

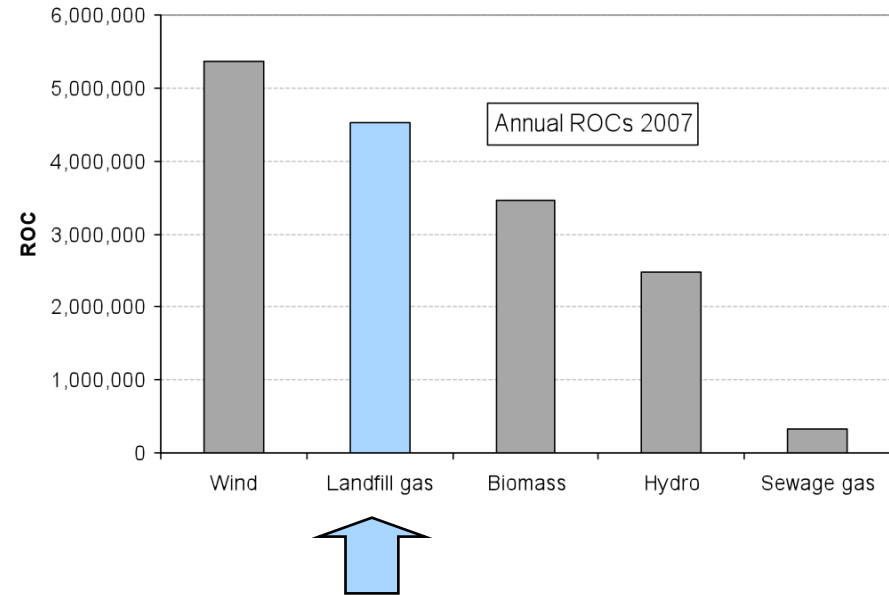
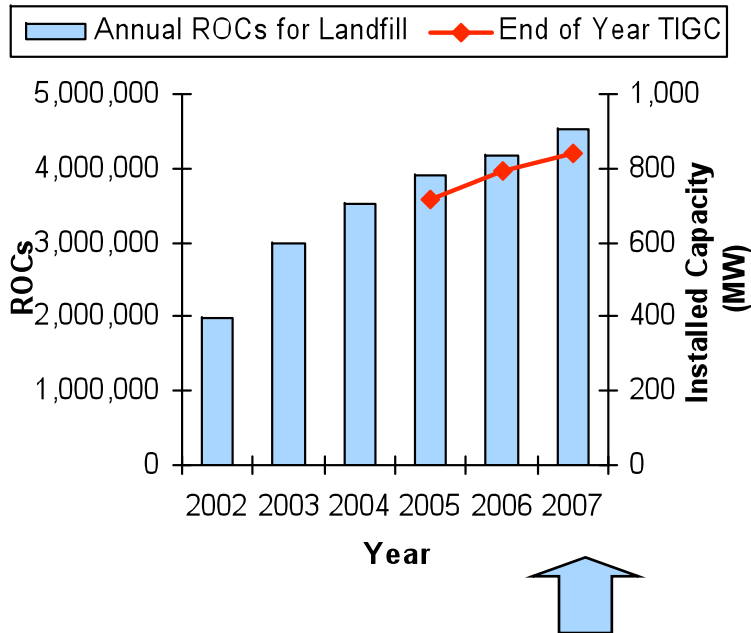
Landfill Gas Technology Overview 2007 September 2008

1. Landfill Introduction
2. Monthly Load Factor Plots
3. Sample Plant: Howden Clough
4. Conclusions
5. Appendix A – Data, methods and calculations
6. Appendix B – Technology description



Landfill Introduction

- Renewable Obligation data has been downloaded from the Ofgem web site (see Appendix A) and the data used to generate a summary on the performance and growth of hydro plant under the RO scheme.



