energy flows assumed, are representative of the technologies that could be adopted for energy recovery from mixed wastes and allow for meaningful comparisons between them.

Alternative energy recovery options

3.8 We have also looked at the use of alternative energy recovery options but do not consider that they will be adopted in substantial number or that such uptake will materially impact on the results of this study. These technologies, discussed below, include:

- MBT with advanced conversion technologies (MBT+ACT);
- provision of Refuse Derived Fuel (RDF) to conventional and biomass power stations;
- co-location of energy recovery providing steam to conventional power stations; and
- cement kilns.

Advanced conversion technologies

3.9 At present, the only technologies that come under the guise of *MBT+ACT* are those RO eligible technologies that use gasification, pyrolysis and anaerobic digestion. As demonstrated in Chapter 2, these contribute a small amount of generation towards the RO at present and on the basis of our least-cost modelling are unlikely to be developed on a substantial scale in the medium term. However, the cost analysis provided in Annex B illustrates that for very small projects ACT may be competitive, making it more attractive for smaller communities.

Co-firing of RDF in conventional or biomass generators

3.10 The economics co-firing of waste, in the form of RDF, with fossil or biomass fuel is primarily restricted by the requirement for the generator to meet the standards set by the Waste Incineration Directive (WID). In effect, this means that co-firing of material quantities of RDF is only possible in large, coal-fired power plant already fitted with appropriate flue gas desulphurisation (FGD) equipment. At present in the UK, only three power stations meet this requirement, Drax, Ratcliffe and West Burton and only a further three are considering/commissioning emissions abatement equipment, Eggborough, Cottam in England and Kilroot in Northern Ireland. Even with these plant there may be a need to invest in additional environmental protection, mills, burners and on-site storage. The other large coal-fired power stations in the UK are expected to close by 2016.

3.11 Where co-firing may be economic in FGD plant, technical uncertainties may still deter its use. To date, operators of FGD plant have been reluctant to co-fire biomass material because of concerns over the impact on the life of the generation assets. These concerns are also likely to be a deterrent to the use of RDF, though we note that large-coal fired plant are able to co-fire RDF in Germany.

3.12 Any investments in co-firing technology could require prohibitively short – and decreasing – pay-back periods, if co-firing of RDF is phased out under the RO by 2015/16, in line with the co-firing of biomass and energy crops. This contrasts with the situation in Germany, where RDF co-firing has more potential in part because the coal plants in use are younger. The problem of a shortened payback period is particularly acute for investments in new burners, which would be required if the plant were to burn more than approximately 5% RDF. Coal plant burning less than this proportion may be able to use the existing burners, but to do so the RDF would need to be specially pelletised, adding to costs.

3.13 Finally, co-firing of RDF presents a number of technical and logistical problems, including the need to guarantee an RDF supply, even for trials, the required storage space. Even if a proportion of RDF were to be burned in these combined plant, most of the results of the analysis show that, changing the economics of the various plant types results largely in substitution with other forms of energy recovery for mixed wastes, rather than additional generation. As a result, it has a limited impact on the total power generated and therefore on the number of ROCs earned.

Co-location with steam-cycle plant

3.14 Waste sorting and incineration facilities could choose to co-locate with conventional steam cycle plant, feeding steam generated into existing steam turbines of the host generator. This has the advantage of avoiding the capital cost of a new steam turbine. Unlike the above co-firing option, only the new incinerator would have to comply with the WID, not the hosting generator.

3.15 However, we consider that the scope for such schemes is limited given the small number of coal or oil plant that will be operating beyond 2015/16. Further, to make efficient use of the steam, both the conventional and waste plant would need to operate at the same time, yet coal and oil plant tend to operate in mid-merit or peaking modes, whilst a waste plant would operate baseload.

3.16 We consider that there is limited scope for co-location with existing combined cycle gas turbine (CCGT) generators, as there is unlikely to be sufficient spare capacity in the steam turbines without unduly constraining the operation of the gas turbines, at the expense of increased NO_x and SO_2 emissions. There may be more scope to co-locate alongside new-build CCGTs, where the steam turbine could be appropriately sized. As with co-firing, any plant that were built would be straight substitution with the projected build of MT+EfW, and would not be expected to lead to an increase in the projected quantity of eligible generation.

Use of RDF in cement kilns

3.17 With regard to the use of cement kilns, there is the potential for this technology to provide a route for some RDF, however, this route would not be eligible under the RO, as no electricity would be produced and RDF would be competing with hazardous waste feedstocks which lack alternative routes.

The economics of energy recovery facilities

Revenue and cost streams

3.18 All of the energy recovery technologies analysed have similar sources of revenues and costs. Revenues come from a gate fee levied on each tonne of MSW they take in, the value of materials recycled during the process and payments for the energy, Renewable Obligation Certificates (ROCs), Levy Exemption Certificates (LECs) and embedded benefits. The gate fee will comprise the LAs avoided costs its alternative waste management option - whether that be landfill disposal and Landfill Tax, recycling, or at the extreme, the LATS penalty. Competition between waste management companies should ensure that gate fees are bid down to the level needed to just cover the cost of the facility. As such, eligibility for ROCs should result in a reduction in gate fees charged to LAs.

3.19 Capital costs include planning, plant and land costs, whilst operating costs include labour, consumables, maintenance and the costs of disposing of outputs or residues. Notably, the Environment Agency is proposing[16] that the compost and

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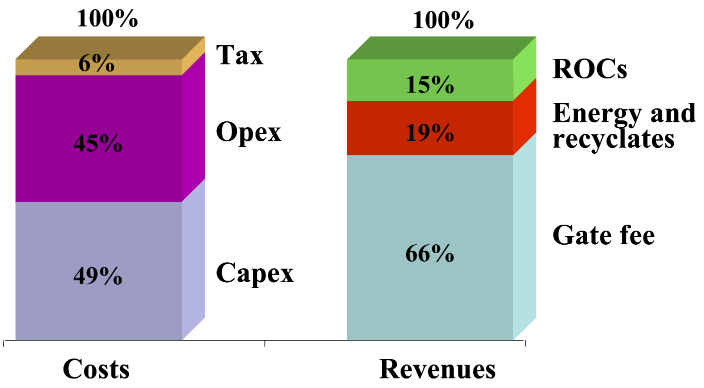
[16] "Monitoring the Diversion of Biodegradable Municipal Waste from Landfill", Environment Agency, 23rd November 2004. Available from: http://www.environment-agency.gov.uk/commondata/acrobat/lats_912842.pdf

fines produced by the MBT process, as modelled, will not be characterised as inert, and so will attract Landfill Tax at the higher rate and count towards LAs biodegradable municipal waste (BMW) landfill targets. Throughout this analysis we have taken the Environment Agency's proposals as a given, but have undertaken a number of sensitivities (see Annex C) to test the impact if these proposals did not materialise. These sensitivities suggest that classifying compost and fines produced by MBT as inert would not affect the conclusions of our least-cost modelling, as the plant mix is unaffected and *MBT+EfW* plant are still not developed. Other factors, may encourage LAs to invest in MBT facilities including their perceived public acceptability and any desire to increase recycling levels beyond that possible for source-segregated schemes.

3.20 Although the relative importance of each of these elements varies by technology, in general, the levelised costs per unit of MSW input are split more or less evenly between capital and operating items. Revenues are dominated by the gate fee for all of the technology options, even if the power generated by the plant is assumed to be eligible for ROCs. The caveat to this statement is that because electricity generation (and therefore the number of ROCs earned) rises in a linear relationship with the volume of MSW processed for all of the technology options, whereas costs per unit MSW decline rapidly with size, energy sales and ROCs are proportionally more important for larger plant.

3.21 A simplified diagram of the apportionment of costs and revenues, including ROCs, for an average technology at a 200ktpa scale is shown in Figure 15. It demonstrates that the gate fee is the balancing item between the costs and the revenues. This replicates the structure of the model, in which the fee is calculated as the present value of the revenue required per tonne of MSW accepted over the operating life of the plant to balance the other costs and revenues at a given rate of return.

Figure 15 – Cost and revenue apportionment for average 200ktpa EfW plant



Source: Electrowatt-Ekono / ILEX

3.22 The relative importance of ROCs as part of the revenue stream of a plant, equivalent to the 15% shown in Figure 15, varies from 5% for small, more complex plant to 21% for large, relatively simple EfW plant with no pre-treatment.

LAWRRD model structure and outputs

3.23 LAWRRD is a cost-driven model whose key input is the gate fee required by a range of waste management processes. It assumes that each LA chooses the cheapest option available to it given the recycling and landfill targets and other pressures. In order for LAWRRD to project the number of EfW plant that could be built, the gate fees from the financial model were input in the same way as the costs of the full range of other waste management and disposal options. A more detailed description of LAWRRD is provided in Annex A. LAWRRD provides results for England only. The results have been interpolated for the UK, taking account of LATS in England and Scotland, but not Wales.

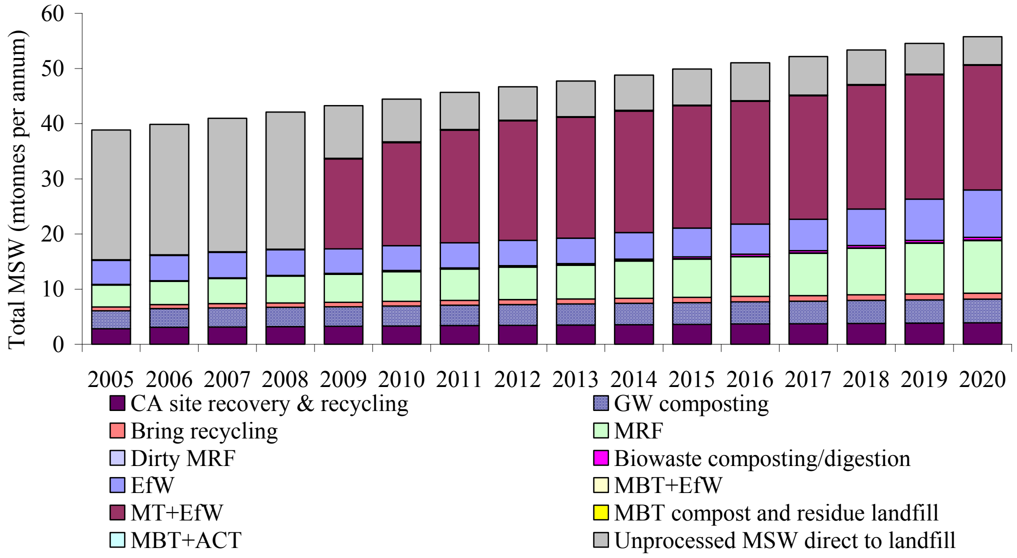
3.24 Although LAWRRD takes some account of planning and other restrictions on plant development, its output is best thought of as representing the number of economically viable plants that could be built, rather than the number of plants that could be expected to be built. As a result, the build rates implied by LAWRRD's raw output may not be considered realistic. A separate step was introduced to derive the deliverable capacity of energy recovery projects taking account of planning, and supply-chain constraints. This aspect is discussed in further detail in paragraph 3.35, below.

3.25 Using two different ROC price scenarios, *Under Compliant* and *Near Compliant* (described in Chapter 4), renewable generation levels were modelled for the different energy recovery technologies considered (see paragraph 3.3). ROCs were awarded to that proportion of the electricity produced from biodegradable fraction of wastes. The remainder of this chapter considers the ROC price under the *Near Compliant* case (with alternative scenarios are considered in Annex B).

The optimal mix of waste management options

3.26 Figure 16 illustrates the optimised mix of waste management options for municipal wastes we have projected using LAWRRD for the UK market. Most significant in this chart is the diversion of wastes from landfill from 2009 onwards, in line with LATS obligations. From Figure 16 it can be seen that much of this waste would be diverted to *MT+EfW* facilities, with growth in *EfW* facilities from 2015. The use of kerbside recycling and materials recovery facilities (labelled as MRF in the chart) grow throughout this period. Other forms of recycling and composting remain unaffected by this change.

