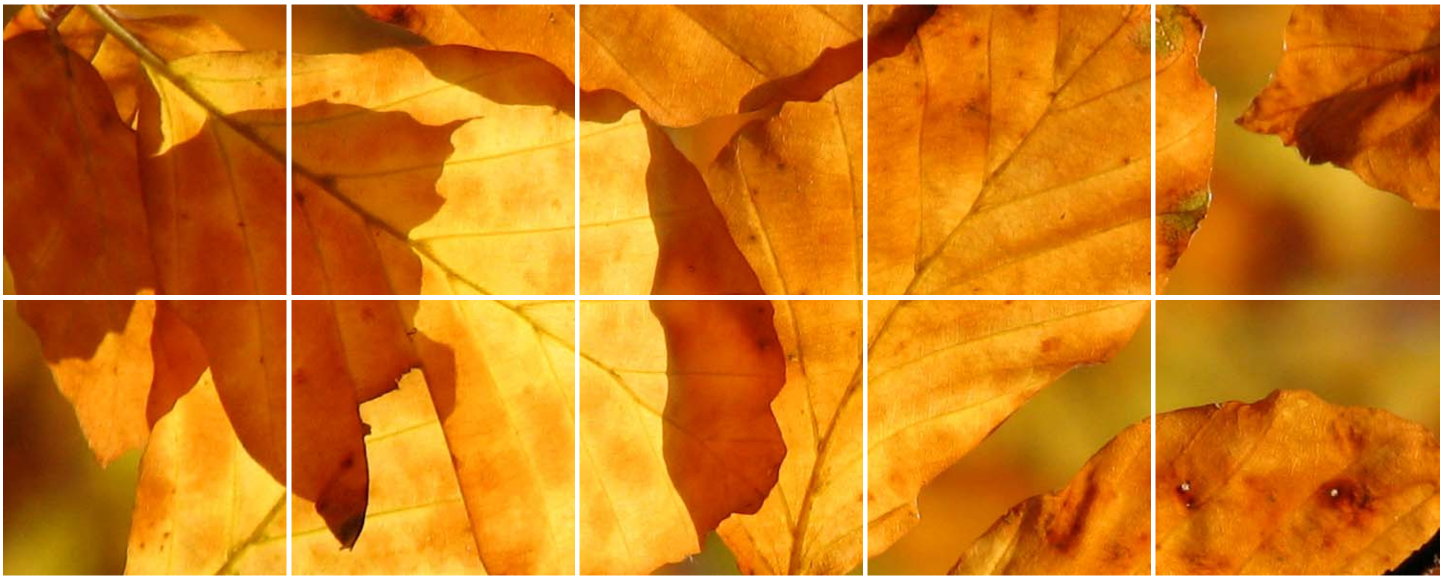

Use of CHPQA Methodology for Permitting Energy from Waste Plants in Scotland

Report to
Scottish Environment Protection Agency

Restricted Commercial

ED02806

Issue Number 2

Date 23 December 2008

Title	Use of CHPQA Methodology for Permitting Energy from Waste Plants in Scotland
Customer	SEPA
Customer reference	PO 4007785
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File reference	
Reference number	ED02806- Treatment Guidelines - Issue 2

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1 Background

The Zero Waste Policy for Scotland, launched in January 2008, sets out ambitious targets for recycling and energy recovery from waste in 2025. These proposals include a 25% cap on energy recovery from municipal waste and a requirement for high levels of energy efficiency for the recovery of energy from waste (EfW). Hence the proposals include an eventual threshold of 60% for energy recovery.

Since the announcement of these proposals SEPA has consulted on the Thermal Treatment guidelines that would be used to assess new proposals for EfW. The draft guidelines cover Thermal Treatment (TT) as well as Anaerobic Digestion (AD) and other Advanced Combustion Technologies (e.g. gasification). The consultation document included details of how the 60% energy efficiency threshold could be met, along with details of the proposed requirement for a Heat Plan. The Heat Plan is a statement of how and when applicants will develop the heat sales from their proposed EfW plant.

The responses to the consultation raised a number of important points regarding:

- The practicality of achieving a 60% energy efficiency threshold.
- The economics of heat vs. electricity recovery.
- The value of power compared to the value of heat in energy and environmental terms.
- The regulatory framework for Combined Heat and Power (CHP), and incentives for CHP.

Following the consultation and meetings with industry representatives, SEPA are now considering an alternative approach to setting thresholds for the guidance. This approach would use elements of Defra's CHP Quality Assurance programme (CHPQA). CHPQA is currently used to assess the performance of the UK's fleet of CHP schemes. CHP certified as Good Quality can claim benefits such as Climate Change Levy (CCL) exemption and Enhanced Capital Allowances (ECAs). The CHPQA programme will in future be used to qualify renewable energy schemes for Renewable Obligation Certificates (ROCs) – though some new definitions have been developed for this.

In principle the use of CHPQA appears to have a number of advantages. These include:

- Alignment with the Cogeneration Directive.
- Alignment with the incentives on offer to Good Quality CHP such as Enhanced Capital Allowances and ROCs.
- Lower regulatory burdens as EfW developers will only require to comply with one certification scheme.
- Use of existing CHPQA technical guidance on issues such as measurement of the calorific value of fuel and metering and measurement arrangements.

A further advantage of CHPQA is the need for synergy with the future incentives for renewable heat. While the details of how these incentives will be implemented are not yet known – the mechanisms will need to comply with the Cogeneration Directive and hence be aligned with CHPQA. Hence by developing guidelines that draw upon CHPQA there is a good chance that SEPA's guidelines will be aligned with the forthcoming heat incentive mechanism.

In view of these potential advantages SEPA have agreed to investigate how CHPQA principles and practices could be adapted for the permitting of EfW schemes in Scotland.

AEA and Fichtner have been commissioned by SEPA to undertake a review of the relevant issues, with this combined report setting out the findings. The report discussion the principles and some options for the thresholds and implementation details that could be used to implement these principles. However the details of the suggested thresholds will be set out in SEPA's Thermal Treatment Guidelines 2009.

2 Key Principles

Discussions between SEPA, AEA, Fichtner and the industry have led to the development of a number of key principles for the guidelines – which have been used to inform the development of this report.

These principles include:

- Existing markets, incentives and practice have resulted in the development of EfW schemes that are focused on recovery of electricity. Hence the industry and potential heat customers have limited experience of developing schemes designed for heat sales.
- Experience with existing UK examples of District Heating show that heat sales build up over many years – driven by the pace of redevelopment or the timeframe for replacement of existing heating systems.
- Housing developers and local authority planners are not familiar with District Heating and how this could be incorporated within local plans.
- Recent energy policy and waste policy is changing to focus on heat and how heat from renewable sources can be encouraged. Initial proposals and consultations on incentives for renewable heat have been published. However it will be some time before these incentives are in place.
- In the absence of an active heat market and planning requirements, developers cannot at present be required to implement schemes that recover significant levels of heat.
- However developers of EfW schemes need guidance now – on what performance or other requirements they need to meet – now and in the future.
- Hence EfW schemes designed and permitted now will need to have the capability to recover heat in the future.
- The most desirable outcome would be for EfW schemes to be fully qualified as Good Quality CHP, i.e. achieving a QI of 100 and thus be able to realise the full benefits of existing financial incentive schemes. However the early state of the heat market in the UK means that this would be a very challenging outcome at present – therefore a different QI threshold may be necessary in the early stages of heat use development in Scotland.

From this, three elements to the guidance on thermal treatment have been proposed:

1. An Initial Threshold – based on high electrical efficiency – recognising that the incentives and planning support to encourage heat recovery are not yet in place. However the scheme should have the capacity to recovery heat in the future.
2. Implementation of the Heat Plan – the Heat Plan will be submitted as part of the application and will set out how and when the applicant plans to increase the level of heat recovered.
3. An Ultimate Target – a requirement for schemes to meet a target Quality Index (QI). This QI target will not necessarily be the QI = 100 used for other regulatory mechanisms.

There are many detailed issues that require to be clarified for each of these elements – e.g. the level of the Initial Threshold and the Ultimate Target. These will be discussed later in this report.

However the principles of the 3 elements and the link to CHPQA are the most important aspects of these proposals.

The first sections of this report consider a number of the principles behind CHPQA and the proposed three elements for SEPA's guidelines. The final section considers how these principles and the 3 elements outlined above would apply to a range of different example EfW schemes.

3 Energy from Waste and Combined Heat and Power

This section sets out key aspects of the existing DEFRA Combined Heat and Power Quality Assurance programme (CHPQA). This looks at how CHPQA could be used by SEPA for the new EfW facility permitting process. This section considers the principles and the practical issues associated with the use of the CHPQA methodology to assist a permit determination.