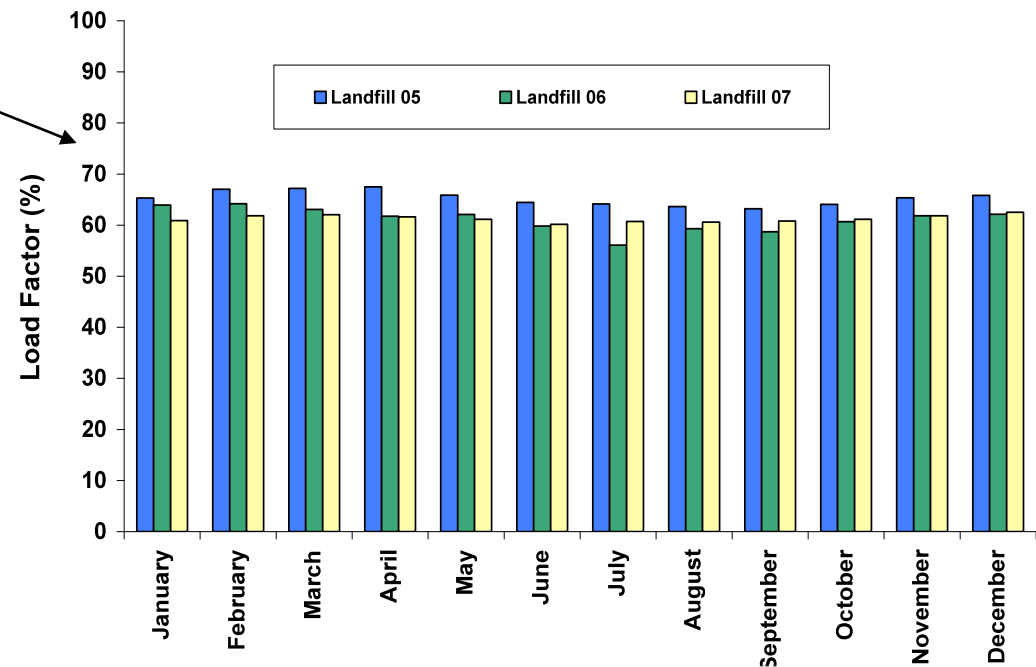
- Claimed Landfill ROCs have increased by 51% since the first full year of the RO in 2003, rising from 3.0 to 4.5 million ROCs
- Total installed generating capacity, (TIGC) increased from 796MW to 839MW between 2006 and 2007 year ends'

- Landfill claimed the second most ROCs in 2007, but growth is limited by future quantities of waste disposal

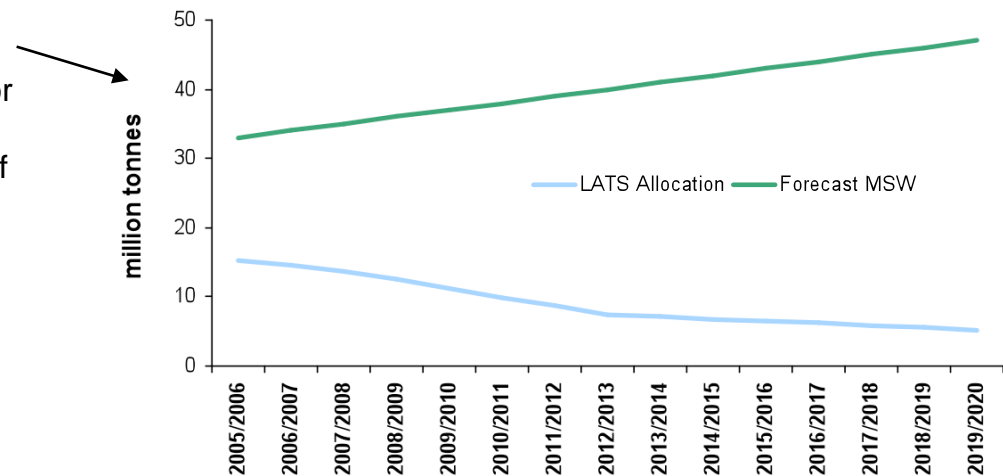


Monthly Load Factor Plots

- Graph of Load Factor by month for the whole UK
- Summing the months gives the National Annual Load Factor (for the 'valid data set' – see Appendix A) which are:
 - 2005: 64.3%
 - 2006: 60.9%
 - 2007: 61.2%