Figure 16 – Total UK MSW by treatment process (assumes only ACT is RO eligible)

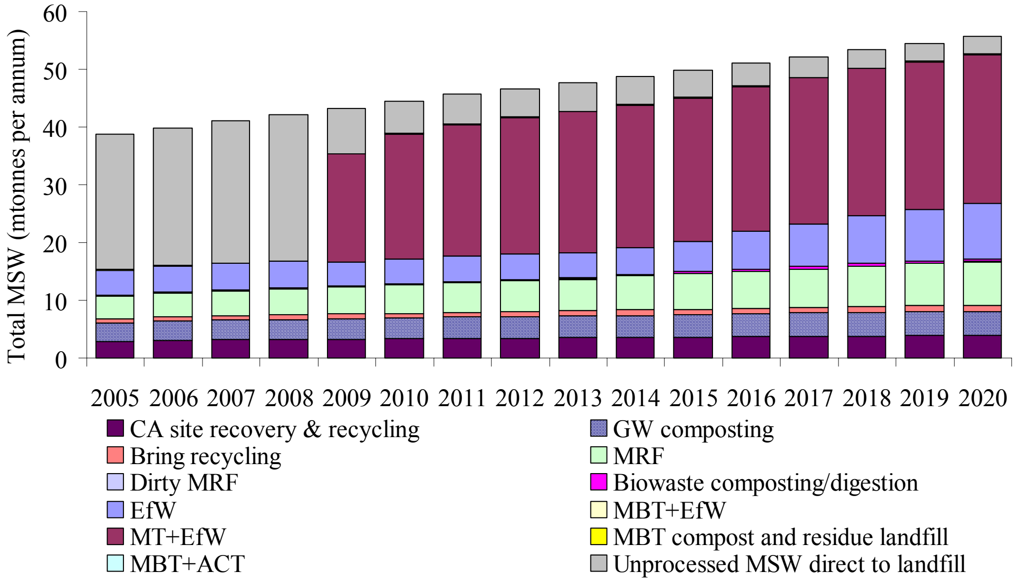


Source: ILEX

Effect of RO eligibility on energy recovery

3.27 Figure 16 illustrates the mix of waste management options assuming that only energy recovery options utilising advance conversion technologies would be eligible for ROCs. By contrast, Figure 17 illustrates the optimal waste management mix where all energy recovery options are eligible for ROCs (on energy derived from the biodegradable proportion of mixed wastes).

Figure 17 – Total UK MSW by treatment process (all energy recovery technologies RO eligible)



Source: ILEX

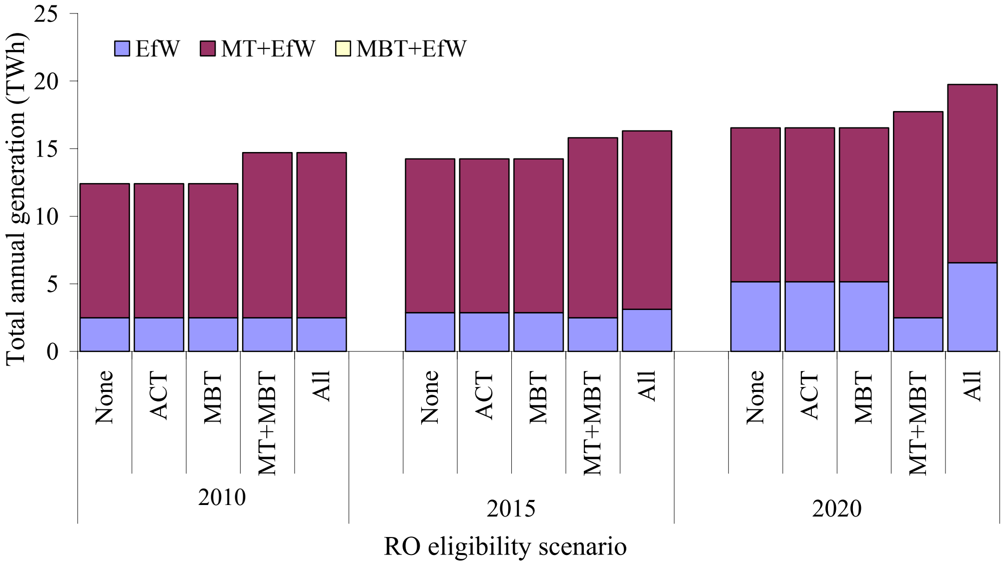
3.28 Comparison of Figure 16 and Figure 17 illustrates that ROC eligibility leads to a small increase in the use of energy recovery options, principally at the expense of landfill, but also dampening the growth in recycling highlighted on paragraph 3.26. In all the scenarios considered the aggregate volume of recycling increases throughout the period considered.

3.29 Figure 18 illustrates the total annual generation from mixed waste technologies under a range of scenarios for RO eligibility. This indicates that the vast majority of capacity gets built even if no form of energy recovery were to be eligible for ROCs. ROC eligibility increases the total amount of generation by 19% in 2010, 15% in 2015 and 17% in 2020.

3.30 Figure 18 additionally shows that, under the assumptions used, only *MT+EfW* and *EfW* plants are built. Differentiating eligibility can change the relative quantity between the two technologies (*EfW* and *MT+EfW*) that will be developed but is insufficient incentive to bring on any energy recovery technologies that would not otherwise be developed. *MBT+EfW* and *ACT* plants do not offer sufficient extra material diversion or recycling, nor is their environmental performance significantly better to justify their higher cost to the LAs. Even if *ACT* or *MBT+EfW* plants are awarded ROCs when *EfW* and *MT+EfW* plants are not, none get built.

3.31 In practice we would not anticipate that mix of technologies will be as clear cut as indicated from the economics. Local Authorities and developers may be influenced by additional factors. For example, current enthusiasm amongst waste managers for MBT plant is likely to lead to a number being developed, that may or may not be retrofitted with energy recovery facilities or supply RDF to other facilities. Our analysis suggests, however, that there is insufficient value to warrant the additional costs incurred in segregating biodegradable material for composting from mixed wastes and disposing of residues (particularly if those residues count against the LATS). LAs seeking to recycle very high proportions of waste, beyond the statutory levels, may find MBT an attractive complement to source-segregated recycling. Such a choice is unlikely to significantly impact on the ROC eligible generation presented in this report, as it is likely to be a direct substitution for *MT+EfW* generation.

Figure 18 – Total annual generation from mixed wastes by technology for a range of RO eligibility options

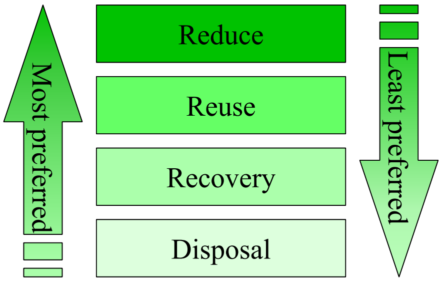


Source: ILEX

Impact on the waste hierarchy

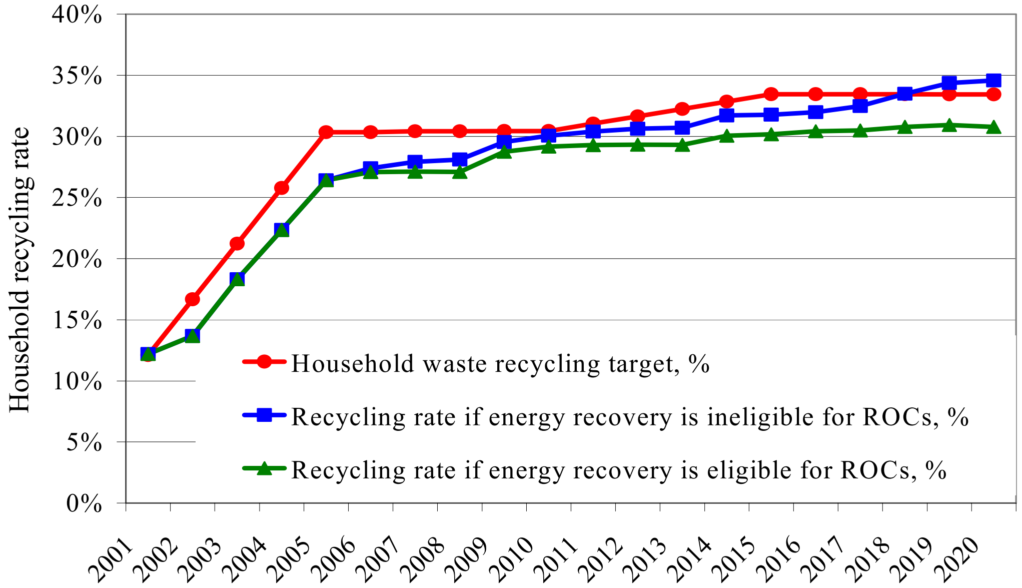
3.32 The waste hierarchy expresses a preference for waste reduction over reuse of materials, reuse over recovery (including recycling, composting and energy recovery) and recovery over disposal.

Figure 19 – Standard waste hierarchy



3.33 From Figure 16 it can be seen that the anticipated growth in energy recovery from mixed wastes remains consistent with the waste hierarchy, in that it is alongside a growth in recycling and constant levels of composting. From Figure 17, it can also been seen that extending ROC eligibility to all energy recovery from mixed wastes could reduce further the volume of wastes being sent to landfill, consistent with the hierarchy, whilst recycling also increases. However, comparison of Figure 17 with Figure 16 indicates that there could also be a slight reduction in recycling where energy recovery is eligible relative to the position if it were not. This position can be demonstrated in Figure 20, which shows the projected household recycling rates from LAWRRD in both cases against the target levels. In both cases the recycling rate continues to rise throughout the period.

Figure 20 – Household waste recycling rates with and without ROC extended eligibility for energy recovery from mixed wastes

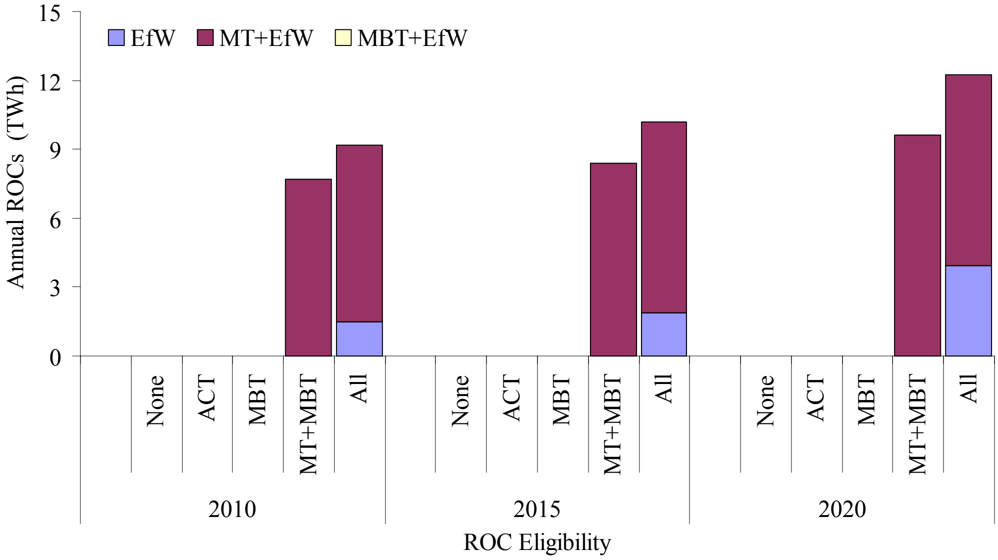


Source: ILEX

ROC eligible generation

3.34 Because only *MT+EfW* and *EfW* plant are projected to be built, ROCs are only earned from energy recovery from mixed waste in cases where these technologies are RO eligible. Furthermore, they are only earned on that proportion of the electricity produced that is deemed to have come from biodegradable wastes. This proportion varies depending on the extent and nature of material recovery and its biodegradable content but approximates 68% of municipal waste on average. Figure 21 shows the number of ROCs awarded to each of these energy recovery technologies under each scenario for eligibility considered.