This section looks at the following issues:

- The philosophy used to underpin the CHPQA standard and its implementation:
    - The relative "value" of heat and power.
    - The impact of scale and technology on CHP.
    - The choice of CHPQA X and Y factors.
- Scheme Boundaries:
    - For conventional technology EfW schemes.
    - For advanced conversion technology EfW schemes.
- Qualifying Heat Use
    - Principles.
    - Scale of heat demand.

3.1 DEFRA's CHPQA philosophy

The CHP Quality Assurance Programme (CHPQA) was developed by AEA on behalf of the UK Government, as a *robust*, *determinate* and *auditable* accreditation methodology for assessing, certifying and monitoring Good Quality CHP (GQCHP) schemes providing heat to industrial, commercial and domestic customers.

Both proposed and existing CHP schemes are assessed, based on design and operational data respectively. These range in size from reciprocating engine based schemes of a few 100's of kWe to Combined Cycle Gas Turbine (CCGT) sized power stations of up to 1,700MWe. In addition to validation and certification of more than 900 schemes a year, site audits are carried out to verify information, design and operation with approximately 100 site audits carried out each year. The methodology allows public support measures to be targeted only at GQCHP that provide significant energy and environmental benefits.

CHPQA provides the following:

- A methodology for assessing the quality of CHP Schemes, and their qualification as Good Quality CHP (GQCHP) for *all or part* of their inputs, outputs and capacity.
- A programme whereby Responsible Persons can apply for the Registration and Certification of their Schemes in accordance with the criteria for Good Quality CHP and hence qualify for benefits. Application to the CHPQA programme is voluntary.
- A programme that provides a robust methodology for calculating primary energy savings from CHP which comply with Article 12(2) of the European Union Directive 2004/008/EC-Promotion of Cogeneration based on a useful heat demand in the Internal Energy Market.

Its Quality Index (QI) definitions are designed to take account of the above EU Directive and these are applied to ensure the following:

- That GQCHP with a total installed capacity of <1MWe provide >0% primary energy savings compared with the Directive's harmonized reference values for separate production of heat and electricity;
- That GQCHP with a total installed capacity of ≥1MWe provide ≥10% primary energy savings;
- That GQCHP with a total installed capacity of >25MWe have an overall efficiency of at least 70% (based on Net Calorific Value).

The general form of the QI definition is:

$$QI = (X \times \eta power) + (Y \times \eta heat)$$

Where X is a coefficient related to alternative power supply options and similarly Y is a coefficient for heat generation, related to alternative heat supply options.

Power Efficiency (η*power*) is the total annual power output divided by the total annual fuel input.

Heat Efficiency (η*heat*) is the qualifying heat output divided by the total fuel input over the period in question. Normally, η*heat* is calculated over Annual Operation.

The QI recognises the value of both power and heat and is modelled against achievable performance for different technologies and fuel types.

Certification issued under the CHPQA programme may be used for determining the eligibility of Schemes for fiscal or other benefits (such as Climate Change Levy exemption, Enhanced Capital Allowances, Business Rate reduction, Renewable Obligation Credits for Energy from Waste CHP schemes, allocation of Carbon allowance from the European Union Emissions Trading Scheme (EU-ETS) CHP New Entrants Reserve and for determining compliance of Schemes with regulatory requirements where quality is relevant to entitlement.

CHPQA will be used to provide renewable energy schemes access to Renewable Obligation Certificates (ROC's). This is the framework under the proposed banded Renewables Obligation anticipated to be introduced in Scotland from April 2009.

For the purposes of the banded Renewables Obligation separate QI definitions have been designed, to ensure that biomass and solid waste fuelled schemes have:

- An overall efficiency ≥35% (based on Gross Calorific Value), and
- Provide ≥10% primary energy savings,

This ensures compliance with the Directive's harmonized reference values for separate production of heat and electricity. This is achieved with a heat efficiency ≥10%.

These QI definitions are set out in Appendix 1.

3.2 Valuing Heat and Power

Respondents to SEPA's consultation paper[1] on the draft Thermal Treatment guidelines have commented that a simple overall energy efficiency definition does not reflect:

- The higher environmental impact of electricity generation vs. heat generation.

[1] SEPA – Draft Thermal Treatment Guidelines 2008

- The higher primary energy use associated with electricity generation cf. heat generation.
- The higher commercial value of electricity vs. heat generation.

These principles were used in the development of DEFRA’s CHPQA scheme to provide assurance that Good Quality CHP schemes would indeed provide the environmental and energy benefits that were needed to justify the significant tax benefits that were on offer through Climate Change Levy exemption and other fiscal benefits.

The development of the EU Cogeneration Directive also follows this principle – using reference values for electricity and heat generation. Extensive collaboration between the EU, DEFRA and AEA has resulted in a re-issuing of the CHPQA Standard, with revised X and Y factors to ensure that the CHPQA programme is compliant with the requirements of the EU Cogeneration Directive.

In a similar vein the Waste Framework Directive uses a weighted calculation to test schemes against its energy efficiency threshold of 0.65. Schemes that exceed this are deemed to be recovery as opposed to disposal facilities. The generation of power is weighted by a factor of 2.6 while the generation of heat is weighted by a factor of 1.1.

3.3 CHP Size & Technology

The development of CHPQA considered a number of principles to ensure that accreditation as Good Quality ensured that all forms and sizes of CHP scheme delivered energy and environmental benefits. These principles recognise that smaller schemes:

- Will be located closer to final energy consumers – reducing the losses associated with distribution of electricity and heat.
- Can have a lower electrical efficiency than larger schemes – an aspect of scale.

Hence the X and Y factors are more challenging for larger schemes – to address these two aspects of CHP scheme size. This facet of CHPQA is therefore aligned to the Scottish Government's zero waste policy – which aims to encourage smaller energy from waste schemes. Thus the use of existing CHPQA principles and guidance will ensure that SEPA's thermal treatment guidelines align with the zero waste policy.

Similarly, different CHP technologies and CHP schemes that use different fuels have different levels of electrical efficiency. Hence the X and Y factors are set for separate technologies and fuels – to ensure that sufficient heat is recovered, as this is the aspect of GQCHP that delivers energy and environmental benefits over electricity only generation.

The EU Cogeneration Directive also recognises the benefit of smaller schemes located closer to final energy consumers. This is implemented via use of an adjustment factor based on the connection voltage for the CHP scheme. Because CHPQA is compliant with the EU Cogeneration Directive these factors are not used in CHPQA – as the use of different X and Y Factors for smaller vs. larger schemes serves to recognise this point.

3.4 CHPQA X and Y

The existing CHPQA X and Y factors and calculation methodology have been chosen so that:

- Good Quality CHP delivers energy and environmental benefits.
- CHPQA certification is aligned with the EU Cogeneration directive and its requirements for primary energy savings.
- Each scheme is set challenging targets to recover heat.
- That partial schemes in operation are progressively rewarded for increasing their environmental performance as increased recovery of heat will increase qualification for benefits.

For each type of GQCHP (size, technology & fuel) the X and Y factors have been chosen such to make a QI of 100:

- A practical and achievable target that can be met by schemes that are well designed and operated.
- Deliver energy and environmental benefits through the use of heat and power in a balanced fashion.

A recent development of the CHPQA programme is to qualify schemes to obtain ROCs under the banded obligation that is expected to apply from April 2009. This uses the same CHPQA principles to assess the performance of CHP schemes that use renewable energy as a fuel input. The QI definitions used are largely the same, except for larger schemes, where the X co-efficient may differ.

These QI definitions are set out in CHPQA Guidance Note 44 and are the most appropriate QI definitions to use for SEPA guidelines.