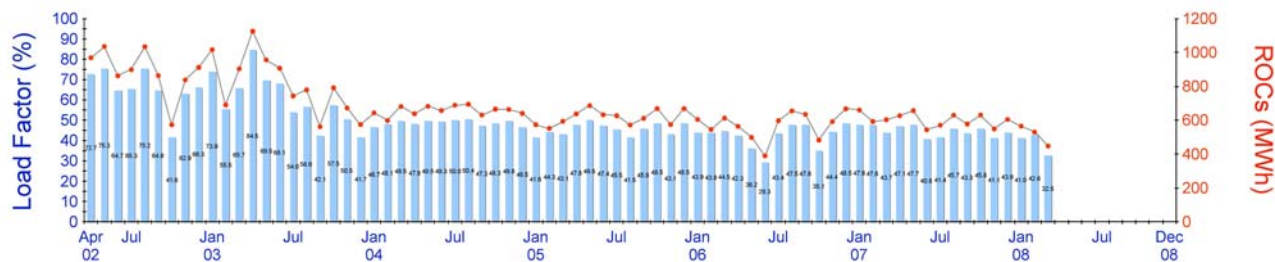


- There is little potential for landfill gas development due to government legislation and policies
 - Government increases landfill tax at a rate of £8/year/tonne from April 2008 to 2010 (Currently £32/tonne)¹
 - Reduction in the future Landfill Allowance Trading Scheme Allocations (LATS)²
 - Graph shows forecast in municipal solid waste (MSW)³ and potential for landfill treatment
 - This shows that in 2020 only 11% of MSW can be treated in landfill sites

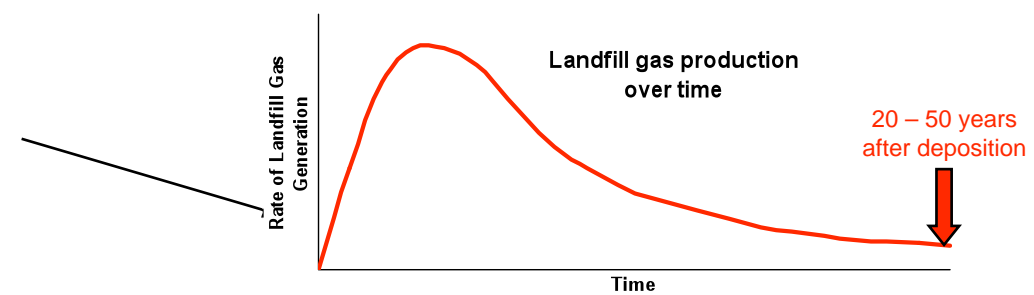
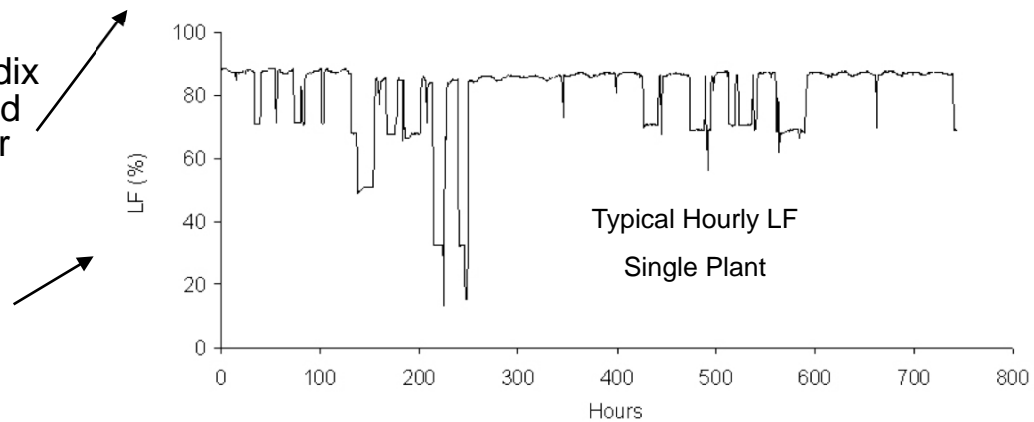


Sample Plant: Howden Clough

Generating Station Name: Howden Clough Road	R.O. ID R00166RJEN
Technology Type : Landfill gas	Current TIGC (kW) :1,850



- Generation output from landfill plant is dependent on biological decay (Appendix B) and the power output and hence load factor is very consistent (unlike weather dependent systems such as hydro and wind)
- Individual plant's hourly load factor is shown to be largely consistent and controlled¹
- Sewage and Biomass, produce similar characteristics
 - Controllable, available, base load
 - However, limited growth potential
- Long term output declines as waste breaks down more fully and the landfill becomes depleted²
 - Highest production within a year and generation continues up until 20 to 50 years depending on waste type