Figure 21 – Total ROCs awarded by eligibility scenario from economically viable capacity



Source: ILEX

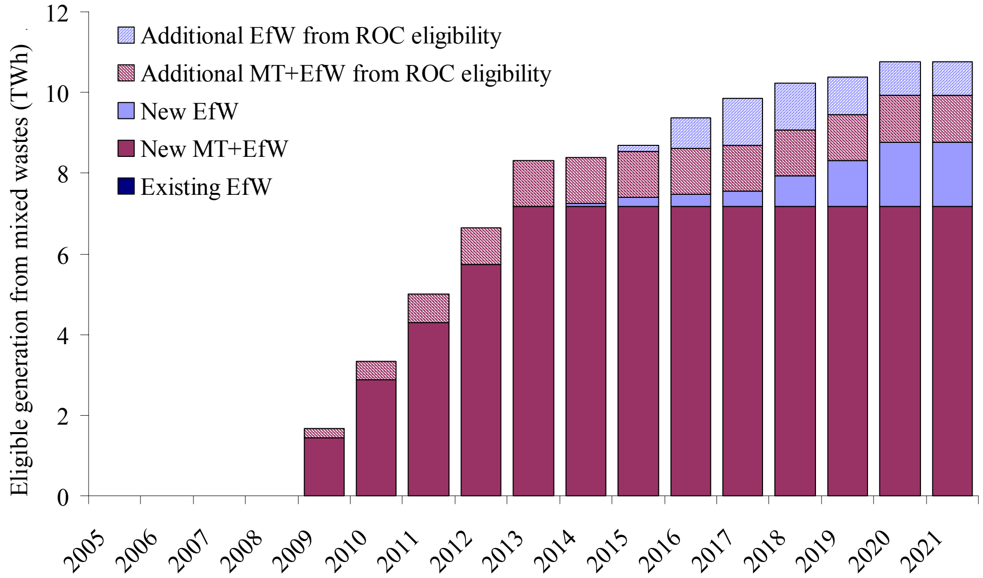
Determining a deliverable build rate for energy recovery facilities

3.35 As noted in 3.24, the plant build rates implied by LAWRRD's outputs are unrealistic. The model suggests that 18 million tonnes of new energy recovery capacity, resulting in 9TWh of new generation, could be economic in 2009 alone. In practice, the deliverable capacity could be substantially less than this at first. Planning and consenting for energy from waste facilities has proven difficult and time-consuming to date because of public perception issues. Even if this capacity were rapidly consented, constraints in the supply chain with equipment supply, engineering, operational expertise and, potentially, access to capital funding would most likely delay development.

3.36 As there seems to be no industry consensus on a possible build-rate, we have assumed two simple growth rates. The first was linear growth in generation output to the level predicted by the model from 2009 to 2014 and the second was linear growth from 2009 to 2018. Figure 22 shows how these build rates translate into ROC-eligible generation under the five-year phase-in and Figure 23 over a ten-year period. We have indicated in this chart how eligibility for energy recovery might increase the annual generation from the two technologies likely to be developed.

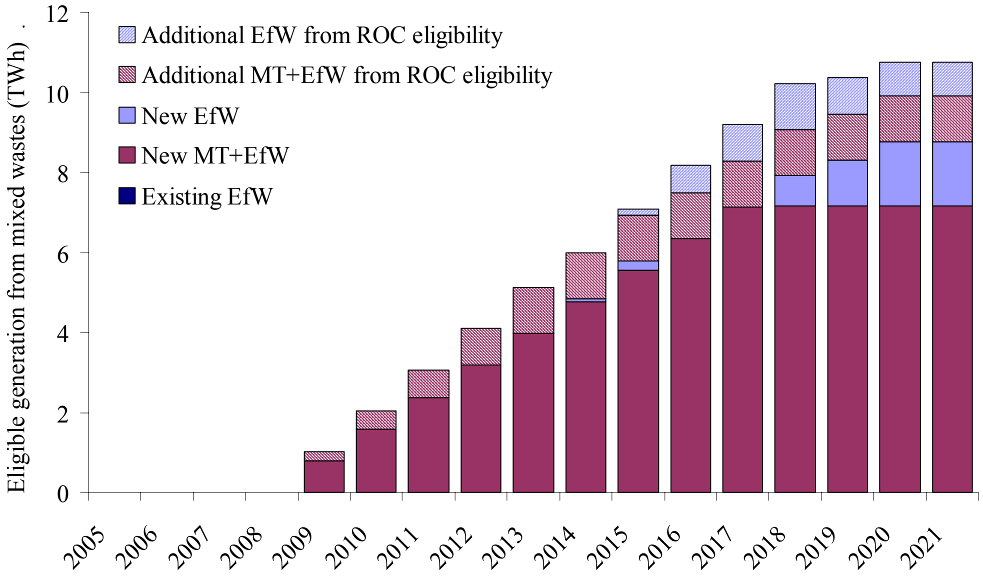
3.37 In Chapter 4 we consider the impact that extended eligibility for energy recovery may have on the RO. In doing so we have illustrated the impact assuming the five-year phase-in described above and in Figure 22.

Figure 22 – Potential growth in RO eligible generation from energy recovery technologies with a five-year phase-in



Source: ILEX

Figure 23 – Potential growth in RO eligible generation from energy recovery technologies with a ten-year phase-in



Source: ILEX

The phase-in of deliverable capacity implies that LAs will find it extremely challenging to meet their landfill diversion obligations and may incur penalties over a number of years. It must also be recognised that this economic capacity might never be achieved if planning restrictions force LAs to adopt more expensive alterative waste management options.

3.38 In addition to the municipal wastes diverted from landfill, there is also the potential in the longer-term for commercial and industrial wastes to also seek to use energy recovery, if the economics were more attractive than the costs of landfill.

Monitoring the biodegradable fraction of mixed wastes for RO eligibility

3.39 As only the generation from the biodegradable proportion of the waste input in to the energy recovery facility will be eligible for ROCs, it will be necessary to monitor the biodegradable proportion of the wastes streams for each plant. Ofgem, which administers the RO and issues ROCs to accredited generators, already administers the Levy Exemption Certificates (LECs) scheme for energy recovery facilities. Under the present LECs scheme[17], energy recovery from mixed wastes is presumed to be eligible for LECs on 50% of its output, but can be accredited at a greater proportion where regular independent audits of the waste stream demonstrate that the calorific value of the biodegradable proportion of the mixed wastes exceeds this threshold.

3.40 In principle this scheme should be equally applicable for ROCs, and has the advantage of allowing Ofgem a single accreditation process. However, it should be considered whether using an arbitrary default value of 50% is appropriate for energy recovery from mixed wastes that might involve pre-treatment of wastes (i.e. *MBT+EfW*). It might be possible to produce two streams of RDF, one with high biomass content that qualifies for a higher accreditation and one with low biomass content which qualifies for a default value – such that the aggregate accredited proportion exceeds that of the waste stream entering the pre-treatment facility. Given the high value of ROCs (relative to LECs), it may not be too arduous to require all energy recovery facilities to undertake regular waste stream audits to determine their accreditation level, rather than using default values.

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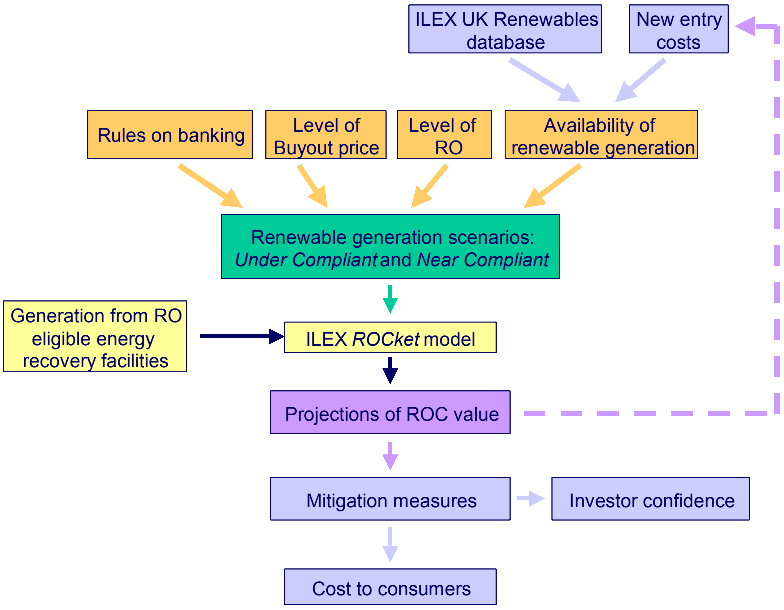
[17] Further information on the accreditation of energy from waste for LECs can be found on Ofgem's website: http://www.ofgem.gov.uk/temp/ofgem/cache/cmsattach/6284_cclinfonote2.pdf

4. IMPACT ON THE RENEWABLES OBLIGATION

4.1 In this chapter we consider the impact that extending the eligibility of energy recovery from mixed wastes could have on the Renewables Obligation (RO). Assessing the impact that extending the eligibility for energy recovery from mixed wastes could have on the Renewable Obligation is complex. In addition to the uncertainty over the build rate energy recovery facilities, described in Chapter 3, there is also uncertainty over the capacity of the other renewable technologies that will be developed under the RO. These two factors are of course interrelated, such that the possibility that large quantities of ROCs could be sourced from energy recovery could reduce investor confidence in the returns available to other technologies – thereby reducing their deployment.

4.2 Figure 24 provides a schematic representation of how we have undertaken analysis on the impact on the RO, whilst the following sections expand on each of the stages. To undertake this assessment we have considered as our starting point two alternative scenarios for the level of renewables development under the present RO[18].

Figure 24 – ROC impact methodology



Source: ILEX

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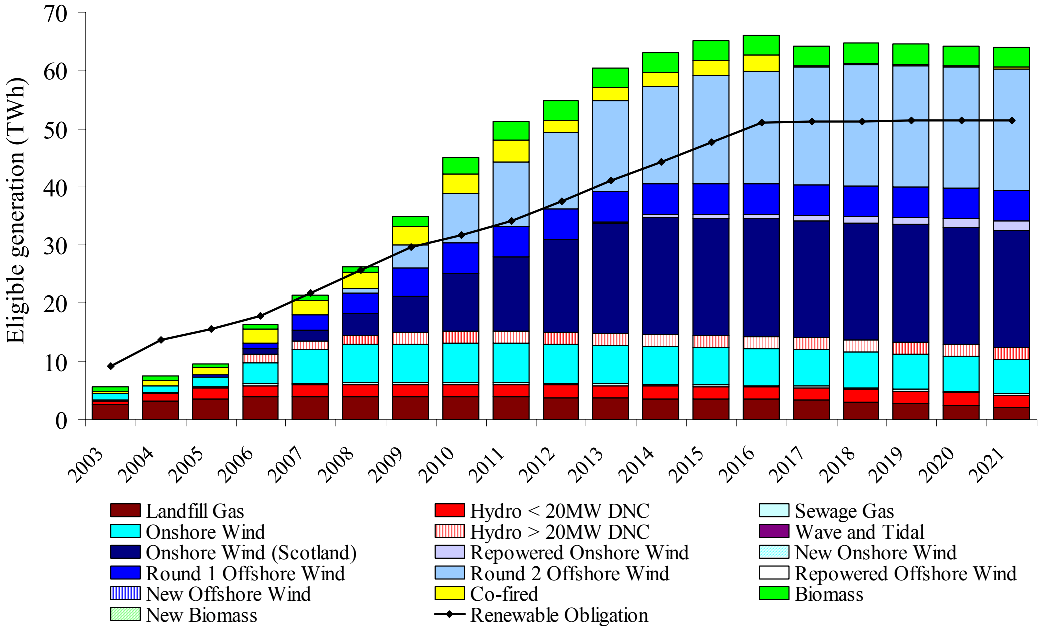
[18] We have assumed that the RO is raised to 15.4% in 2015/16 and incorporates the UK wide market, as envisaged in the draft Renewables Obligation Order 2005.

