Biomass
September 2008

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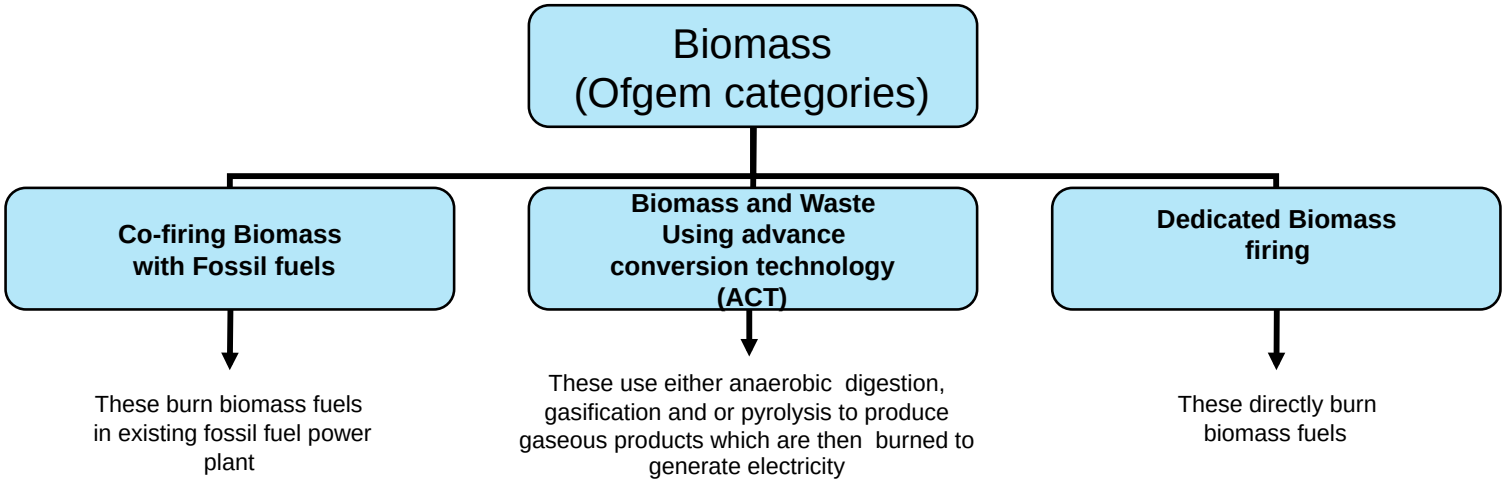
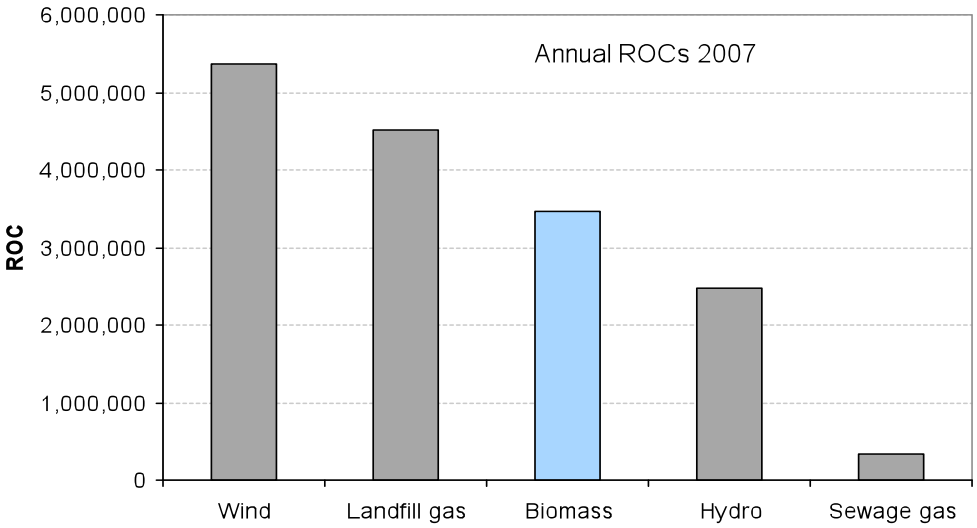
Biomass Sectors