4 Scheme Boundaries

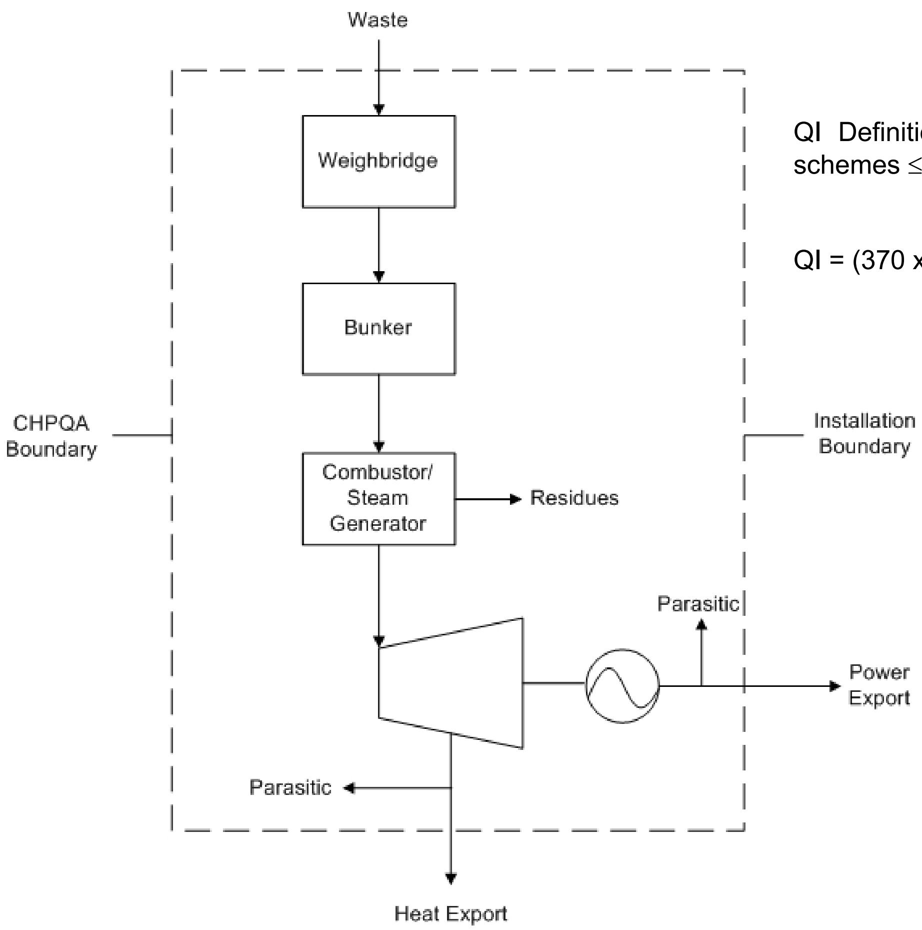
One of the principles of CHPQA is the avoidance of a prescriptive rule-based approach to the definition of scheme boundaries. Thus applicants with multiple prime movers connected in parallel by heat distribution systems, or applicants with auxiliary and back-up boilers, are permitted to determine their own CHP Scheme boundaries, subject to appropriate metering installed to support the CHP Scheme boundaries proposed.

However for the purposes of qualifying for ROCs, CHPQA Guidance Note 44 requires that ACT using gas engines or gas turbines measure the fuel in the biogas or syngas as supplied to the prime mover (see note below).

4.1 Boundaries for Conventional Energy from Waste Technologies

For conventional moving grate or fluidised bed technologies, this approach is relatively straightforward – fuel input energy is considered at the waste reception. The energy content of the solid heterogeneous fuel input is typically calculated using an energy balance following the losses method. This is set out in CHPQA guidance note 20.

Figure 4.1 Possible (simplified) Installation/CHPQA Boundaries for a Conventional Energy from Waste Facility



QI Definition at Installation boundary for schemes ≤25MWe is

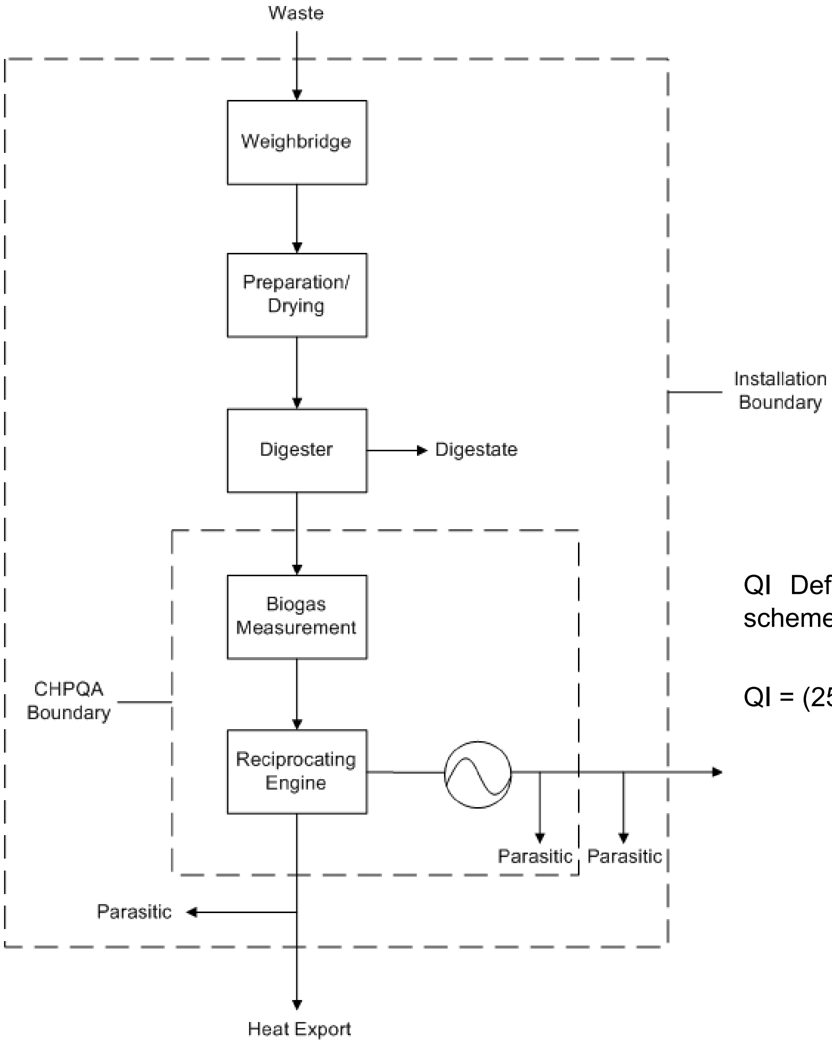
QI = (370 x η_{power}) + (120 x η_{heat})

4.2 Boundaries for Advanced Conversion Technologies

Where Advanced Conversion Technologies (ACT) such as gasification and anaerobic digestion are utilised, then there are wider possibilities for the consideration of scheme boundaries. For example, standalone gasifiers produce a synthetic gas (syngas) that can be fired in reciprocating engines – offering higher efficiency electrical generation. Similarly the digester gas produced from the anaerobic digestion of wastes or biomass can be utilised in reciprocating engines. There are two possibilities here for adoption of a suitable fuel input boundary – either at the reception point for the solid waste or at the syngas supply – with the syngas being considerably more homogeneous than the solid waste and thus considerably easier (and thus lower cost) to measure.

CHPQA Guidance Note 44 sets out the boundary that should be used for ACT schemes that use reciprocating gas engines or gas turbines – this is measurement of the biogas or syngas as the fuel input.

Figure 4.2 Possible (simplified) Installation/CHPQA Boundaries for an Anaerobic Digestion Energy from Waste Facility



QI Definition at CHPQA boundary for schemes >1 to ≤25MWe is

$$QI = (251 \times \eta_{power}) + (120 \times \eta_{heat})$$

4.3 Discussion on Boundaries

The flexibility with CHPQA regarding boundaries was required to address a strong concern from industry that the CHPQA scheme should be as flexible and straightforward as possible. Hence operators were offered a choice over the scheme boundary. This choice is heavily influenced by the metering systems in use, the technology type and the number and type of plant items that form the scheme.

In the case of the SEPA thermal treatment guidelines all the schemes that apply are not yet built. The practical and cost barriers to retrofit metering systems are therefore not relevant. Hence the SEPA guidelines could recommend or require a particular way in which the boundary should be defined and hence where the fuel inputs and energy outputs are to be measured.

The issues that would need to be considered include:

- Consistency with other legislation that will apply to the scheme (Waste Framework Directive)
- Consistency with CHPQA principles.
- Practical issues regarding measurement – see Guidance Note 13

In the case of ACT with reciprocating gas engines or gas turbines the boundary is set out in GN44.

5 Qualifying Heat Use

CHPQA does not distinguish between different forms of heat recovery and use or the heat transfer medium. Hence heat recovered as steam, as hot water, as direct heat from exhaust gases and heat recovered by other means can all qualify. CHPQA is concerned with the quantity of useful heat recovered in MWh per annum.

5.1 Heat use Principles

The key principle is to test if the heat recovered is useful heat, i.e. does it displace heat that would otherwise have been provided by other means – i.e. are energy and environmental benefits being conferred through the use of this heat? The CHPQA definition for useful heat determines whether the production of the heat via CHP is **economically justifiable** when compared to conventional or alternative means of generation (CHPQA Guidance Notes 16 and 44 refer). This is designed to promote the development of CHP schemes that are providing a real environmental and economic benefit to the operators, and to the heat consumers, and prevent the development of schemes where the destined heat consumer is spurious.

What is most effective in delivering high efficiency heat is to ensure the plant design considers a wide mix of heat use (e.g. community heating – residential supply, leisure centres, swimming pools - commercial, industrial consumers, eco-industrial parks, food production).

As the temperature of heat required by different consumers will vary, the choice of heat recovery system and the design temperatures is one for the CHP operator. In making this choice the CHP operator will wish to consider a range of technical and economic issues.