Renewable generation scenarios

4.3 Our assessment of the volume of generation from projects presently eligible under the RO is derived from ILEX's Renewables Database of over 1300 operational, developing and proposed projects. Over the past year there has been a rapid rise in the number of proposed projects applying for connection – driven in part by an incentive in Scottish generators to apply prior to 31 December 2004 under NGC's mechanism for allocating GB access rights.

4.4 Figure 25 illustrates that if all proposed renewable projects were to come on as and when proposed, aggregate renewable generation could exceed the RO. However, these levels of generation are improbable, given the number of hurdles that renewable projects have to overcome, such as, planning issues, transmission constraints, acquiring finance and regulatory matters. Furthermore, the value of ROCs available to generators at this level of eligible output would be insufficient to allow many of the developments to recover their costs.

Figure 25 – Eligible generation from proposed renewable projects (excluding energy recovery from mixed wastes)

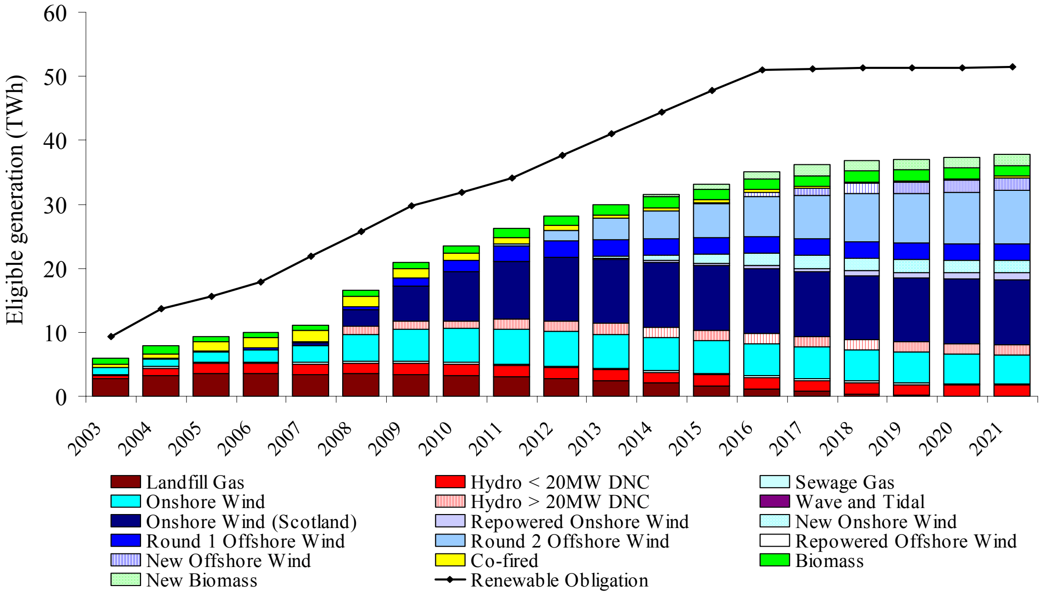


Source: ILEX Renewables Database
These numbers excludes several large, low probability wind and tidal barrage schemes

4.5 We have therefore, developed two renewable generation scenarios, *Under Compliant* and *Near Compliant*, to reflect more plausible profiles for renewable developments. We consider that each of these cases as equal probability of materialising. Figure 26 and Figure 27 illustrates the volume of eligible generation likely to come on under the two scenarios.

4.6 The *Under Compliant* case illustrates a moderate renewables build with not all proposed schemes being developed as, or when, proposed. Planning consent will not be granted for a substantial number of projects and transmission constraints will restrict onshore developments, particularly in Scotland. Developers would be cautious about developing new and offshore technologies. Under this scenario annual eligible generation is substantially below the level of the RO in all years and ROC prices remain significantly above the Buyout Price, as the quantity if eligible generation is constrained by non-price issues.

Figure 26 – Renewable generation under the *Under Compliant* case



Source: ILEX Renewables Database

4.7 In contrast, the *Near Compliant* case illustrates a relatively high renewables build, but still substantially less than the aggregate capacity of proposed projects. We assume all developers act rationally to only develop projects that are economically viable given projections for future value of income stream. As such renewable generation remains less than the RO in all years and ROC prices are above the Buyout level with the quantity of eligible generations being constrained by the new entry costs for each technology.

4.8 In both cases, *Under Compliant* and *Near Compliant*, we have ensured that the level of renewables build that comes on is consistent with new entry costs for dedicated biomass, offshore wind and onshore wind projects compared against the total value of renewable power[19].

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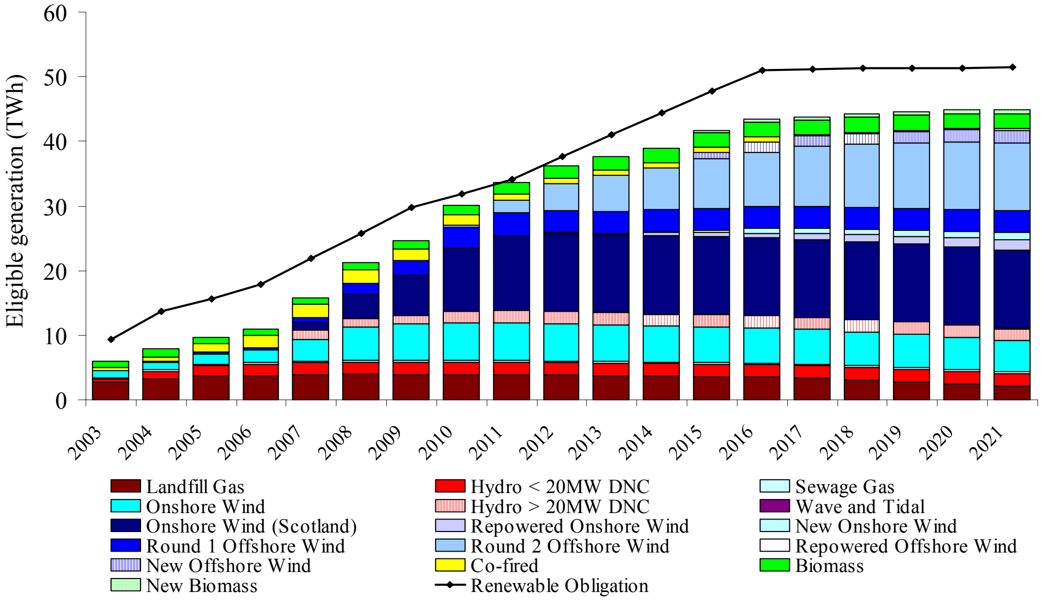
[19] The total value includes the generator's share of the value of wholesale power, ROCs and, if applicable, LECs and embedded benefits. Annex D provides a high level discussion on how we ensure that new entry costs can be recovered from the available revenue streams.

Figure 27 – Renewable generation under the *Near Compliant* case



Source: ILEX Renewables Database

4.9 Figure 28 and Figure 29 illustrates how the *Under Compliant* and *Near Compliant* generation cases are reflected in the ROC price. We have assumed that the Renewables Obligation will rise to 15.4% by 2015/16 as per the Renewables Order 2005 and that the Northern Ireland Renewables Obligation goes ahead in April 2005 with the proposed targets as per the statutory consultation[20]. UK demand growth has been based on growth patterns derived from published numbers in DUKES[21].

4.10 In the *Under Compliant* case, ROC prices remain significantly above the Buyout price. As eligible generation does not exceed the level of the Renewables Obligation in any year, the ROC price always contains a substantial element from the recycling of the Buyout Fund. The average ROC value for the fifteen year period 2006 – 2021 under this scenario is £46/MWh.

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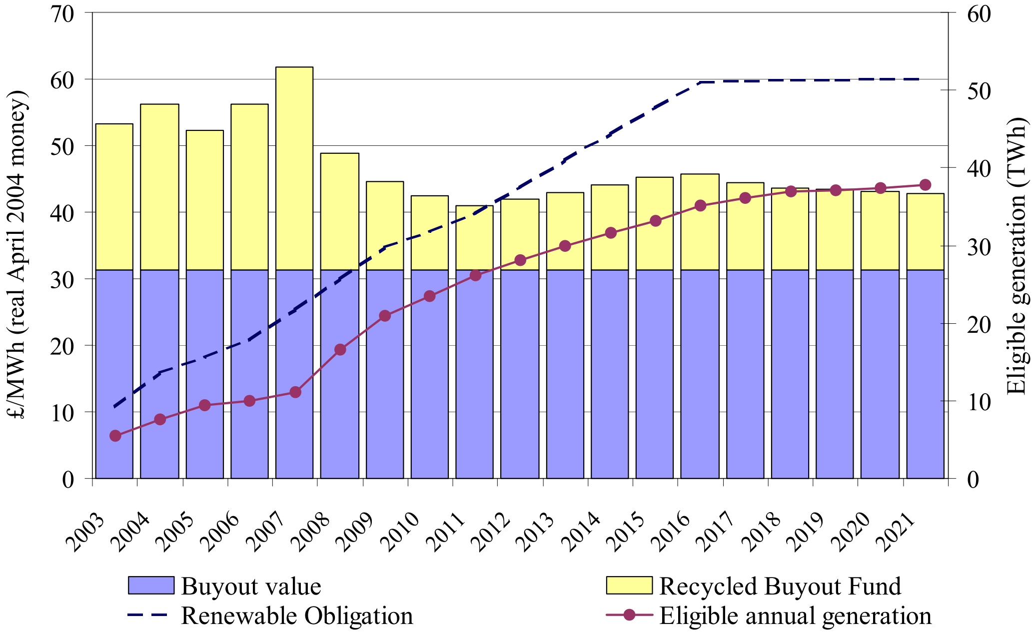
[20] The Northern Ireland Renewables Obligation: Statutory Consultation. Department of Enterprise, Trade and Investment. October 2004.

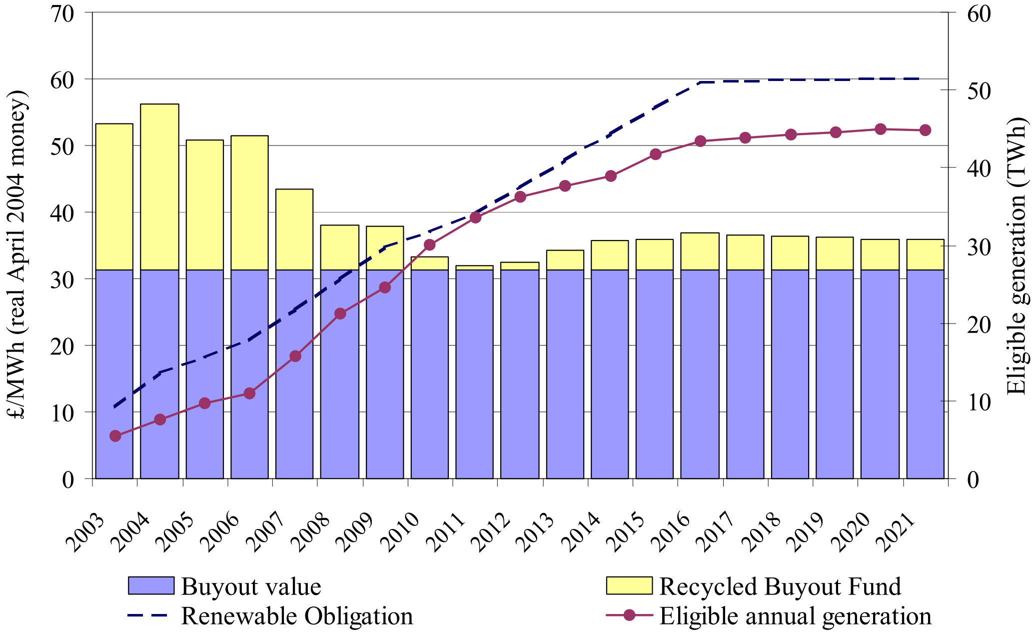
[21] Digest of UK Energy Statistics. DTI.