- 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 the Biomass sector
- In 2007 the combined biomass sectors claimed the third largest number of ROCs.
- The individual sectors claimed:
  - Co-firing plant: 2.2million ROCs
  - Dedicated biomass: 1.2million ROCs
  - Alternative Conversion Technologies: 0.02million ROCs



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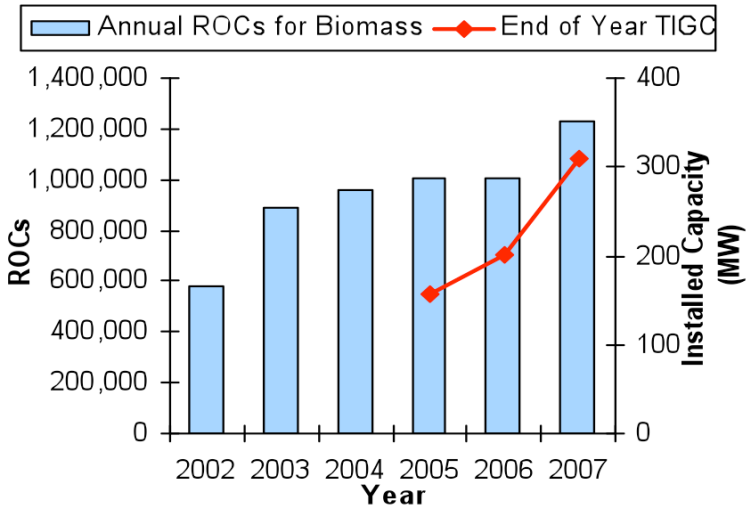
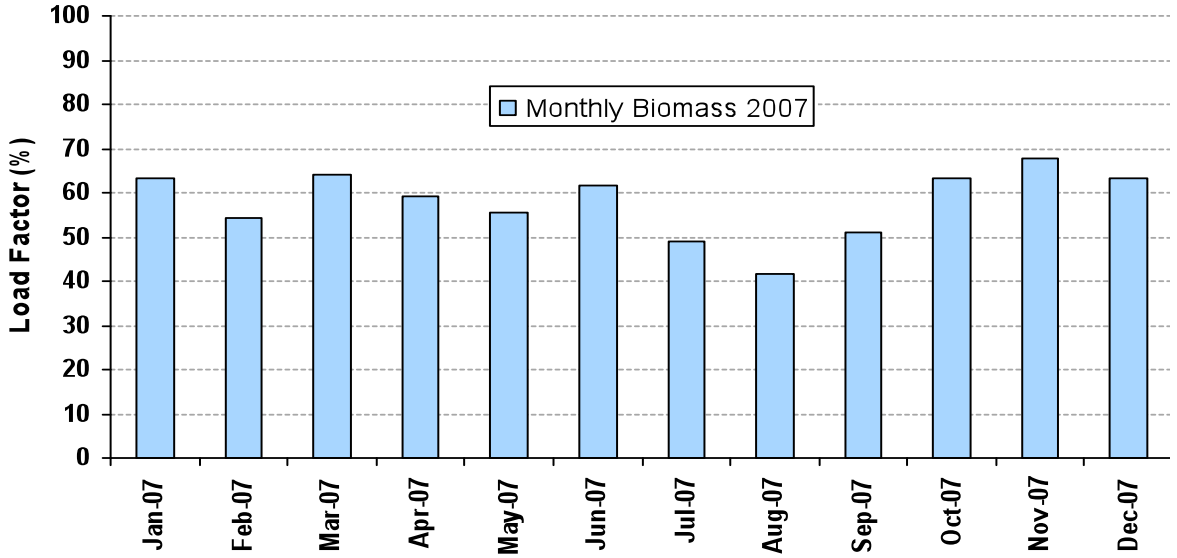
1. Dedicated Biomass