These issues may be complex and there will often be a trade off between options. For example:

- For CHP schemes using pass out condensing steam turbines electricity generation reduces as increasing amounts of heat are recovered. This effect is more pronounced if the temperature of the heat recovered is higher. Hence low temperature heat recovery addresses this, maintaining higher electrical efficiency and hence maintaining the value of electricity sales.
- However distribution of low temperature heat via District Heating has a number of pros and cons:
  - Heat losses will be lower in the heat network.
  - The physical dimensions of the distribution pipes will be greater, increasing capital costs, and pumping costs.
  - The temperature at the supply point may require use of heating systems with higher surface areas (e.g. underfloor heating or embedded in walls). This may be impractical, unaffordable or impossible for installation in existing buildings.

For the avoidance of doubt the CHPQA excludes heat rejected to the environment **without any beneficial use**. Examples include, *inter alia*, heat lost from chimneys or exhausts and heat rejected in equipment such as condensers and radiators.

Hence we propose that the use of existing CHPQA approaches to the type of heat recovery should be used by SEPA in their thermal treatment guidelines.

5.2 Scale of Heat Load

An important practical consideration for the thermal treatment guidelines is the ability of EfW schemes to serve sufficient heat consumers.

Accordingly, respondents to SEPA's consultation on the thermal treatment guidelines included a number of worked examples. These illustrated their points by calculating the number of homes that would need to be connected to the example scheme to deliver a given level of energy efficiency. These examples typically used the average gas use of a home in Scotland of circa 20 MWh pa. The number of homes that would need to be connected to the EfW CHP was calculated as 7,200 homes in one case and 11,700 homes in the other – although the comments in Section 3.1 above regarding mix of heat use should be borne in mind.

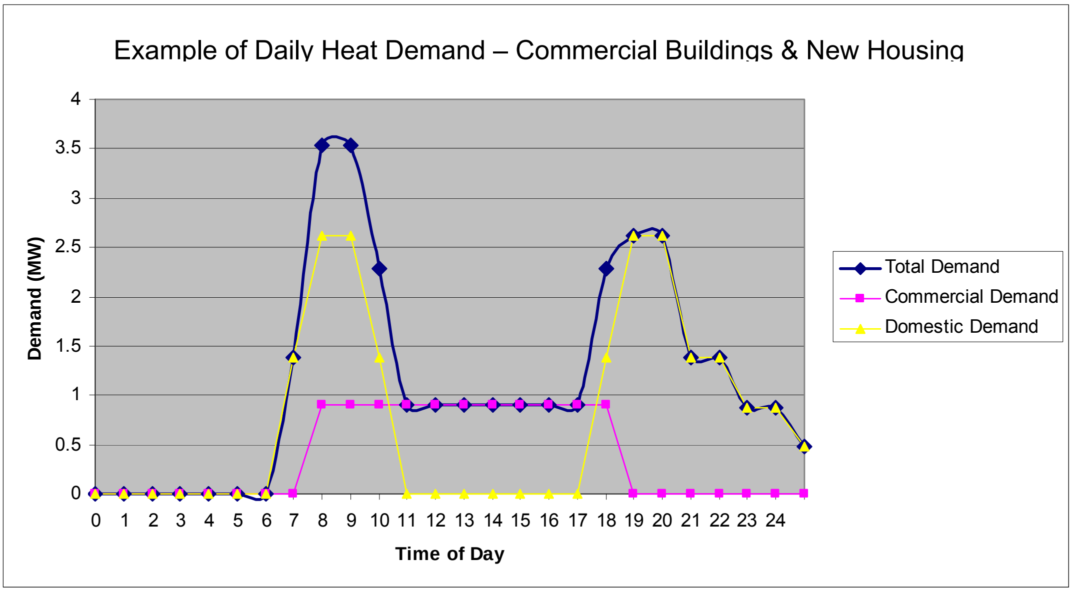
In addition, Municipal Solid Waste (MSW) arisings in Scotland are approximately 2.9 million tonnes pa[2], with the number of homes about 2.1 million. This equates to about 1.4 tonnes waste per home pa. The second of the above examples is based on a 200,000t pa facility – or the waste from approximately 143,000 homes. Thus this facility could provide heat to around 8% of the households whose waste it treats.

We have a number of observations regarding the number and type of consumers that may need to be served:

- The average gas use by homes in Scotland encompasses all homes of all ages and all standards of energy performance. Progressive editions of the Scottish Building Standards have tightened the energy performance requirements for new homes. AEA estimate the amount of heat needed by a typical 3 bed new home (to 2007 regulations) as 12.1MWh pa. Hence the number of homes quoted above would increase to around 11,900 and 19,300 respectively. Assuming occupancy of 2 per dwelling this is a population of 23,800 to 38,600. From the 2001 census there only 20 towns in Scotland with a population over 38,600. This illustrates the strong association between high heat recovery and serving local heat demands.
- The Sullivan Report has recommended that Scotland aims for net zero carbon buildings by 2016/2017, with two intermediate steps to achieve this[3]. This policy both creates an opportunity for heat from EfW CHP schemes (as these buildings are potential heat customers) yet this also has the potential to reduce the market (as inclusion of energy efficiency measures will reduce the heat needed by these buildings). To be truly effective policy on planning for buildings and planning for EfW CHP needs to take an holistic view of both issues.
- At present around 25,000 new homes are built in Scotland each year. The Scottish Government has proposed a target to increase this to 35,000 pa. Hence on the figures suggested by the consultation respondents, the scale of development required is very large.
- The present 'credit crunch' and impact on the housing market has impacted the house building sector, leading to lower levels of new build. This illustrates the uncertain nature of the market for heat – which can be influenced by factors outside of the control of the EfW developer.
- For financial, technical and operational reasons GQCHP will operate better if it serves a range of different types of heat load. This should include buildings with heat demand in both the summer and at weekends (industry, hospitals, swimming pools, hotels etc), buildings with cooling demands that could be met via absorption chilling (offices) etc.
- As an example a recent AEA study for a Scottish local authority considered the inclusion of a range of existing public buildings along with 900 new homes in a District Heating network. One of the existing public buildings was a hospital, this is a heat load equivalent to 1,000 existing homes or 1,700 new homes. In addition the heat load of the hospital extends throughout the night and into the summer months.

[2] SEPA Waste Digest 7
[3] http://www.sbsa.gov.uk/sullivanreport.htm

The following chart illustrates this where the demand from a large number of new homes dominates the peak heat demand of a mixed use Community Energy scheme.



6 SEPA Thermal Treatment Guidelines

This section sets out the three elements of the proposed approach to measuring efficiency of energy use in energy from waste plants. As set out earlier this approach has three elements:

1. An Initial Threshold – based on high electrical efficiency – recognising that the incentives and planning support to encourage heat recovery are not yet in place.
2. Implementation of the Heat Plan – that requires schemes to increase the level of heat recovered over time.
3. An Ultimate Target – a requirement for schemes to meet a target Quality Index (QI)

These three elements will follow one after another as the scheme develops:

Stage	Initial Operation	Implementation of Heat Plan	Ultimate Threshold

6.1 Initial Threshold

At present there are limited policy levers and financial incentives that will support the development of District Heating systems to supply heat from EfW schemes. In the absence of these it is not yet appropriate for SEPA to require heat recovery at the outset of a scheme's operation.

However the direction of future energy policy and waste policy is to encourage heat recovery. At present the details of the policy mechanisms and incentives to encourage heat recovery are not available. Hence the Initial Threshold should include a requirement for the design of the scheme to be capable of recovery of heat, but not set a target for heat recovery in the early years of operation.

There will typically be a delay between the initial commissioning of the scheme and the connection of the first heat load. Hence the Initial Threshold will apply for a period of Initial Operation, a period that will cease when the Heat Plan is implemented.

There are a number of details of the Initial Threshold that will need to be clarified. These are discussed below:

Details	Suggestion
Initial Threshold for electricity only operation	Should be a minimum of 20% - a CHPQA threshold for fossil fuel schemes. To be consistent with CHPQA this should be measured on a Gross CV basis in the "as fired" condition. AD schemes will pass this threshold with ease. The use of the three elements means that schemes will quickly move away from the Initial Threshold and be assessed against the Heat Plan. This suggests that the Heat Plan and the Ultimate Threshold should be more testing – not the Initial Threshold. As a counter argument there will be an interest amongst community and environmental groups in the efficiency performance of the scheme – from the start of its operation.
Period of initial operation.	CHPQA uses at least 2 years for DH schemes (plus any part year).