Figure 28 – ROC prices under the *Under Compliant* scenario



Source: ILEX

Figure 29 – ROC prices under the *Near Compliant* scenario



Source: ILEX

4.11 In the *Near Compliant* case, ROC prices remain above the Buyout price. Although the Renewables Obligation is never exceeded in any year, there are a number of years (2010 – 2013), where generation levels are close to the RO. Consequently, in these years there is a very small recycling element. The average

ROC value, over the same fifteen period, under this particular scenario is £38/MWh.

Impact of extending RO eligibility to mixed wastes

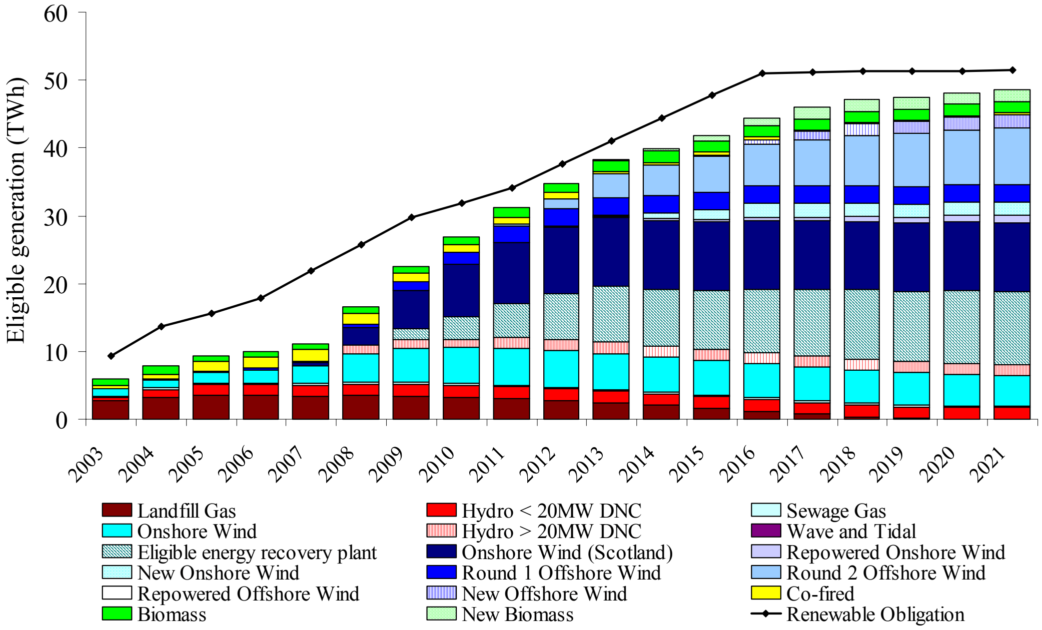
4.12 In Chapter 3, we demonstrated the volume of generation that could materialise from energy recovery facilities, if the various technologies considered became eligible under the RO (see Figure 22). Excluding the volume of generation that from existing EfW generation, we have added the additional generation from eligible energy recovery facilities to the two scenarios, *Under Compliant* and *Near Compliant*.

4.13 As Figure 30 illustrates, additional ROCs generated from eligible energy recovery facilities could make the *Under Compliant* scenario nearly RO compliant. Running these particular levels through our model we found that the ROC prices were depressed to just above the Buyout price, with some recycling element in the majority of years (see Figure 31). Under this particular scenario, there was no significant impact on the viability of new entry from the other renewables anticipated, hence, growth in eligible energy recovery facilities could largely be additional, with limited substitution.

4.14 However, it is important to note that although this particular scenario could accommodate the extension of eligibility, investor confidence could be dented and proposed projects may be postponed or abandoned as a result.

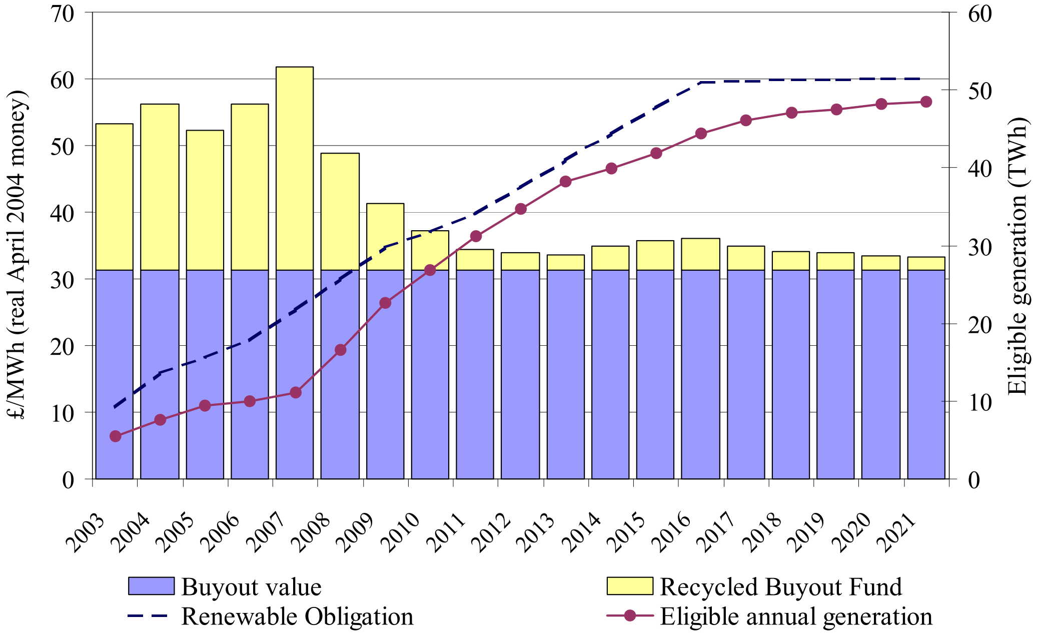
4.15 It is clear that combining the level of generation from eligible energy recovery facilities, as shown in Figure 30, with the level of renewable generation under the *Near Compliant* scenario would far exceed the Renewable Obligation. This would not be sustainable, and it is likely that developers of biomass and offshore (and even some of the larger onshore wind) projects would either postpone or abandon their plans to develop them. Consequently, under the Near Compliant scenario there could be little additional renewable generation, with eligible energy recovery facilities substituting offshore wind and biomass generators. Figure 32 illustrates how this could develop, whilst Figure 33 shows the level of substituted generation.

Figure 30 – Eligible renewable generation for the *Under Compliant* case including additional from eligible energy recovery facilities



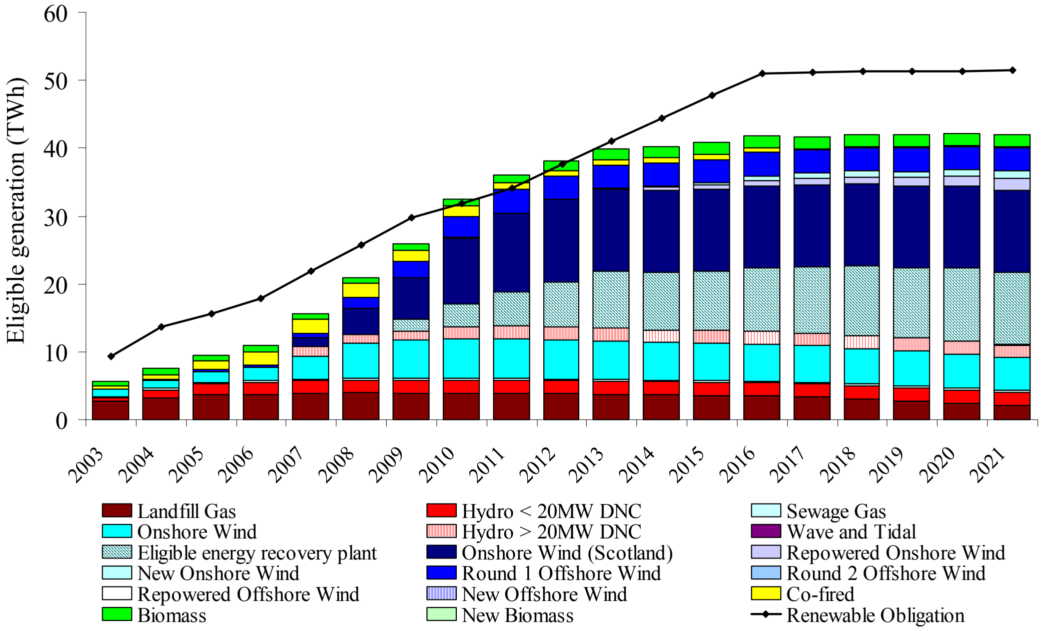
Source: ILEX Renewables database

Figure 31 – ROC prices under the *Under Compliant* scenario including additional from eligible energy recovery facilities



Source: ILEX

Figure 32 – Eligible renewable generation for the *Near Compliant* case including eligible energy recovery facilities (with substitution for offshore wind and biomass)



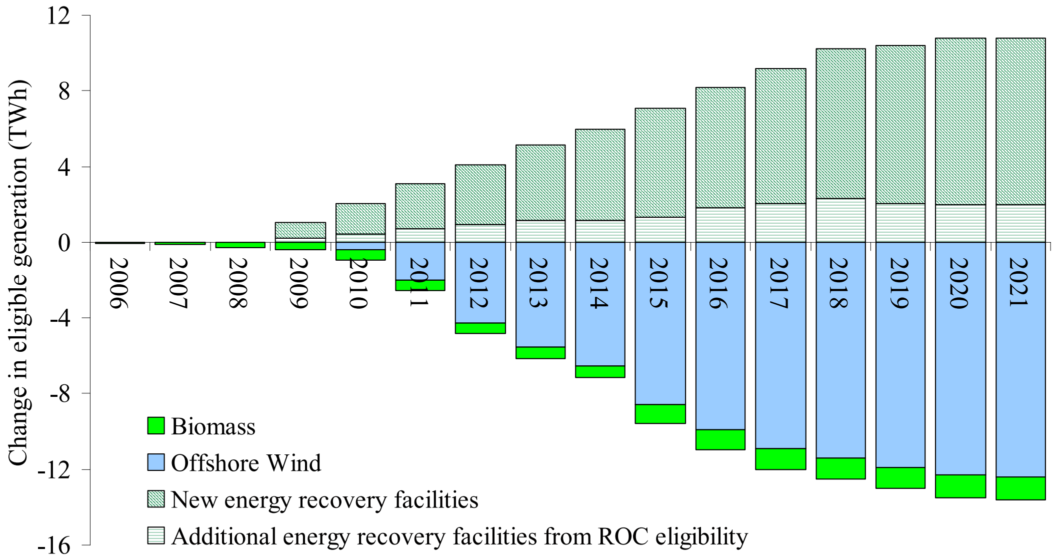
Source: ILEX Renewables database

4.16 Furthermore, extended eligibility to energy recovery facilities under the two renewable generation scenarios, *Under Compliant* and *Near Compliant*, have only considered generation from new-build energy recovery plant. Extending the RO to include generation from existing energy recovery facilities would exacerbate the impact shown in the previous charts.

4.17 Table 7 provides an indication of the range that the average ROC price over the period of fifteen years (2006 – 2021) could decrease by under the two different cases, *Under Compliant* and *Near Compliant*. In the *Under Compliant* case, the average ROC price decreases by £6/MWh (13% drop from the base) when new energy recovery facilities are RO eligible, whilst including existing facilities causes a further additional decrease of £3/MWh (20% drop from the base). However, under this particular scenario, extending eligibility to energy recovery facilities, both new and existing, does not affect other new entrant renewable technologies.

4.18 In the *Near Compliant* case, however, the volume of new entrant renewable generation that is substituted from the extension of RO eligibility to energy recovery facilities, is around 14TWh by 2021 (see Figure 33). The substitution of technologies does not affect on the average ROC price over the fifteen years.