1. UK Annual ROCs & 2007 LF
2. Sample plant- Ely Power Station

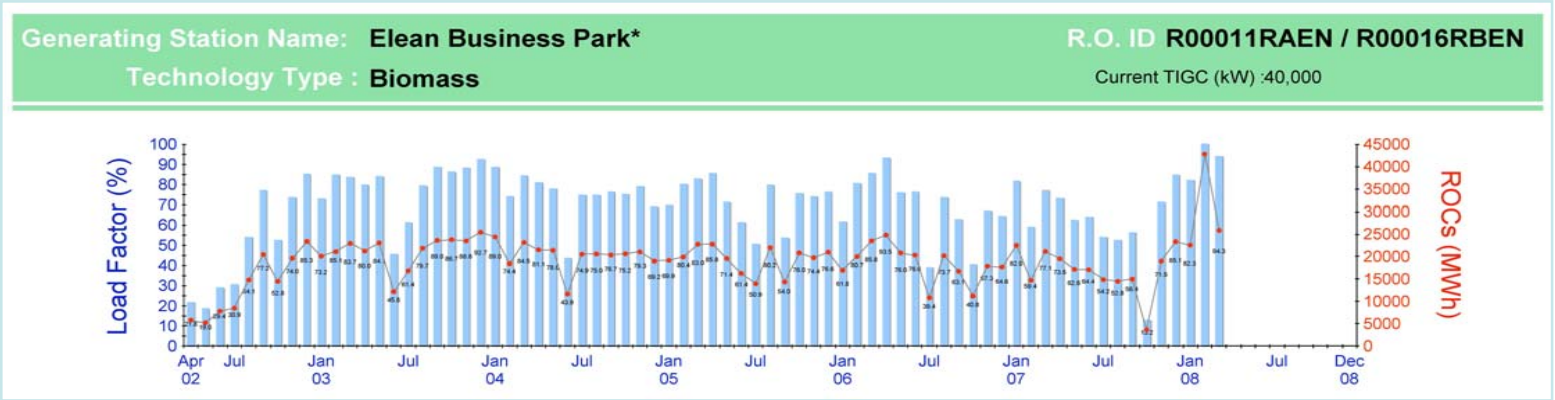
Dedicated Biomass: UK, 2007 ROCs and LF



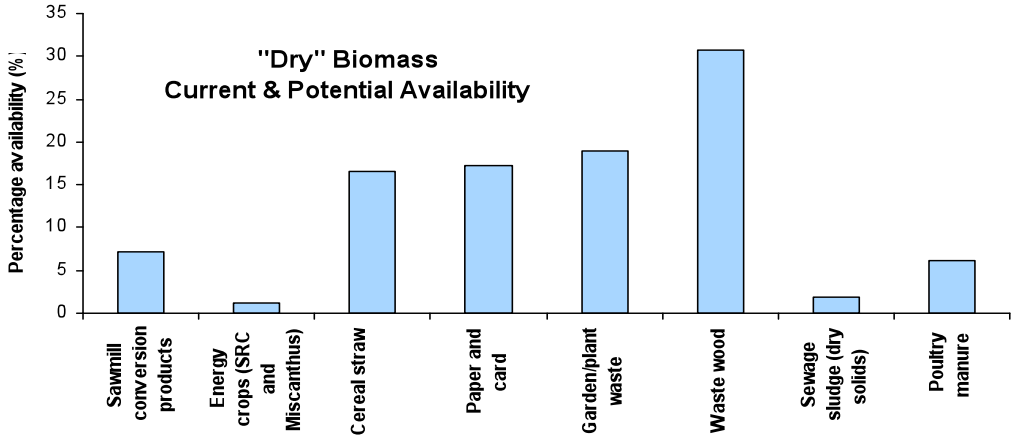
- The dedicated biomass plot shows a steep growth in installed capacity since 2006
  - There are now 28 sites in the UK listed on Ofgem's website (definition in Appendix B.2)
- The monthly Load Factor was fairly consistent. This is because Biomass fuel flow can be controlled and can deliver steady power output, unlike intermittent renewable plant
  - The annual Load Factor for 2007 was 58.0%