Capacity for heat recovery	Schemes must have the main plant items required for heat recovery from the outset – i.e. those items that need to have heat recovery designed in from the outset. For example a steam turbine would need to have a pass out port, sized to meet the Ultimate Target for the scheme. However, the plant would not need to install the heat exchanger for the DH circuit – but would need to leave site space free for the relevant plant items. Choice of location would also need to have the potential to meet the Ultimate Target. These requirements mean that it is vital that the ultimate target is practical and achievable – the level of ultimate target is discussed later on in this report.
CHP or not CHP?	Electricity only schemes should not be called CHP – as they are clearly not CHP. Not being CHP such schemes should not be attributed a Quality Index – CHPQA will never issue a certificate for these schemes. Hence in this report electricity only schemes do not have a QI figure.
Measurement methods	The assessment against the Initial Threshold can use a number of the Guidance Notes issued under the CHPQA. These include: Fuel measurement, power measurement etc.
Scheme is heat only or CHP from the outset.	In the case where a new scheme already recovers heat: - The power efficiency test is irrelevant. - Period of initial operation is 1 year. - Heat Plan starts earlier.
Parasitic loads	Some of the electricity generated by the EfW facility will be used for the energy recovery, while some will be used for the handling/treatment of waste. CHPQA allows applicants to define the boundary of their scheme. So the meter can be immediately on the output of the generator or at any point after this. To be consistent with CHPQA this flexibility should remain. NB the commercial value of power generation still provides an incentive to minimise on-site electricity use.
What if the 20% power efficiency threshold is not met?	If not met at design stage – no permit issued. If not met when built – issue enforcement notice, with ultimate sanction of withdrawing permit.

6.2 Implementing the Heat Plan

While the initial operation of the EfW scheme may be to recover electricity only, the Heat Plan will require progressive increases in heat recovery. Under CHPQA increasing benefits are available for schemes that incrementally increase heat recovery.

SEPA's Draft Thermal Treatment guidelines include a requirement for submission of a Heat Plan. The Heat Plan will set out:

- Heat capture system
- How heat will be provided
- Assumptions regarding heat plan
- Identity of heat users (including details of annual and season demand, timetable etc)
- Potential future heat users and the likely heat demand
- Outcome of discussions with the local authority.

These qualitative elements should remain.

However there may be a need for some quantified requirements that can be used to measure the development of the heat recovery aspects.

There are a number of details of the Heat Plan that will need to be clarified. These include:

Details	Suggestion
When does the plan start?	After period of initial operation – minimum of 2 full calendar years.
When will the plan complete?	Heat loads tend to develop over significant timeframes. In addition the main policy frameworks are not yet in place. Hence this could be a significant timeframe. A counter argument is that if the timeframe is too long the economic and environmental advantages of heat recovery are not enjoyed for long enough. 10 years would be a significant proportion of the EfW scheme's operational life. 5 years would be a short period and would require planning and build out of new developments in a short period of time. SEPA's draft guidelines suggest a period of 5 to 7 years – this is an appropriate timeframe.
Annual targets?	Should annual progress be made on increasing heat recovered? CHPQA uses annual assessment of operation. However the build out of a new development may not be annual – there may be gaps in development. An alternative would be to use the Heat Plan to tailor progress to the individual scheme – providing this does not have all of the heat recovery added in the final years.
What quantified targets should the Heat Plan require?	The Ultimate Threshold will be a target QI value. Hence the developer should calculated the QI expected at each stage of the implementation of the Heat Plan. These can be verified via CHPQA.
What if the Heat Plan is not followed?	Potential enforcement notice, with ultimate sanction of withdrawing permit. The development of the heat load may depend on many factors that are outwith the control of the EfW operator, such as the planning consent for new developments. Hence these factors would need to be taken into account.

6.3 Ultimate Target

The CHPQA sets a target for Good Quality – above this threshold CHP schemes are eligible for all relevant benefits. Schemes that do not meet the criteria may be eligible for a proportion of the benefits. The aim for the Ultimate Target is to set a QI threshold for EfW schemes that they will achieve at the end of the Heat Plan phase.

This will be an absolute target – measured by the QI for the scheme.

There are a number of details of the Ultimate Target that will need to be clarified. These include:

Details	Suggestion
What CHPQA X Factor and Y Factor should be used?	EfW schemes will wish to establish eligibility for ROCs where possible. Hence the same CHPQA X Factor and Y Factor as used for ROCs would be appropriate. These Factors are set out in CHPQA Guidance Note 44 and Appendix 1 of this report.
What ultimate QI value should be set?	There are three QI thresholds used at present: QI = 105 – for schemes at design stage QI = 100 – for existing schemes that are in operation QI = 95 – for schemes in their period of initial operation (a relaxation to allow schemes operation to bed in). In terms of alignment with CHPQA for the purposes of ECAs a 105 threshold is already used for new schemes. While there is a logic to use this threshold, this is a testing threshold which some schemes would struggle to meet. QI = 100 would align with schemes in operation and at the point when the Ultimate Threshold is assessed the EfW schemes will have been in operation for some time. Use of QI = 95 normally applies to schemes in initial operation – a different test is proposed for EfW schemes. An alternative view is that none of these values is appropriate. Other uses of the QI allow scaling back of the benefits if the QI is less than 100. A permit cannot be scaled back – so this argues that a lower QI figure should be used. This issue is discussed in more detail in the following section.
What if the Ultimate Target is not met?	Issue enforcement notice, with ultimate sanction of withdrawing permit.

6.3.1 Ultimate Threshold QI Target

For the Ultimate Threshold there is a need to set a QI threshold that can be used to test if schemes have met an acceptable level of long term heat recovery.

There are a wide range of different fuels and technologies that could be deployed on EfW schemes now and in the future. Hence there are a wide range of performance factors that these schemes will achieve. One of the benefits of using CHPQA is that these differences are dealt with by the use of different X and Y factors in the QI calculation.

However the diversity of these technologies may mean that it is unlikely that there is a perfect QI threshold to apply to all schemes for the Ultimate Threshold. Developers and other parties will have views on the appropriate thresholds and they should have an opportunity to comment on the principles and details in these revised arrangements.

Most (if not all) schemes will wish to claim ROCs on eligible power output. This is the amount of power that, if eligible, will be certified using CHPQA and is known as the Qualifying Power Output (QPO). The normal QI threshold of 100 will be used to calculate QPO. Schemes which do not meet QI = 100 will have the QPO scaled back to a fraction of the total power generated.

Hence Scheme operators will have a strong economic incentive to increase heat recovery to maximise potential ROC income.

However unlike permitting, the eligibility for ROCs can be scaled back if the scheme does not meet the Good Quality CHP threshold of QI = 100.

This being the case, there is an argument that the threshold QI level for permits should be lower than the Ultimate Threshold. For example if the Ultimate Threshold was QI = 100, but the scheme QI is less than 100, then SEPA would have the powers to withdraw a licence from a plant that is recognised by the ROC regime as providing valuable renewable power generation. This would be incongruous. Hence for the purposes of permitting and setting an Ultimate Threshold a QI lower than 100 at the end of the implementation of the Heat Plan may be appropriate for the purposes of SEPA's permitting process.

Fichtner have modelled the energy performance of a range of different EfW schemes, showing the impact of increasing heat load – on power efficiency, heat efficiency and QI. These include proposals for QI thresholds for the Ultimate Threshold.

These calculations are on a CHPQA basis – using the QI formula for ROCs – and using Gross CV and fuel "as fired".

6.3.2 MSW

The key assumptions for the MSW examples are:

- 70,000 tonnes/year as an example of a small plant and 200,000 tonnes per year as an example of a medium sized plant
- Net calorific value (NCV) of the waste is 9.2 MJ/kg.
- Gross electrical efficiency assumes a NCV of 9.2 MJ/kg, moisture content of 35% and a parasitic load of 12% of the gross electrical output.

The following table and chart shows the efficiency and QI data for two different MSW fuelled EfW schemes[4]:

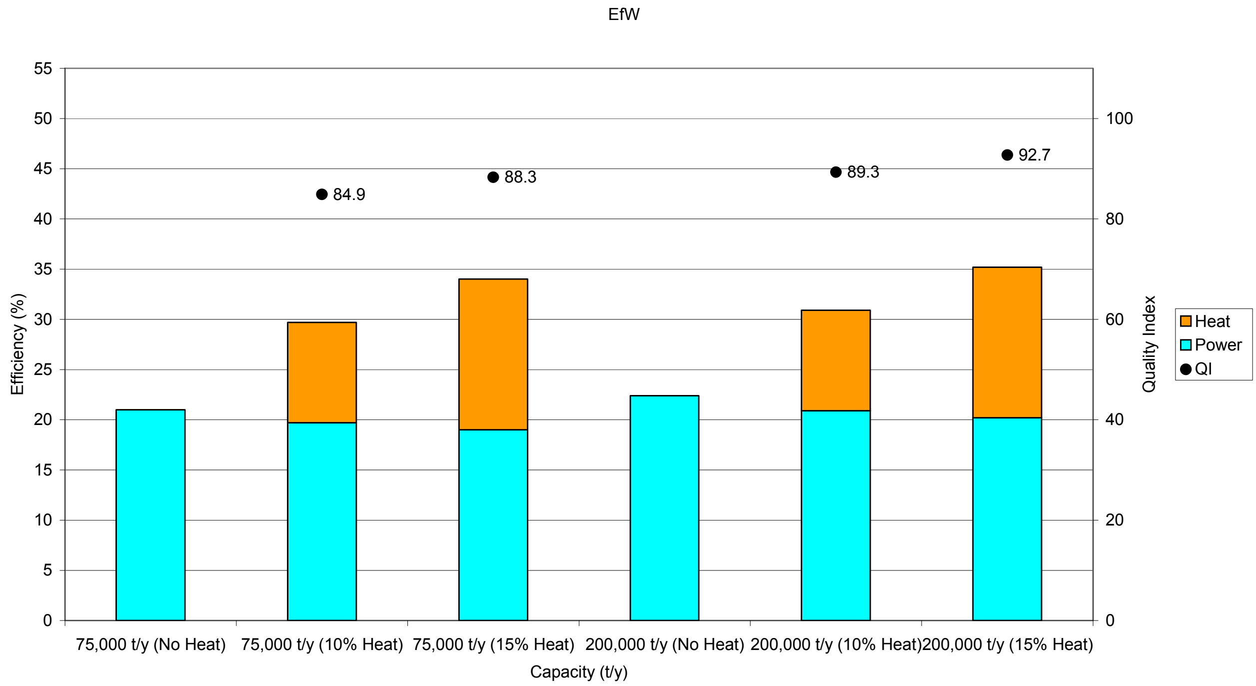
- 75,000 tpa
- 200,000 tpa

In each case the scheme is shown with:

- No heat recovery
- 10% heat recovery
- 15% heat recovery

		Power Efficiency	Heat Efficiency	Total Efficiency	QI
75,000 tpa	No heat recovery	21	0	21	
	10% heat recovery	19.7	10	29.7	84.9
	15% heat recovery	19	15	34	88.3
200,000 tpa	No heat recovery	22.4	0	22.4	
	10% heat recovery	20.9	10	30.9	89.3
	15% heat recovery	20.2	15	35.2	92.7

In each case the QI increases as heat load increases – to around QI 90. In each case the power efficiency falls as more heat is extracted from the steam turbine.



[4] More details are included in Appendix 2.

6.3.3 Waste Wood

The key assumptions for the Waste Wood examples are:

- A 50,000 tonnes/year threshold between small and large plants due to the higher NCV of the wood compared to waste.
- NCV of 13.7 MJ/kg.
- Moisture content 25% (no parasitic load identified).

The following table and chart shows the efficiency and QI data for two different Wood Waste fuelled EfW schemes[5]:

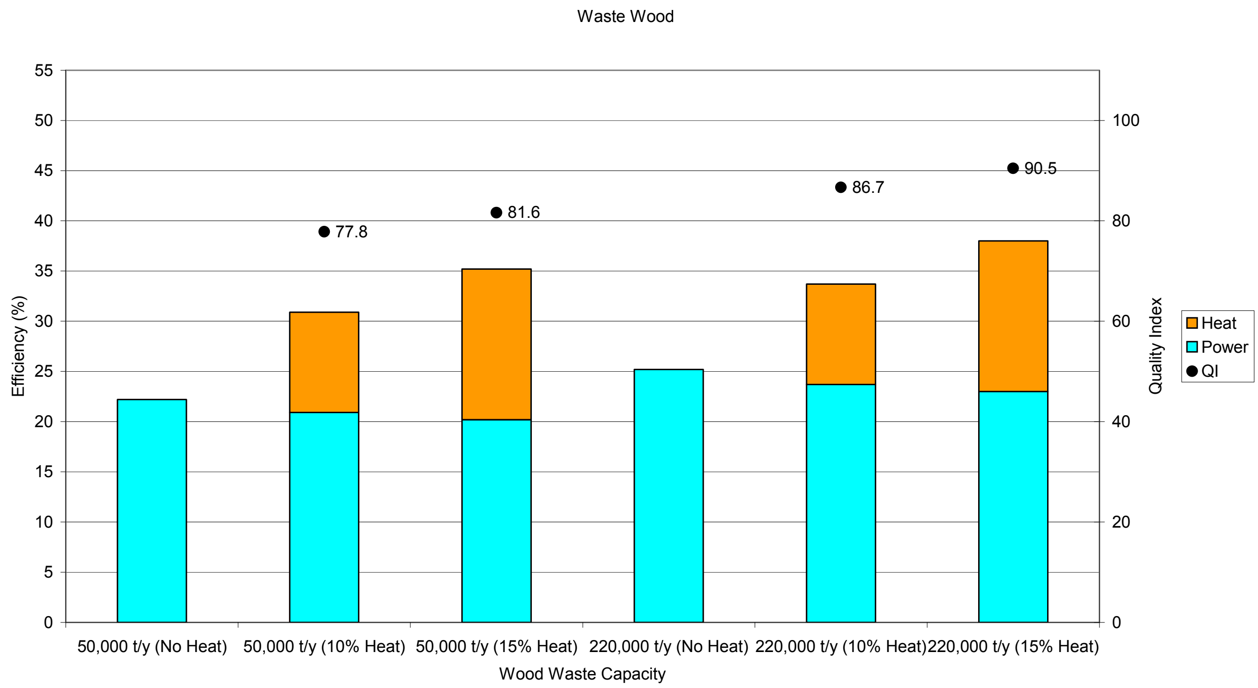
- 50,000 tpa
- 220,000 tpa

In each case the scheme is shown with:

- No heat recovery
- 10% heat recovery
- 15% heat recovery

In each case the QI increases as heat load increases – to around QI 77 to over 90. In each case the power efficiency falls as more heat is extracted from the turbine.

		Power Efficiency	Heat Efficiency	Total Efficiency	QI
50,000 tpa	No heat recovery	22.2	0	22.2	
	10% heat recovery	20.9	10	30.9	77.8
	15% heat recovery	20.2	15	35.2	81.6
220,000 tpa	No heat recovery	25.2	0	25.2	
	10% heat recovery	23.7	10	33.7	86.7
	15% heat recovery	23	15	38	90.5



[5] More details are included in Appendix 2.

6.3.4 Advanced Conversion Technologies (ACT)

Two types of technology are considered in the ACT category
- Anaerobic Digestion
- Gasification

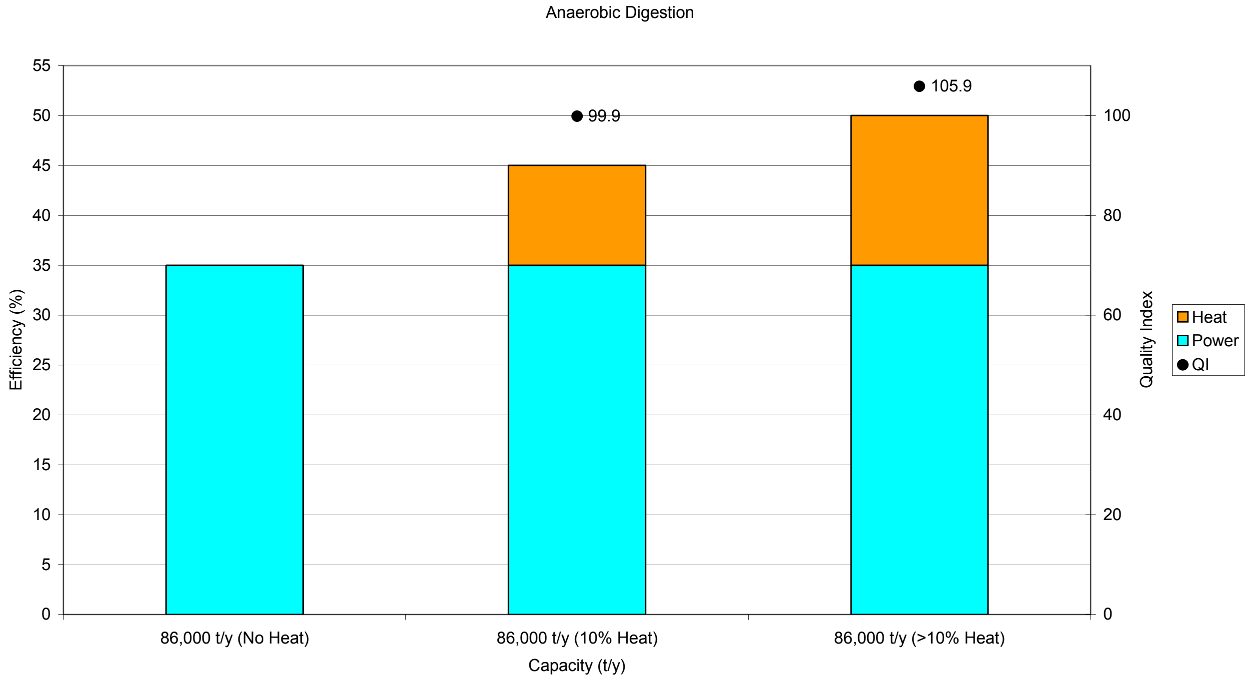
The key assumptions for the ACT examples are:

- AD – assumes operation for 7,800 hrs/year and a NCV of 3.68 MJ/kg (no moisture content details or parasitic loads identified).
- AD – boundary is set as the biogas input to the scheme and hence the heat used in the digester is qualifying heat use.
- Gasification – assumes NCV of 9.2 MJ/kg (no moisture content details or parasitic loads identified).
- Gasification – the boundary is set as the fuel input to the gasifier – due to the difficult and impractical aspects on measuring the syngas produced.
- In both cases a gas engine is used for power and heat production. Hence increasing heat recovery does not reduce power generation and the CHPQA rules in Guidance Note 44 require measurement of the fuel input of the scheme as the biomass or syngas input to the gas engine.