Figure 33 – Substitution of generation technologies in the *Near Compliant* scenario



Source: ILEX

4.19 In Chapter 3 we identified that the majority energy recovery capacity could be developed without ROC eligibility (9TWh of the 11TWh of eligible generation in 2021), whilst approximately 2TWh of addition generation could be brought on through extending eligibility. This additional generation has been separately identified in Figure 33. In a *Near Compliant* case extending eligibility to energy recovery from mixed wastes could increase lead to an increase in generation of up to 2TWh but at the expense of up to 14TWh of offshore wind and biomass generation, a net reduction in renewable generation.

4.20 Chapter 5 discusses some of the mitigation measures that may be required in order to maintain confidence in the Renewables Obligation, but it is clear that under certain scenarios, one such measure would require an increase in the level of the RO.

Table 7 – Impact on the ROC price from a number of different sensitivities

	Are existing energy recovery facilities eligible?	Reduction in average ROC price 2006-21	Level of new entry plant affected in 2021 (TWh)
Under Compliant	No	13%	None
	Yes	20%	None
Near Compliant	No	0%	13.6
	Yes	6%	13.6

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5. MITIGATION MEASURES

5.1 In Chapter 3 we identified the potential volume of eligible generation that could be deliverable from mixed waste. In considering the various energy recovery options and technologies we were unable to identify any significant environmental advantage of one approach over another. On this basis we assumed that if eligibility were extended to energy recovery it would apply to all new-build (and potentially existing plant too).

5.2 In Chapter 4 we indicated the impact that this generation could have on other renewable developments, which varies considerably depending on the aggregate level of eligible generation. We have identified that in circumstances where there is a substantial volume of renewable generation (the *Near Compliant* case presented in Chapter 4), eligible generation from energy recovery facilities could be at the expense of dedicated biomass and offshore wind developments. As much of the generation from energy recovery could potentially occur without ROC eligibility, the substitution of generation for mixed wastes for these technologies may not be desirable.

5.3 As we cannot know at this time whether renewable deployment will follow the *Near Compliant* or *Under Compliant* cases, we have to assume that to retain investor confidence in the RO that mitigation measures be introduced ensure that the levels of renewable generation anticipated under a *Near Compliant* case could still be developed after any change to the eligibility rules for energy recovery from mixed wastes. Failure to introduce mitigation measures after a change to eligibility would almost certainly ensure that generation from other renewables technologies does not exceed that in the *Under Compliant* case, as it would not be rational for investors in other renewables to develop these projects if there is the potential for substantial generation from mixed wastes.

5.4 The uncertainty over the level of generation from mixed wastes does not aid the development of mitigation measures. If investor confidence is to be maintained following a change to eligibility then it could be necessary to ensure that ROC prices even under optimistically higher levels of mixed waste generation are no less than that which would have arisen in a *Near Compliant* case before the change in eligibility.

Increasing the level of the Renewables Obligation

5.5 Our consideration of mitigation measures has concluded that only an increase to the level of the RO would be sufficient to maintain investor confidence. If new build *MT+EfW* and *EfW* energy recovery plant become eligible we estimate that the RO may have to be increased from 2008/9, rising to 11.7% in 2010/11, 18.4% in 2015/16 and 18.7% in 2020/21. This proposed new RO is set out in Table 8. In Figure 34 we illustrate that this increase in the RO could restore the anticipated mix of other renewable technologies under the *Near Compliant* case, whilst also accommodating the potential eligible generation from energy recovery.

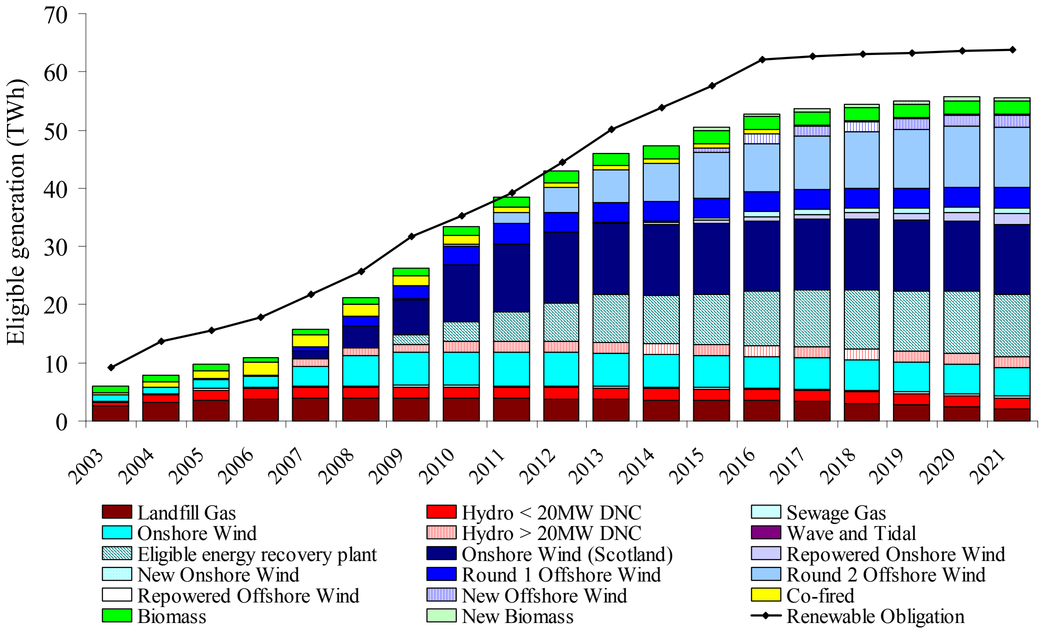
Table 8 – Proposed Obligation level to mitigate the extension of RO eligibility to all new energy recovery from mixed wastes

	2006	2007	2008	2009	2010	2011	2012	2013
Current GB RO	5.5%	6.7%	7.9%	9.1%	9.7%	10.4%	11.4%	12.4%
Equivalent UK RO	5.4%	6.6%	7.8%	8.9%	9.5%	10.2%	11.2%	12.2%
Proposed UK RO	5.4%	6.6%	7.8%	9.5%	10.6%	11.7%	13.3%	14.9%

	2014	2015	2016	2017	2018	2019	2020	2021
Current GB RO	13.4%	14.4%	15.4%	15.4%	15.4%	15.4%	15.4%	15.4%
Equivalent UK RO	13.2%	14.2%	15.1%	15.1%	15.1%	15.1%	15.1%	15.1%
Proposed UK RO	16.0%	17.1%	18.4%	18.5%	18.6%	18.6%	18.7%	18.7%

Note: The *Equivalent UK RO* values represent the current level of the Obligation including Northern Ireland, which takes effect from 1 April 2005

Figure 34 – *Near Compliant* case with proposed increase in UK RO (including new energy recovery facilities)



Source: ILEX Renewables database

5.6 This increase in the level of the RO is necessary to accommodate the potential use of energy recovery from municipal mixed wastes. In the longer-term we consider energy recovery may also become viable for commercial and industrial wastes. However, as these wastes are not subject to a cap on landfill, we would not anticipate that a significant volume of biodegradable material from such wastes could be diverted to energy recovery until such time as sufficient capacity has first been developed to recover energy from diverted municipal wastes (perhaps between 2015 and 2020). However, the timing and extent of this generation from commercial and industrial wastes cannot be determined at this time. Further, we consider that it will be very difficult to differentiate between municipal and commercial and industrial wastes for the purposes of RO eligibility, and may not be desirable. It may therefore be necessary to review the potential for the development of energy recovery from commercial and industrial wastes in due course, to assess any additional mitigation measures might be needed after 2015/16.

Eligibility for existing EfW plant

5.7 We have also modelled the impact that extending eligibility to existing as well as new build energy recovery plants would have on the Renewables Obligation (this analysis is presented in Annex D). Should eligibility encompass energy recovery plant the RO may have to be increased by a further 0.5% in each year, to 19.2% by 2020/21, as illustrated in Table 9.

Table 9 – Proposed Obligation level to mitigate the extension of RO eligibility to all energy recovery from mixed wastes (including existing energy recovery facilities)

	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Current GB RO	5.5%	6.7%	7.9%	9.1%	9.7%	10.4%	11.4%	12.4%
Equivalent UK RO	5.4%	6.6%	7.8%	8.9%	9.5%	10.2%	11.2%	12.2%
Proposed UK RO	5.4%	7.2%	8.3%	10.1%	11.1%	12.2%	13.7%	15.4%

	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Current GB RO	13.4%	14.4%	15.4%	15.4%	15.4%	15.4%	15.4%	15.4%
Equivalent UK RO	13.2%	14.2%	15.1%	15.1%	15.1%	15.1%	15.1%	15.1%
Proposed UK RO	16.5%	17.6%	18.9%	19.0%	19.1%	19.1%	19.2%	19.2%

Note: The *Equivalent UK RO* values represent the current level of the Obligation including Northern Ireland, which takes effect from 1 April 2005

Costs to the consumer

5.8 The cost of the electricity consumer of the Renewables Obligation is principally driven by the level of the Buyout price and the annual Obligation level. It follows that an increase in the Obligation, in line with that proposed above could lead to an increase in the cost to consumers of the order of £100m in 2010/11, £300m in 2015/16 and £400m in 2020/21 (in April 2004 money), as illustrated in Table 10.

Table 10 – Annual cost to consumers of the RO (£bn)

£bn	**2010/11**	**2015/16**	**2020/21**
15% UK RO in 2015/16	1.1	1.6	1.6
18.7% UK RO in 2019/20	1.2	1.9	2.0
19.2% UK RO in 2019/20	1.3	2.0	2.1

5.9 However, this increase in costs may lead to an increase in renewable generation. Expressing this cost per unit of eligible renewable generation produced in each year illustrates that unit costs might remain the same or fall. If renewable generation were towards the higher end of expectations (the *Near Compliant* case) the unit cost to consumers could remain the same at £32/MWh in 2010/11 and £36/MWh in 2020/21.

Table 11 – Cost to consumer per MWh of eligible renewable generation (£/MWh)

£/MWh	**2010/11**	**2015/16**	**2020/21**
Under Compliant - 15% RO	41	46	43
Under Compliant with EfW eligible - 18.7% RO	40	44	41
Under Compliant with EfW eligible - 19.2% RO	39	44	41
Near Compliant - 15% RO	32	37	36
Near Compliant with EfW eligible - 18.7% RO	32	37	36
Near Compliant with EfW eligible - 19.2% RO	32	37	36

5.10 If the volume of renewable generation were towards the lower end of expectations (the *Under Compliant* case), then the unit costs could be greater than in the above *Near Compliant* case but lower than under the present eligibility rules and level of Obligation. This is illustrated in Table 11.

5.11 These numbers assume that the volume of generation from mixed wastes is line with the projections in this report. We have identified that there is considerable uncertainty over the capacity and timing of such developments. Whilst it may be necessary to increase the Obligation to ensure investor confidence is maintained, if the volume of generation from mixed wastes fall below that anticipated the unit cost to the consumer could be greater.

5.12 Where suppliers are able to satisfy their Obligation through purchasing eligible generation at price (net of the recycled Buyout Fund payments) below the Buyout Price, then it is possible that in a competitive supply market, that cost saving could be passed back to consumers, reducing the cost to consumers below the figures quoted above.

Additionality

5.13 However, in our discussions on the volume of generation we might expect from mixed wastes, we identified that the bulk of this generation might be developed without ROC support. If we consider the cost to consumer per unit of additional generation brought on by RO support we see that the unit costs might be considered to increase, as illustrated in Table 12.

Table 12 – Cost to consumer per MWh of additional eligible renewable generation brought on through support from the RO (£/MWh)

£/MWh	**2010/11**	**2015/16**	**2020/21**
Under Compliant - 15% RO	50	53	49
Under Compliant with EfW eligible - 18.7% RO	56	61	57
Under Compliant with EfW eligible - 19.2% RO	58	61	57
Near Compliant - 15% RO	37	42	40
Near Compliant with EfW eligible - 18.7% RO	42	48	48
Near Compliant with EfW eligible - 19.2% RO	44	50	49

Interaction with Council Tax bills

5.14 Local Authorities expenditure on waste management will increase substantially over the period to 2020, as alternatives to landfill are considerably higher cost. Local Authorities may also incur fines under LATS for exceeding their cap on biodegradable municipal waste.