Sample Plant: Ely



- Elean power station (Total Installed Capacity of 40MW)[1]
  - Biomass fuel: Straw (200,000 tonnes pa), produced from wheat, barley and oats, can also include corn, maize and rye
- Dedicated biomass plants show high LF; the production is stable throughout the year
- Defra figure shows that waste from wood has the highest availability[2]

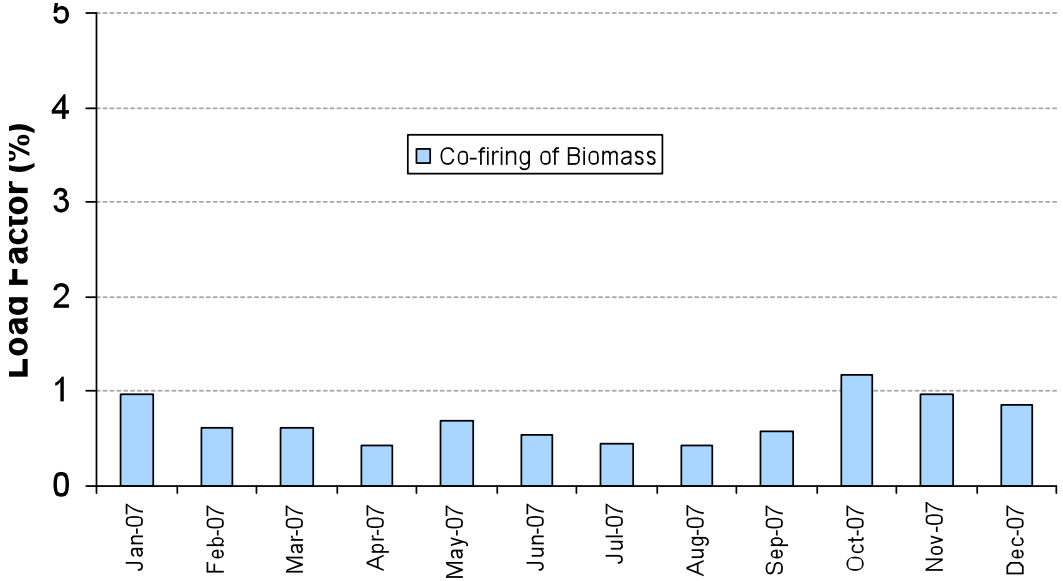


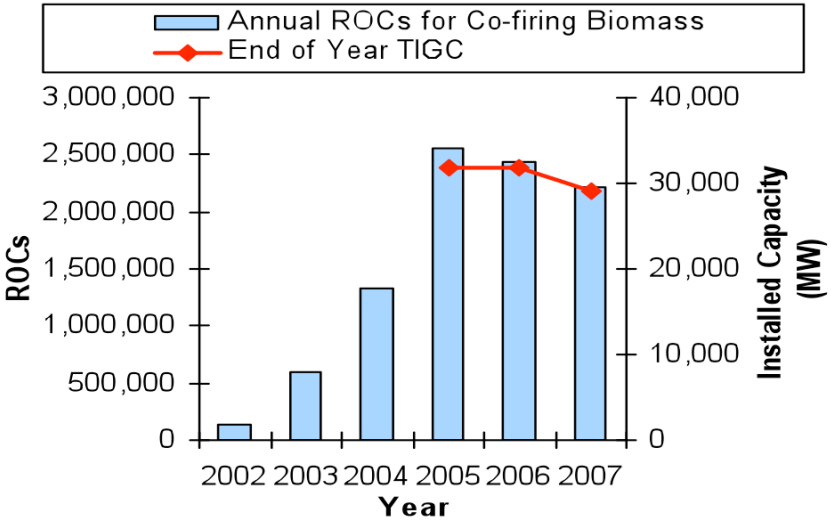
1. A trial burn of rape straw and whole crops harvested for energy use to access efficiency implications, Robert Newman, Energy Power Resources Ltd., DTI Report Nov 2003 URN 03/1569 http://www.dti.gov.uk/files/file14920.pdf
2. UK Biomass Strategy http://www.defra.gov.uk/environment/climatechange/uk/energy/renewablefuel/pdf/ukbiomassstrategy-UK 0507.pdf