The following chart shows efficiency and QI data for an 86,000 tpa AD scheme with:
- No heat recovery
- 10% heat recovery
- 15% heat recovery

In reality heat is almost always recovered for use in the AD digester tank – hence the most relevant example is the 15% heat recovery one.

		Power Efficiency	**Heat Efficiency**	**Total Efficiency**	**QI**
86,000 tpa	No heat recovery	35	0	35	
	10% heat recovery	35	10	45	99.9
	15% heat recovery	35	15	50	105.9

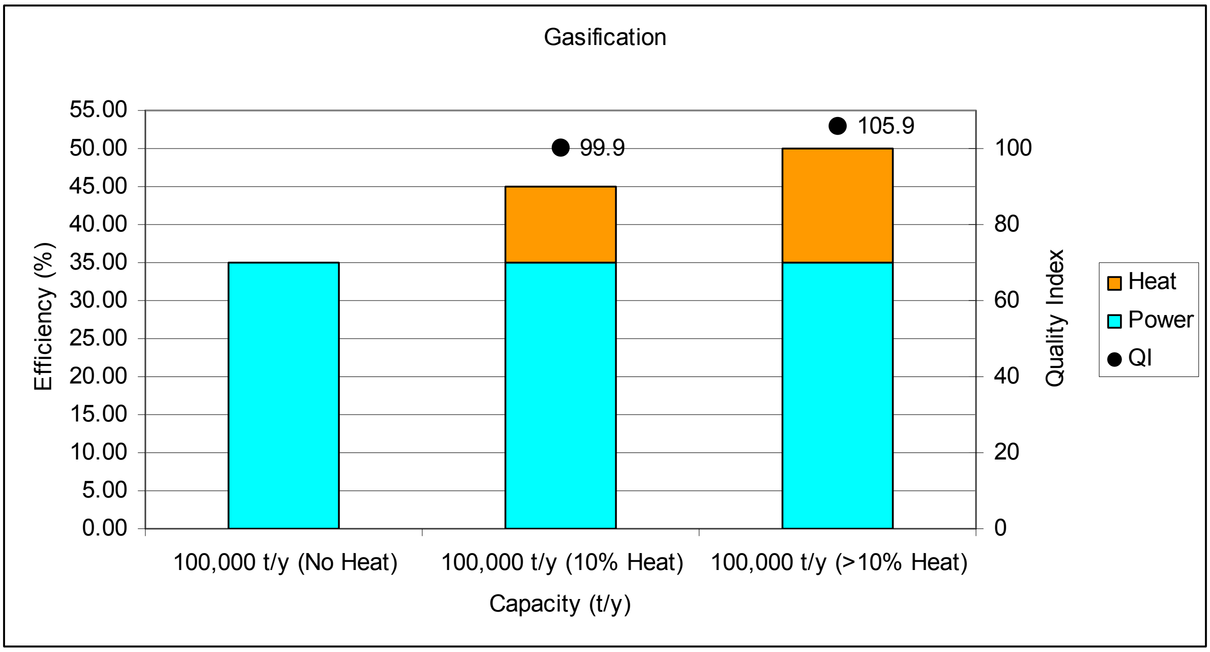

Anaerobic Digestion
Efficiency (%)
Quality Index
Capacity (t/y)
86,000 t/y (No Heat)
86,000 t/y (10% Heat)
86,000 t/y (>10% Heat)
99.9
105.9
Heat
Power
QI
0
5
10
15
20
25
30
35
40
45
50
55
0
20
40
60
80
100

The following chart shows efficiency and QI data for a 100,000 tpa gasifier scheme, with:

- No heat recovery
- 10% heat recovery
- 15% heat recovery

		Power Efficiency	Heat Efficiency	Total Efficiency	QI
100,000 tpa	No heat recovery	35	0	35	
	10% heat recovery	35	10	45	99.9
	15% heat recovery	35	15	50	105.9

The fuel is measured at the input to the gasifier due to the practical difficulties of measurements of the syngas.



6.3.5 Discussion

From the examples developed:

- All examples meet or exceed a power efficiency of 20% when no heat load is connected. Hence an Initial Threshold of 20% seems appropriate and is consistent with existing CHPQA practice.
- For an Ultimate Threshold a range of QI values are shown in the examples with 15% heat efficiency from 77 to 90 for Thermal Treatment to over 100 for AD and Gasification.
- This suggests that Ultimate Threshold QI values may need to vary by fuel type and size of scheme.

<u>Thermal Treatment</u>

- The fact that in most cases the QI value for the Thermal Treatment technologies is below 100 strengthens the case for choosing a value (or values) below 100.
- Choosing the lowest value from the 15% heat efficiency examples (QI below 80) would set a threshold that is too low – so this suggests individual thresholds for each technology.
- For Thermal Treatment schemes the power output of the steam turbine reduces as more heat is recovered. Hence increasing heat efficiency reduces power efficiency.
- To reach a QI of 100 is technically possible – steam turbines are available that can meet this.
- The difficultly is securing sufficient heat customers to use the large quantities of heat that would be available from a scheme with QI = 100. At present the planning and financial incentives are not in place to support this large scale change in the heating market.
- These market changes may take place – but the timing and the scale of change is not certain.

<u>Advanced Conversion Technologies</u>

- For the Advanced Conversion technologies both AD and gasification reach a QI of over 105 with 15% heat efficiency, and almost meet a QI of 100 at 10% heat efficiency. Unlike the steam turbine schemes used for MSW and Waste Wood there is no penalty on power generation if heat recovery is increased.
- Hence we propose an Ultimate Threshold of 100 for the ACT schemes. This means that for ACT schemes the permitting regime would be fully aligned with normal CHPQA practices.

<u>Mixed Fuel Schemes</u>

- Schemes that have a mix of fuel inputs will have a composite QI formula based on the ratio of the types of fuel input. Hence the thresholds for small schemes may be used in these cases as well as for small schemes using a single type of fuel.

Suggesting threshold values that have been developed from analysis of a small number of examples cannot capture all of the ideas for EfW schemes that may be proposed in the future. However the examples have been strongly informed by Fichtner's work with developers on a number of EfW schemes. While this is a good basis for this analysis, there is a need for developers and others to comment on the practical and commercial aspects of the proposed thresholds.

Hence we suggest the following Threshold values for discussion with SEPA:

	Thermal Treatment		**ACT**
	Small	Large	
Initial Operation – Power Efficiency	20%	20%	20%
Ultimate Threshold – QI (Heat Efficiency > 10%)	85	93	100

(For MSW Large is > 70,000 tpa, For Waste Wood Large > 50,000 tpa)

The stages and thresholds are shown in terms of the timeline in the diagram below:

Stage	Initial Operation	Implementation of Heat Plan	Ultimate Threshold
Duration	1 to 2 years	5 to 7 years	Ongoing
Thresholds	Power Efficiency > 20%	As per individual Heat Plan, and increasing QI	QI >= Ultimate Threshold Heat Efficiency > 10%

Appendices

Appendix 1: CHPQA QI Definitions

Appendix 2: Example Outline Diagrams: MSW schemes

Appendix 1

CHPQA QI Definitions

Extract from the DEFRA CHPQA Standard. Issue 2, November 2007

Table 2: QI Definitions for Various Sizes and Types of New* CHP Scheme *(continued)*