5.15 Other things being equal, this could lead to increases in Council Tax bills. ROC eligibility for energy recovery from mixed wastes could help reduce the net cost of this form of waste management. We envisage that new waste management contracts signed by LAs could benefit from ROCs as this would permit developers to reduce the residual gate-fee charged to LAs. It is not clear whether existing contracts would allow for the pass back of ROC incomes to LAs or whether this income may be retained by the operator of the waste contract and/or the energy recovery facility – but it is likely to vary on a site-by-site basis.

5.16 There is considerable uncertainty concerning the revenues that could be passed back to LAs. In estimating these revenues we have only considered new contracts and that share of the total value of the ROC that a generator may receive. On this basis, a total of perhaps £140m might be passed back to LAs might in 2010/11, £290m in 2015/16 and £330m in 2020/21. This equates to approximately 80% of the cost to the electricity consumer. The residual is likely to be retained by electricity suppliers as the transaction costs of the ROC market.

5.17 As has been discussed above, if generation from mixed wastes were less than projected, perhaps due to planning constraints, then the savings that may be made by LAs would be reduced proportionally. However, the cost of the electricity consumer would remain unaffected.

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ANNEX A – OVERVIEW OF LAWRRD MODEL

A.1 The Local Authority Waste Recycling Recovery and Disposal (LAWRRD) model was developed for Defra by AEA Technology. The model's purpose is to predict Local Authority waste management costs, flows of materials and the facilities needed for waste treatment to meet the EU Landfill Directive targets and increased rates of recycling and recovery. Different policy initiatives can be modelled using the LAWRRD.

Methodology

A.2 LAWRRD is a costs-driven, bottom-up model. It models waste management by taking input data on waste arisings, numbers of actual or planned facilities from each LA in turn and then summing the relevant outputs to develop a picture representing England as a whole. Generally speaking, the local wastes data are reasonably well characterised, so that this input forms a robust starting point for the modelling.

A.3 Each LA is assigned to one of up to three main 'typologies' (urban, suburban, rural). The typologies allow user input of waste composition, growth rates, local gate fees and 'pressure factors' reflecting political and practical weighting against certain options (e.g. anti-incineration and non-achievement of targets). The assignment of typology is determined by the socio-economic and demographic characteristics of each area. The typology approach allows for the introduction of local variations in the model that cannot be reflected when the country is, in effect, treated as a single LA.

A.4 The model works by simulating the decision processes of each LA. Each year, the costs of adding different waste management facilities at various operational scales is compared with the cost of making no change to the existing suite of facilities. The cost of each option includes the gate fees (which can in turn be broken down into their constituent parts for detailed analysis), costs of residue treatment and disposal, taxes, penalties for failing to meet targets, tradable allowances, fines and 'pressure' factors.

A.5 Having identified the lowest cost additional plant (or found that 'no change' is cheapest), the model then adds a facility of the selected type to the existing options for that local authority and then repeats the process for the following year. By basing decisions on economic costs, the model simulates the main driver for local authority decision-making.

A.6 LAWRRD considers the material flows and costs from collection of recyclates and residual waste via civic amenity (CA) sites, 'bring' and direct recycling and kerbside collection options. The waste management options in the model are placed in a hierarchy, in which recyclates are removed at the top of the hierarchy, leaving residues for treatment in the lower levels.

Developments

A.7 Further developments of the LAWRRD model are planned, including the incorporation of more robust supply elasticities into the model.

ANNEX B – COST ASSUMPTIONS FOR ENERGY RECOVERY PLANT

B.1 Table 13 and Table 14 below show the capital and operating cost assumptions, respectively, used in the financial model, whilst Figure 35 shows how the net gate fee (after income from energy and recyclates) changes given economies of scale of MSW input capacity and the relative costs of the technologies considered.

Table 13 – Capital costs assumptions for plant types modelled

	kt/yr MSW input capacity			
£m	**50**	**100**	**200**	**400**
EfW				
Sorting	0.0	0.0	0.0	0.0
EfW	42.8	48.1	58.6	97.0
Total	42.8	48.1	58.6	97.0
MT + EfW				
Sorting	5.0	7.0	10.0	15.0
EfW	42.2	45.6	57.0	93.9
Total	47.2	52.6	67.0	108.9
MBT + EfW				
Sorting	13.0	20.0	32.0	52.0
EfW	40.1	42.8	48.1	79.2
Total	53.1	62.8	80.1	131.2
MBT + ACT				
Sorting	13.0	20.0	32.0	52.0
EfW	12.5	23.1	33.1	67.6
Total	25.5	43.1	65.1	119.6

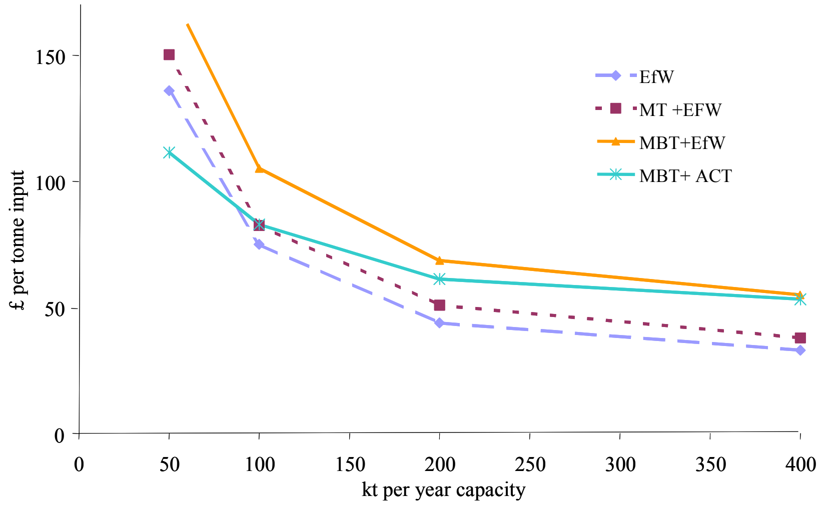
Source: Electrowatt-Ekono

Table 14 – Operating cost assumptions for plant types modelled

	kt/yr MSW input capacity			
£m	50	100	200	400
EfW				
Labour	1.4	1.5	1.7	1.8
Other variable	0.1	0.2	0.3	0.6
Maintenance	1.2	1.3	1.6	2.7
Total	2.6	3.0	3.6	5.1
MT + EfW				
Labour	1.5	1.7	2.0	2.1
Other variable	0.1	0.1	0.3	0.6
Maintenance	1.3	1.5	1.9	3.0
Total	2.9	3.3	4.1	5.7
MBT + EfW				
Labour	1.6	1.7	2.0	2.4
Other variable	0.4	0.8	1.7	3.3
Maintenance	1.5	1.8	2.2	3.7
Total	3.5	4.3	5.9	9.3
MBT + ACT				
Labour	1.6	1.7	2.0	2.4
Other variable	0.4	0.8	1.6	3.2
Maintenance	0.7	1.2	1.8	3.3
Total	2.7	3.7	5.4	8.9

Source: Electrowatt-Ekono

Figure 35 – Net gate fee equivalents (after income from energy and recyclates) illustrating economies of scale and relative costs of technologies



Source: Electrowatt-Ekono / ILEX

ANNEX C – DETAILED RESULTS FROM LAWRRD

C.1 As referred to in Chapter 4, we have run a number of different sensitivities using various ROC prices to determine the scale of impact they could have on the results from the waste management modelling using LAWRRD. We concluded that the technology mix and capacity of energy recovery facilities is not overly sensitive to changes in ROC or energy price assumptions and demonstrate this of with results drawn from highest and lowest ROC prices considered.

- The lower price ROCs average £36/MWh over the period 2007-21 and arise in a *Near Compliant* case (with a five-year build rate for energy recovery facilities) and assuming the RO was raised in mitigation.
- The higher value ROCs average £44/MWh over the period 2007-21 and arise from an *Under Compliant* case (with a ten-year build rate for energy recovery facilities) and assuming the RO was raised in mitigation.

Results for lower price ROCs (*Near Compliant* case)

Table 15 – Total UK MSW by treatment process (under existing RO eligibility rules)

mtonnes per annum	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
CA site recovery & recycling	2.8	3.1	3.1	3.2	3.3	3.3	3.4	3.5	3.5	3.6	3.6	3.7	3.7	3.8	3.8	3.9
Bring recycling	0.7	0.7	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.1	1.1
MRF	4.0	4.2	4.6	4.9	5.1	5.4	5.7	5.9	6.1	6.7	6.9	7.2	7.7	8.4	9.2	9.5
Dirty MRF	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
GW composting	3.2	3.4	3.5	3.5	3.5	3.6	3.7	3.8	3.8	3.9	3.9	4.0	4.1	4.2	4.2	4.3
Biowaste composting/digestion	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.4	0.5
MT+EfW	0.0	0.0	0.0	0.0	16.3	18.7	20.4	21.7	21.9	22.0	22.2	22.3	22.4	22.5	22.5	22.6
MBT+EfW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MBT compost and residue landfill	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
EfW	4.4	4.6	4.6	4.6	4.4	4.5	4.5	4.6	4.6	4.8	5.2	5.5	5.7	6.6	7.5	8.6
MBT+ACT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unprocessed MSW direct to landfill	23.5	23.7	24.2	24.9	9.5	7.8	6.7	6.1	6.5	6.4	6.5	6.8	7.0	6.2	5.5	5.1

Table 16 – Total UK MSW by treatment process (all energy recovery technologies RO eligible)

mtonnes per annum	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
CA site recovery & recycling	2.8	3.1	3.1	3.2	3.3	3.3	3.4	3.5	3.5	3.6	3.6	3.7	3.7	3.8	3.8	3.9
Bring recycling	0.7	0.7	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.1	1.1
MRF	4.0	4.1	4.3	4.5	4.7	4.9	5.1	5.3	5.4	5.9	6.1	6.4	6.6	6.9	7.3	7.5
Dirty MRF	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
GW composting	3.2	3.4	3.4	3.5	3.5	3.6	3.7	3.7	3.8	3.8	3.9	4.0	4.0	4.1	4.1	4.2
Biowaste composting/digestion	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.4	0.4
MT+EfW	0.0	0.0	0.0	0.0	18.6	21.6	22.7	23.7	24.3	24.6	24.9	25.0	25.2	25.4	25.6	25.7
MBT+EfW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MBT compost and residue landfill	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
EfW	4.4	4.6	4.6	4.6	4.2	4.3	4.3	4.4	4.4	4.6	5.2	6.5	7.5	8.3	8.8	9.7
MBT+ACT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unprocessed MSW direct to landfill	23.5	23.8	24.5	25.3	7.8	5.5	5.2	4.9	5.0	4.9	4.7	3.9	3.5	3.1	3.2	3.1

Table 17 – ROCs from economically viable energy recovery facilities by technology for each eligibility scenario

Eligibiltity	Energy recovery technology type			
scenario	**EfW**	**MT+EfW**	**MBT+EfW**	**MBT + ACT**
2010				
None	0.0	0.0	0.0	0.0
ACT	0.0	0.0	0.0	0.0
MBT	0.0	0.0	0.0	0.0
MT+MBT	0.0	7.7	0.0	0.0
All	1.5	7.7	0.0	0.0
2015				
None	0.0	0.0	0.0	0.0
ACT	0.0	0.0	0.0	0.0
MBT	0.0	0.0	0.0	0.0
MT+MBT	0.0	8.4	0.0	0.0
All	1.9	8.3	0.0	0.0
2020				
None	0.0	0.0	0.0	0.0
ACT	0.0	0.0	0.0	0.0
MBT	0.0	0.0	0.0	0.0
MT+MBT	0.0	9.6	0.0	0.0
All	3.9	8.3	0.0	0.0

Results for higher price ROCs (*Under Compliant* case)