1. Load Factor Data provided courtesy of private UK operator wishing to remain anonymous
 2. Practical landfill gas flow monitoring , Report number ETSU B 1317 – page extracted from http://www.landfill-gas.com/LFG_production_vs_Time_Graph.pdf

Conclusions

- There was a 51% increase in ROCs claimed in 2007 compared to 2003 (the first full year of the ROC system):
 - 2.99 million ROCs in 2003; 4.5 million ROCs in 2007
 - 374 plants claiming ROCs in December 2007, compared to 329 in December 2005
- Limited growth can be expected from the Landfill renewables sector as
 - The Landfill Allowance Trading Scheme Allocations (LATS) are being reduced such that only 11% of municipal waste can be sent to Landfill in 2020
 - Landfill Tax is set to increase at a rate of £8/tonne per annum from April 2008 until 2010



Appendix A – Data, Methods and Calculations

1. ROCs & Ofgem
2. Data: 'The Valid Set'
3. Load Factor & Installed Capacity



ROCs & Ofgem

- Renewable Obligation Certificates (ROCs) are granted for each MWh of electricity produced by an accredited renewable generator in the UK. The administration of the Renewables Obligation is conducted by Ofgem. Each ROC has a value to its owner and can be sold or traded. The average value of each ROC sold at auction in July 2008 was £53.27/MWh (see Non-Fossil Purchasing Agency Ltd <http://www.nfpa.co.uk/>).
- Ofgem publishes raw ROC claims data in their ROC Register and this can be accessed through their web site at:
 - <https://www.renewablesandchp.ofgem.gov.uk/Reports/ReportManager.aspx?ReportVisibility=1&ReportCategory=0>
 - While Ofgem publishes a valuable annual report on the RO, they do not summarise or interpret this data on a station by station basis, and the work here aims to present this data in a fair and concise way and then draw conclusions on the performance of the established renewables industry in the UK.
- Total Installed Generating Capacity:
 - For the purposes of this summary all RO data for renewable generation “stations over 50 kW” was downloaded from Ofgem in December 2005, May 2006, March 2007 and then monthly up to May 2008. This provides a complete set of ROCs from 2002 to December 2007 and also a detailed account of changes in total installed generating capacity (TIGC) for each generating station. This was downloaded from their website:
 - [http://www.ofgem.gov.uk/Sustainability/Environment/RenewablStat/Documents1/Accreditation OVER50kw.xls](http://www.ofgem.gov.uk/Sustainability/Environment/RenewablStat/Documents1/Accreditation_OVER50kw.xls)
- Cleaning up the data:
 - Once downloaded, it was found that some generators show duplicate entries for a month. Ofgem advised us that some accredited sites split their monthly ROCs for commercial reasons. They advised us to sum the monthly ROC values for these sites to obtain the total ROCs claimed for the site. Other records have been tidied such as removing revoked ROCs.



Data: 'The Valid Set'

- The aim of this report is to fairly represent the performance achieved by generators in the UK, compare these and draw conclusions.
- With this in mind it has been decided to:
 - Exclude generators which were under construction during 2007 as these would have an unrepresentatively low output. This has been done by only including generators which first claimed ROCs prior to January 2007.
 - Exclude generators which were repowered during 2007. This was done by only including generators which had not changed the value of installed capacity during 2007, as recorded by Ofgem
 - Generators which pass both tests are termed 'the valid set' and are used to calculate Monthly and Annual Load Factors for the particular technology.
- Note that a generator which generates ROCs at the beginning of the year but suffers a failure later in year will be included in the valid set. This means the performance data such as National Annual Load Factor registers loss of availability.



Load Factor & Installed Capacity

- Load factor is the proportion of energy produced over a time period compared to the energy which would be produced if operating continuously at full power, e.g:

$$\text{Monthly Load Factor} = \frac{\text{MWh produced in month}}{\text{number of hours in month} \times \text{installed capacity}}$$

- e.g. for a 10 MW generator which produced 3,000 MWh
 - $\text{LF} = 3,000 / (10 \times 31 \times 24) = 40.3\%$.
 - Load Factor is a clear and convenient way to summarise the output of a generator over a given time period such as an hour, a month or a year
- Total Installed Generating Capacity (TIGC)
 - The installed capacity for each generator was obtained from the Ofgem list of accredited RO generators which was downloaded from Ofgem web site in December 2005, May 2006, March 2007, and every month thereafter until May 2008. This provided the installed capacity recorded for each site on that date. It has not been possible to obtain the levels of installed capacity prior to May 2006 and so this capacity has been assumed to exist prior to that date. Best endeavours have been made to cross check the installed capacities with generators.