Size Of Scheme (CHP_{TPC})	QI Definition
ALTERNATIVE FUEL SCHEMES[3]	
By-Product Gases	
≤1MWe	$QI = 294 \times \eta_{power} + 120 \times \eta_{heat}$
>1 to ≤25MWe	$QI = 221 \times \eta_{power} + 120 \times \eta_{heat}$
>25MWe	$QI = 193 \times \eta_{power} + 120 \times \eta_{heat}$
Biogas	
<=1MWe	$QI = 285 \times \eta_{power} + 120 \times \eta_{heat}$
>1 to ≤25MWe	$QI = 251 \times \eta_{power} + 120 \times \eta_{heat}$
>25MWe	$QI = 193 \times \eta_{power} + 120 \times \eta_{heat}$
Waste Gas or Heat	
≤1MWe	$QI = 329 \times \eta_{power} + 120 \times \eta_{heat}$
>1 to ≤25MWe	$QI = 299 \times \eta_{power} + 120 \times \eta_{heat}$
>25MWe	$QI = 193 \times \eta_{power} + 120 \times \eta_{heat}$
Liquid Biofuels	
≤1MWe	$QI = 275 \times \eta_{power} + 120 \times \eta_{heat}$
>1 to ≤25MWe	$QI = 191 \times \eta_{power} + 120 \times \eta_{heat}$
>25MWe	$QI = 176 \times \eta_{power} + 120 \times \eta_{heat}$
Liquid Waste	
≤1MWe	$QI = 275 \times \eta_{power} + 120 \times \eta_{heat}$
>1 to ≤25MWe	$QI = 260 \times \eta_{power} + 120 \times \eta_{heat}$
>25MWe	$QI = 176 \times \eta_{power} + 120 \times \eta_{heat}$
Biomass or Solid Waste	
≤1MWe	$QI = 370 \times \eta_{power} + 120 \times \eta_{heat}$
>1 to ≤25MWe	$QI = 370 \times \eta_{power} + 120 \times \eta_{heat}$
>25MWe	$QI = 220 \times \eta_{power} + 120 \times \eta_{heat}$
Wood Fuels	
≤1MWe	$QI = 329 \times \eta_{power} + 120 \times \eta_{heat}$
>1 to ≤25MWe	$QI = 279 \times \eta_{power} + 120 \times \eta_{heat}$
>25MWe	$QI = 220 \times \eta_{power} + 120 \times \eta_{heat}$

Extract from CHPQA Guidance Note 44. Version 2, 2008

Table 1: QI Definitions For Various Types Of CHP Biomass Schemes >25MWe

Solid waste	QI =	364 x	η_{power}	+	120	x η_{heat}
Agricultural Biomass	QI =	338 x	η_{power}	+	120	x η_{heat}
Wood Fuels	QI =	315 x	η_{power}	+	120	x η_{heat}

Table 2: QI Definitions For Various Types Of CHP Biomass Schemes Equal To Or Less Than 25MWe

Biomass or Solid waste						
≤25MWe	QI =	370 x	η_{power}	+	120	x η_{heat}
Wood Fuels						
≤1MWe	QI =	329 x	η_{power}	+	120	x η_{heat}
>1 to ≤25MWe	QI =	315 x	η_{power}	+	120	x η_{heat}

Table 3: QI Definition For Advanced Conversion Technology Producing Syngas To Be Used In Reciprocating Engines Or Gas Turbines.

Syngas						
≤1MWe	QI =	285 x	η_{power}	+	120	x η_{heat}
>1 MWe	QI =	251 x	η_{power}	+	120	x η_{heat}

Appendix 2.

Scheme Outline Diagrams

Examples of 3 diagrams:

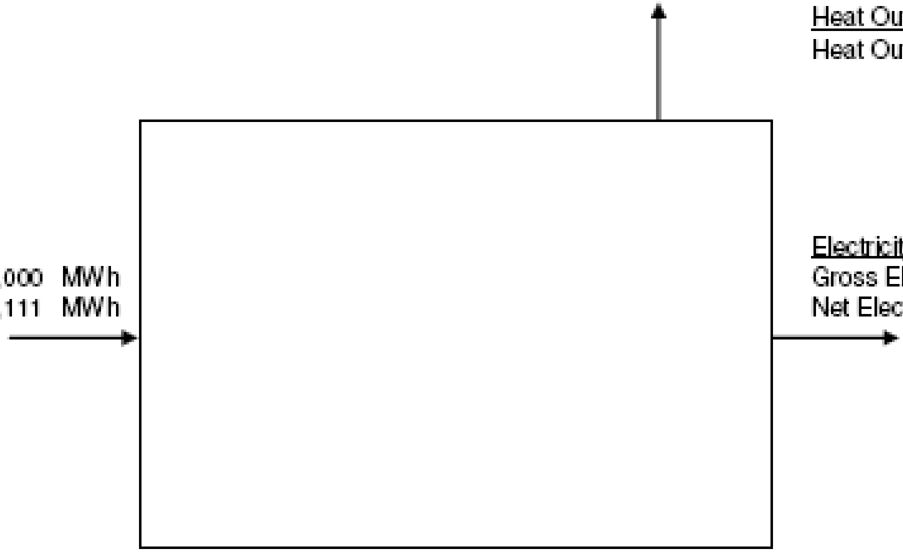
MSW 200,000 tpa – no heat recovery
MSW 200,000 tpa – 10% heat recovery
MSW 200,000 tpa – 15% heat recovery

Example: 200,000 t/y EfW plant operating in non-CHP mode for 7,884 hours annually with waste of average NCV 9.2 MJ/kg and moisture content of 35%

<u>Heat Out</u>

Heat Output = - MWh

≅ - Houses



<u>Fuel In</u>

Gross Energy Input = 600,000 MWh

Net Energy Input = 511,111 MWh

<u>Electricity Out</u>

Gross Electrical Generation = 134,232 MWh

Net Electrical Generation = 118,796 MWh

<u>CHP Quality Index Assessment</u>

η electrical = Gross Electrical Generation / Gross Energy Input

= 22.4%

η heat = Heat Output / Gross Energy Input

0%

X = 370

Y = 120

Quality Index = 83

Example: 200,000 t/y EfW plant operating in CHP mode (10% heat) for 7,884 hours annually with waste of average NCV 9.2 MJ/kg and 35% moisture

<u>Heat Out</u>

Heat Output	=	60,000	MWh
	≡	2,864	Houses

<u>Fuel In</u>

Gross Energy Input	=	600,000	MWh
Net Energy Input	=	511,111	MWh

<u>Electricity Out</u>

Gross Electrical Generation	=	125,683	MWh
Net Electrical Generation	=	111,229	MWh

<u>CHP Quality Index Assessment</u>

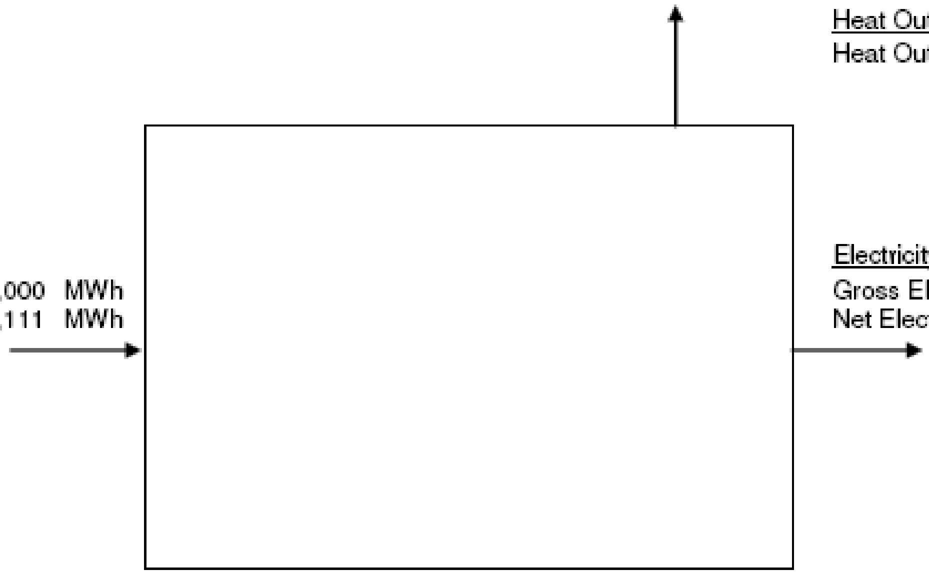
η electrical	=	Gross Electrical Generation	/	Gross Energy Input
	=	20.9%		
η heat	=	Heat Output	/	Gross Energy Input
		10.0%		
X	=	370		
Y	=	120		

Quality Index = 90

Example: 200,000 t/y EfW plant operating in CHP mode (15% heat output) for 7,884 hours annually with an average waste NCV = 9.2 MJ/kg and 35% moisture

Heat Out

Heat Output	=	90,000	MWh
	≡	4,296	Houses



Fuel In

Gross Energy Input	=	600,000	MWh
Net Energy Input	=	511,111	MWh

Electricity Out

Gross Electrical Generation	=	121,323	MWh
Net Electrical Generation	=	107,371	MWh

CHP Quality Index Assessment

η electrical = Gross Electrical Generation / Gross Energy Input

= 20.2%

η heat = Heat Output / Gross Energy Input

15.0%

X = 370

Y = 120

Quality Index = 93

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