2. Biomass with Co-firing of Fossil Fuels

1. UK Annual ROCs & 2007 LF
2. Sample Plant: Ferrybridge “C”

Biomass with Co-firing, 2007: ROCs and Load Factor





- Low load factors for co-firing are due to the large installed capacity of coal fired stations
  - 2007 annual load factor was only 0.70%
  - There are 30 sites of this type in the UK (definition in Appendix B.2)
- However, the total number of ROCs were higher compared to dedicated biomass in 2007
  - Dedicated biomass claimed 1.2million ROCs
  - Co-firing biomass claimed 1.6million ROCs

[1]Total installations of all coal plant in the UK was recorded at 28,832 MW

[2]The fall in TIGC in 2007 is mainly dominated by the fall in TIGC at both the Ferrybridge plant and Eggborough plant. These sites are under refurbishment

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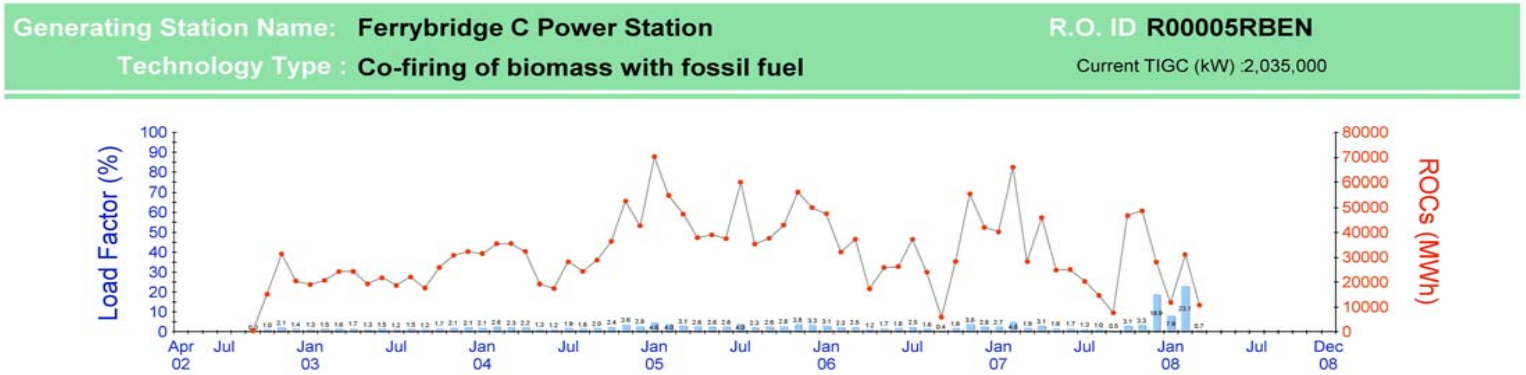
1. http://www.ecoworld.com/articles/images/CleanCoal_UKCoalPlants_table.gif
2. http://www.scottish-southern.co.uk/SSEInternet/doSearch.aspx

Sample plant: Ferrybridge “C”



- [1]Ferrybridge “C” is a coal power station with a total installed capacity of ~ 2GW
- The chart and table shows ROCs claimed for Ferrybridge in 2007 and the very low load factor achieved by co-firing biomass i.e. the fuel is dominated by coal
  - 2007 LF was 2.2%
- 920,000 tonnes biomass used[2]:-
  - Olive pellets
  - Palm kernels