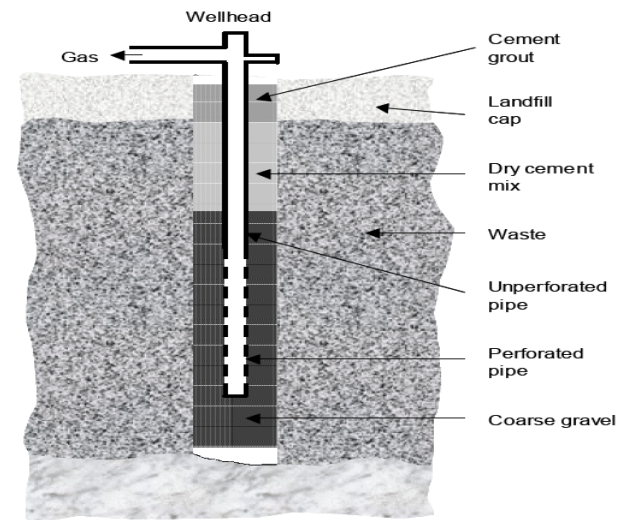
Appendix B – Technology description

1. Description of the technology
2. Operational summary



Description of the Technology

- In landfill sites, municipal solid waste (MSW) (domestic and industrial waste) are covered with soil and the anaerobic process breaks down the waste at depths > 5 metres
- Undiluted landfill gas can be expected to have a calorific value of 15 to 21 MJ/m³
- Landfill gas is produced from ageing MSW and is broken down by anaerobic digestion
- Landfill gas produced is then collected from mature landfill sites using strategically placed wells, as shown
- Perforated pipes surrounded by coarse gravel allow collection of gas without potential clogging of stray MSW
- Due to the variability of waste input, a gas clean up system must be incorporated to eliminate the low level contaminant gases
- Under optimum conditions, one tonne of waste will produced 150 to 200m³ of gas³

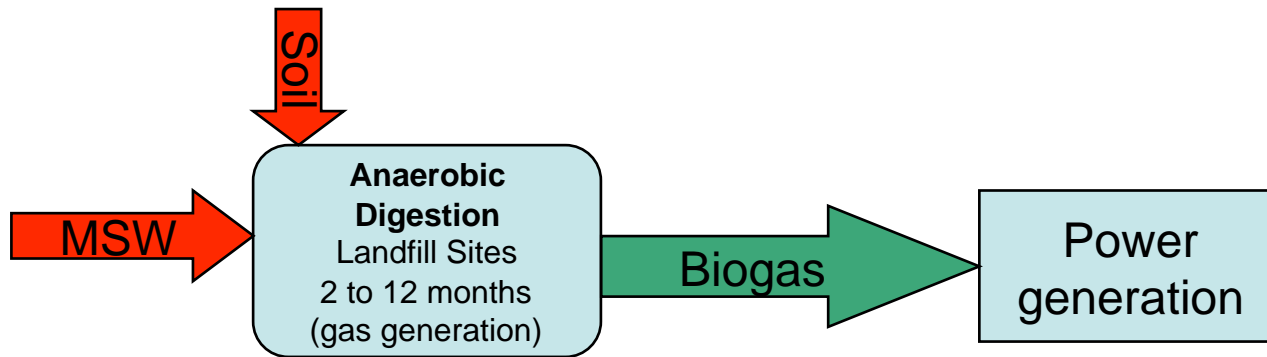


Fuels	Methane (%)	45 - 65
	Hydrogen (%)	0 - 1
Diluents	Carbon dioxide (%)	34-55
	Nitrogen (%)	0-20
	Oxygen (%)	0-5
Contaminants	Hydrogen sulphide (ppm)	0.5 - 100
	Ammonia (ppm)	Trace amounts

Biogas Constituents from Landfill²



Operational Summary



- 377 plants claimed 4.5 million ROCs in 2007
- The Energy White Paper, 2007 allocates 0.25 ROCs/MWh to landfill gas, starting from 1st April 2009
- Growth potential
 - Very small, likely to reduce as landfill becomes restricted



*Salt Ayre Power,
Lancaster (1136 kW)*