Table 18 – Total UK MSW by treatment process (under existing RO eligibility rules)

mtonnes per annum	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
CA site recovery & recycling	2.8	3.1	3.1	3.2	3.3	3.3	3.4	3.5	3.5	3.6	3.6	3.7	3.7	3.8	3.8	3.9
Bring recycling	0.7	0.7	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.1	1.1
MRF	4.0	4.2	4.6	4.9	5.1	5.4	5.7	5.9	6.1	6.7	6.9	7.2	7.7	8.4	9.2	9.5
Dirty MRF	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
GW composting	3.2	3.4	3.5	3.5	3.5	3.6	3.7	3.8	3.8	3.9	3.9	4.0	4.1	4.2	4.2	4.3
Biowaste composting/digestion	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.4	0.5
MT+EfW	0.0	0.0	0.0	0.0	16.3	18.7	20.4	21.7	21.9	22.0	22.2	22.3	22.4	22.5	22.5	22.6
MBT+EfW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MBT compost and residue landfill	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
EfW	4.4	4.6	4.6	4.6	4.4	4.5	4.5	4.6	4.6	4.8	5.2	5.5	5.7	6.6	7.5	8.6
MBT+ACT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unprocessed MSW direct to landfill	23.5	23.7	24.2	24.9	9.5	7.8	6.7	6.1	6.5	6.4	6.5	6.8	7.0	6.2	5.5	5.1

Table 19 – Total UK MSW by treatment process (all energy recovery technologies RO eligible)

mtonnes per annum	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
CA site recovery & recycling	2.8	3.1	3.1	3.2	3.3	3.3	3.4	3.5	3.5	3.6	3.6	3.7	3.7	3.8	3.8	3.9
Bring recycling	0.7	0.7	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.1	1.1
MRF	4.0	4.1	4.3	4.5	4.7	4.8	5.0	5.1	5.2	5.6	5.8	6.1	6.2	6.7	7.0	7.2
Dirty MRF	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
GW composting	3.2	3.4	3.4	3.5	3.5	3.6	3.6	3.7	3.7	3.8	3.9	3.9	4.0	4.1	4.1	4.2
Biowaste composting/digestion	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.4	0.4
MT+EfW	0.0	0.0	0.0	0.0	19.1	22.0	23.2	24.0	24.9	25.4	25.7	25.9	26.1	26.3	26.5	26.6
MBT+EfW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MBT compost and residue landfill	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
EfW	4.4	4.6	4.6	4.6	4.1	4.2	4.2	4.3	4.3	4.5	5.0	6.3	7.1	8.1	8.7	9.2
MBT+ACT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unprocessed MSW direct to landfill	23.5	23.8	24.5	25.3	7.5	5.4	5.0	4.9	4.8	4.5	4.4	3.5	3.3	2.8	2.7	3.0

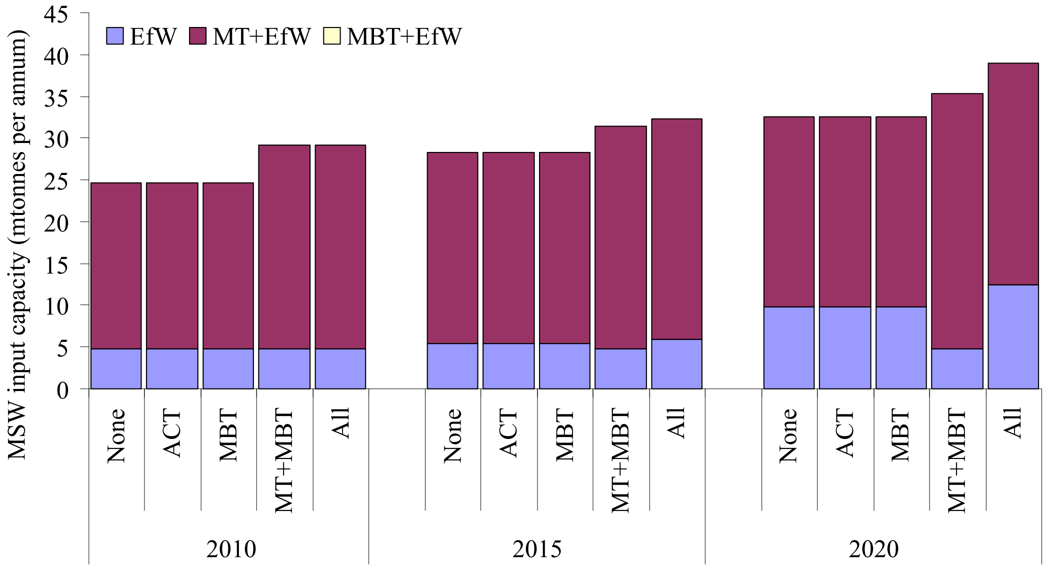
Table 20 – ROCs from economically viable energy recovery facilities by technology for each eligibility scenario

Eligibiltity	Energy recovery technology type			
scenario	EfW	MT+EfW	MBT+EfW	MBT + ACT
2010				
None	0.0	0.0	0.0	0.0
ACT	0.0	0.0	0.0	0.0
MBT	0.0	0.0	0.0	0.0
MT+MBT	0.0	7.9	0.0	0.0
All	1.5	7.9	0.0	0.0
2015				
None	0	0	0	0
ACT	0.0	0.0	0.0	0.0
MBT	0.0	0.0	0.0	0.0
MT+MBT	0.0	8.8	0.0	0.0
All	1.9	8.6	0.0	0.0
2020				
None	0	0	0	0
ACT	0	0	0	0
MBT	0.0	0.0	0.0	0.0
MT+MBT	0.0	9.9	0.0	0.0
All	3.9	8.6	0.0	0.0

Further consideration of Mechanical Biological Treatment (MBT)

C.2 Although not included in the modelling of the impacts on the Obligation in Chapter 4, we also considered the impact if the compost output from MBT processes was not inert (see 3.19). As demonstrated by Figure 36 and comparing these figures with those shown in Figure 18 there is no difference in the number of type of energy recovery facilities built.

Figure 36 – MSW input capacity assuming MBT output is considered inert



Source: ILEX

ANNEX D – ADDITIONAL ANALYSIS OF THE IMPACT ON OTHER RENEWABLE TECHNOLOGIES

D.1 In Chapter 4, we discussed how the combining of the level of generation from eligible energy recovery facilities with the level of renewable generation under the *Near Compliant* case could far exceed the Renewables Obligation, and that consequently energy recovery facilities could be substituted for offshore wind and biomass. This result is derived from a number of iterative steps that compare new entry costs for dedicated biomass, offshore wind and onshore wind projects against the total value of renewable power. The following section describes this part of the analysis.

New entry costs

D.2 Figure 37 illustrates how the new entrant costs for dedicated[22] biomass, offshore wind and onshore wind projects compare against the total value of renewable power[23] under the *Near Compliant* case. It illustrates the total cost of operating a particular technology (the *new entry* cost), based on capital costs, operating costs and financing, expressed in real terms as a charge per unit of generation. Over time we expect these costs to fall, such that the new entry cost for a generator commissioning in 2010 is lower than for one in 2005. Against these tracks of costs is shown the 15-year rolling average value of the real income stream available to the generator. In this simplified model, for new entry to be justified in each year, the generator's average income must remain above the new entry cost.

D.3 Figure 37 demonstrates that onshore and offshore wind projects are viable throughout the period (2003 – 2021), whilst dedicated biomass plant, will become cost-effective after 2011.

D.4 The addition of eligible generation from energy recovery facilities to the level of renewable generation under the *Near Compliant* case could reduce the ROC price below the value of the Buyout Price, such is the extent of the surplus generation over the Obligation. This is based on the assumption that competition amongst generators to secure sales for their ROCs will force down the price of ROCs to the net marginal cost of generation. The net marginal cost will be the short-run avoidable costs of generation (fuel and some variable other works costs) less the revenues received from other income sources, including wholesale prices (net of imbalance costs), LECs, any carbon value, and embedded benefits. For most

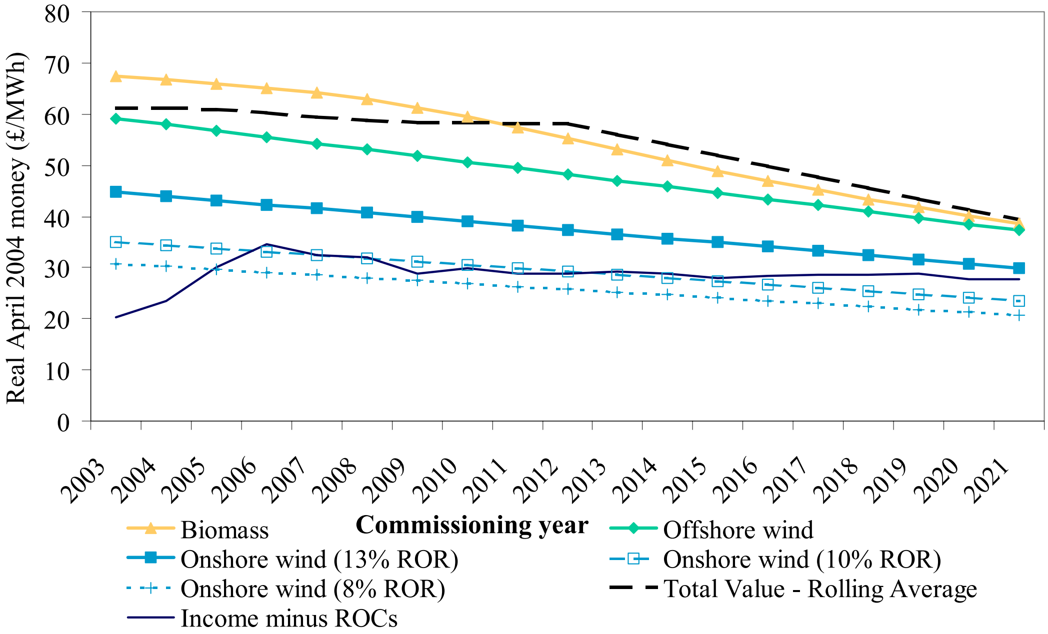
---

[22] A generating station fuelled solely by biomass according to the eligibility criteria of the Renewables Obligation.

[23] The total value of renewable power is the sum of the generator's share of wholesale electricity prices (including carbon costs), ROCs, embedded benefits, Levy Exempt Certificates (LECs) and imbalance costs.

forms of renewable generation the short-run avoidable costs of generation are very low, as they have no fuel costs – so the net marginal cost may be less than zero.

Figure 37 – Comparison of new entry costs with total value of income stream (based on the *Near Compliant* case) over a 15 year period



Source: ILEX

D.5 If the ROC price were to crash, the total value available to renewable generators would be reduced to the level indicated by the line "Income minus ROCs" in Figure 37. This significantly reduced total value of renewable power compared against new entry costs means that dedicated biomass, offshore wind and onshore wind projects with a high real rate of return would not be viable. Consequently, developers of these particular projects would either postpone or abandon their plans to develop them until such a time that ROC prices were sufficiently high enough again.

D.6 We model this postponement/abandonment of dedicated biomass and offshore wind projects by reducing the volume of generation from uneconomic projects until the aggregate volume of eligible generation has fallen to the level that ROC prices recover sufficiently to justify the investment in all the operating technologies. From this we are then able to determine the level of renewable generation that is substituted from energy recovery facilities as shown in Figure 29.

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Quality Control Check Sheet

ELIGIBILITY OF ENERGY FROM WASTE – STUDY AND ANALYSIS

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Director: Stephen Andrews	Date: 16 March 2005
Project Manager: Richard Slark	Date: 16 March 2005
Authors: Richard Slark Julian Scutter Anton van Santen Fleur Cuer Justin FitzHugh	Date: 16 March 2005
Quality Control: Beverly King	Date: 16 March 2005

ILEX Energy Consulting
King Charles House
Park End Street
Oxford, OX1 1JD
UK

Tel: +44 (0)1865 722660
Fax: +44 (0)1865 722988
E-mail: energy.consult@ilexenergy.com
www.ilexenergy.com
www.ewe.ch

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