Date	MWh / ROCs	Load factor (%)
01/01/2007	40165	2.65
01/02/2007	65983	4.83
01/03/2007	28227	1.86
01/04/2007	45848	3.13
01/05/2007	24825	1.64
01/06/2007	25030	1.71
01/07/2007	20286	1.34

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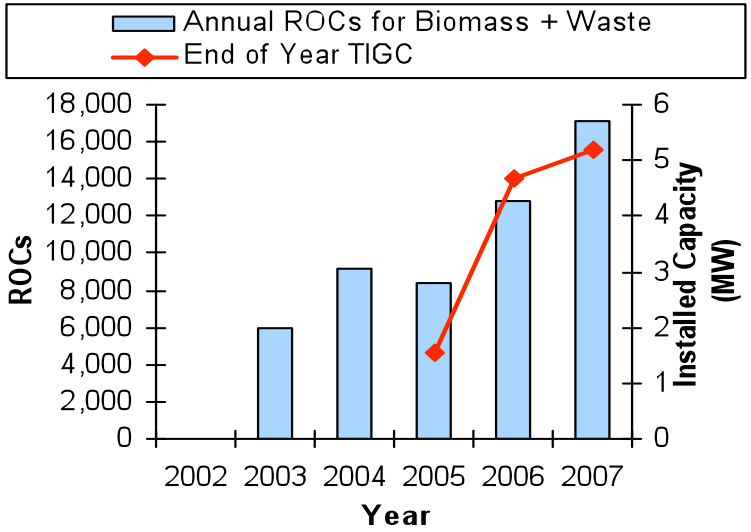
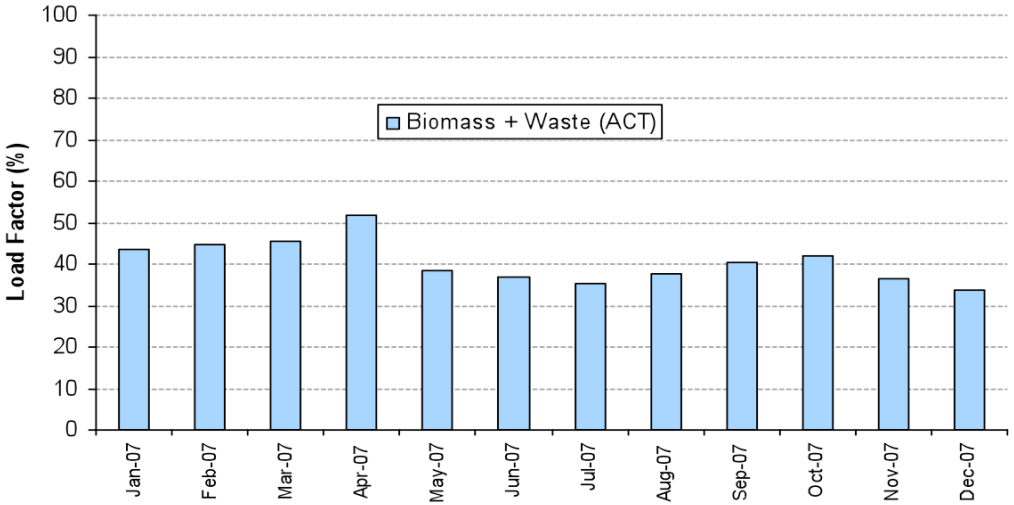
1. Photograph of Ferrybridge “C” Station http://www.geograph.org.uk/photo/35089, licensing under http://creativecommons.org/licenses/by-sa/2.0/
2. Biomass co-firing Ferry “C” Power Station, 19th Annual Meeting of Coal Combustion and Conversion http://www.coalresearchforum.org/20080410_wynn.pdf

3. Biomass using Advanced Conversion Technology (ACT)

1. UK Annual ROCs & 2007 Load Factor
2. Sample plant: Holsworthy & Avonmouth

Biomass using (ACT), 2007: ROCs and Load Factor





- Biomass and waste using ACT has seen steep growth in ROCs since 2005
  - However, it is a very small sector compared to dedicated biomass
  - ACT biomass, 2007: 17,000 ROCs
  - Dedicated , 2007: 1.2 million ROCs
- Fuel flow can be controlled and plant can run at base load
  - Annual LF for 2007: 40.6%
- There were 7 sites listed by Ofgem in December 2007 (definition in Appendix B.3)

Station	TIGC (kW)	Technology adapted
Bedfordia Biogas Ltd (Twinwoods)*	786	Anaerobic Digestion
Biogas Engine, Mauri Products Ltd	850	Anaerobic Digestion
Holsworthy Biogas Company Project	2696	Anaerobic Digestion
Little Woolden Hall Farm	85	Anaerobic Digestion
South Shropshire Biowaste Digester	200	Anaerobic Digestion
Twyford Power Station	250	Anaerobic Digestion
Bio Gask	340	Anaerobic Digestion

Sample plant: Holsworthy and Avonmouth

Holsworthy Biogas, Devon
(2696 kW)

Avonmouth Plant
(225 kW)[1]

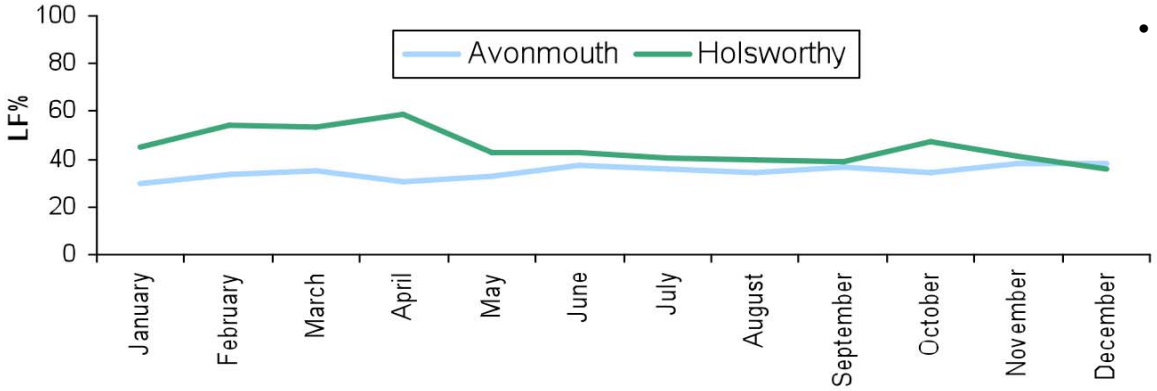
Anaerobic Digestion

Gasification and pyrolysis

ACT

- Uses Anaerobic Digestion
- The plant uses cattle, pig, poultry waste and food waste to produce biogas from the anaerobic digester
- LF for 2007 was 34.7%

- A combined pyrolysis and gasification unit
- The plant uses municipal and priority wastes, such as scrap tyres and clinical waste up to 8,000 tonnes per annum
- This plant also captures up to 80% of the heat waste for power generation in combined heat and power (CHP) applications
- LF for 2007 was 45.0%



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1.http://www.compactpower.co.uk/pages/technology_process.php

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/Environmnt/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
    - LF = 3,000/(10 x 31 x 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: Description of the Technology

1. Fuel groups
2. Dedicated biomass
3. Co-firing biomass with fossil fuel
4. Advanced Conversion Technology (ACT)

1. Fuel Groups

- Biomass is a term used to describe biological material that produced from living processes
- In renewable energy, biomass can be characterised into four fuel types:

1. **Wood fuels:** energy from wood or wood products
   e.g. firewood, charcoal and wood waste
2. **Agro-waste**: waste associated with farming and crops processing
   e.g. cereal straws, rice husks and bagasse
   Moisture content: can vary from 1 to 20% and effects the energy value
   Ash content: the substance that forms ash has no energy value
3. **Animal waste**
   e.g. cow dung, pig dung and poultry manure
4. **Fuel crops:** crops grown primarily for energy production
   e.g. sugar cane and cassava
   In the UK, The Renewable Obligation defines fuel crops as either
   1. Crops planted after 31st December 1989 and grown primarily for the purpose of being used as fuel or
   2. Miscanthus giganteus, Salix (short rotation coppice willow) or Populus (short rotation coppice poplar

1. Wereko-Brobby C.Y. and Hagen E. B., Biomass conversion and technology, 1996, John Wiley and sons
2. Renewables Obligation Order 2006 (Amendment) Order 2007, Final Decisions, Jan 2007 – URN 07/648 http://www.dti.gov.uk/files/file37597.pdf

2. Dedicated Biomass Power Station

- The Renewable Obligation defines biomass fuel as fuels with at least 90% of the energy content derived from biomass (plant or animal matter or substances derived directly or indirectly from agricultural, forestry or wood waste, sewage and energy crops)[1]
- ROCs are only issued for the actual biomass fraction of the total fuel input
- Table shows both biomass and biomass co-firing stations are eligible for ROCs
- Under RO 2005, suppliers can meet 25% of their obligation by presenting ROCs generated from co-firing power stations
- Power generating stations are entitled to 1 ROC for every MWh of electricity generated using biomass fuel. However, the Energy White Paper 2007 declared that from 1st April 2009, dedicated biomass firing are to receive 1.5 ROCs/ MWh

Biomass Composition in fuel (%)	ROCs eligibility
> 90	Dedicated Biomass ROCs
25 to 90	Alternate between Dedicated biomass ROCs and Co-fired ROCs
< 25	Co-fired ROCs

- Ely Power station is one of the Dedicated Biomass Power Generating stations, but has reported using more than 10% (no more than 75%) of fossil fuel to generate electricity. When this occurs, the station will be entitle to co-fired biomass ROCs instead of dedicated biomass ROCs

1. Renewables Obligation Order 2006 (Amendment) Order 2007, Final Decisions, Jan 2007 – URN 07/648 http://www.dti.gov.uk/files/file37597.pdf

3. Biomass with Co-firing Fossil Fuels

- Co-firing is the supplementary addition of biomass fuel to fossil (invariably coal) fired power stations
- At the moment energy crops used in co-firing are generally short rotation coppice (SRC) and energy grass (miscanthus)
- Under RO 2006, crops planted after 31st December 1989 and grown primarily for the purpose of being used as fuel can be considered as energy crops
- 90% of co-firing in the UK is from wood fuel (inc. wood pellets) and imported food processing residues, e.g. palm kernel expeller, palm kernel shell, palm nut oil, olive residues and shea nuts
- A total of 60,000 to 300,000 tonnes/month was used in the UK for co-firing biomass in the year 2005/2006[1]
- Most of the biomass chosen for co-firing in the UK is selected for ease of milling, so that it can be added directly to the pulverised coal

1. The sustainability of biomass in co-firing. Bates et al (Nov 2006), A study for British Energy by AEA Environment & Environent

4. Biomass Using Advance Conversion Technology (ACT)

- Advanced Conversion Technology includes gasification, pyrolysis or anaerobic digestion, or any combination of the techniques to produce combustible gas
  - which in turn is combusted in an engine to produce electricity :

1. Gasification is a substoiciometric oxidation or steam reformation of a substance to produce a gaseous mixture containing two or all of the following: oxides of carbon (carbon dioxide and carbon monoxide), methane and hydrogen
2. Pyrolysis is a thermal degradation of a substance in the absence of any oxidising agent (other than that which forms part of the substance itself) to produce a char and one or both of gas or liquid
3. Anaerobic digestion (AD) involves breakdown of organic materials by using naturally occurring bacteria in a heated vessel to produce biogas consisting predominantly of methane

- The Energy White Paper 2007 declared that as from 1st April 2009, ACT is to receive 2 ROCs/ MWh