CHP QA

A Quality Assurance Programme for Combined Heat and Power

A Consultation Paper

Prepared for, and issued by, the Department of the Environment, Transport and the Regions, in consultation with The Scottish Executive, The National Assembly for Wales, and the Northern Ireland Department of Enterprise, Trade and Investment.

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A Quality Assurance programme for Combined Heat and Power

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1 CHP achieves efficiencies of 60-80% or more, and makes significant fuel savings, and thus cost and emissions savings, over conventional forms of electricity generation and heat-only boilers. The UK has around 4,000 MW_e of CHP installed at the present time, which is estimated to save around 3.5 MtC (million tonnes of carbon) and around £650 million per year. The Government's Climate Change Consultation Paper estimated that CHP could save up to a further 6 MtC per year by 2010, as well as saving around a further £1 billion per year. It provides one of the most cost-effective approaches for reducing CO_2 emissions and will play a crucial role in the UK Climate Change programme.

2 CHP capacity is anticipated to reach 5,000 MW_e within the next two years, and the UK Government is working towards a target of at least 10,000 MW_e by 2010. The Government will consult early in the new year on a strategy for CHP for the next decade, setting out regulatory, fiscal and other measures to encourage the uptake of CHP. The first of these measures - exemption from the Climate Change Levy for 'Good Quality' CHP and a consultation on Enhanced Capital Allowances for a range of energy efficient technologies - were announced by the Chancellor of the Exchequer in his November 1999 Pre-Budget Report.

3 This consultation paper from the Department of the Environment, Transport and the Regions (DETR) was prepared in consultation with other Government Departments and with the Devolved Administrations. It was foreshadowed in the technical papers on the Climate Change Levy and the exemption for 'Good Quality' CHP published by Customs and Excise alongside the Pre-Budget Report.

4 Comments are specifically invited on:

- The proposals for the ***CHP*QA** programme.
- The proposed methodology for calculation of the Quality Index of a CHP scheme (paragraphs 2.1-2.31).
- The proposed methodology for calculation of CHP Equivalent Generation Limit CHP_{EGL} and CHP Equivalent Capability (CHP_{EC}) (paragraphs 3.1-3.17).
- The use of ***CHP*QA** and its QI methodology for determining entitlement of a CHP scheme to Climate Change Levy Exemption.

5 The ***CHP*QA** programme will be entirely voluntary and will be available to schemes in Great Britain and Northern Ireland. However, given the developing roles of the Devolved Administrations and their Agencies across the UK, the benefits available to schemes may be different across the UK.

6 ***CHP*QA** is being developed and implemented under the Government's UK-wide Energy Efficiency Best Practice Programme (EEBPP).

7 The ***CHP*QA** programme has two main aims:

- First, to provide a practical, determinate, and reliable method for Quality Assessment and monitoring of the various types and sizes of CHP scheme. This is based on the energy efficiency and environmental performance of CHP plant compared to good alternative energy supply options. This Quality Assessment will determine the eligibility of schemes for Climate Change Levy exemption and Enhanced Capital Allowances. ***CHP*QA** is designed to be relevant to the operation of any further regulatory or fiscal measures affecting CHP, where the level of quality is relevant to entitlement.

- Second, to improve the quality of CHP schemes, in order to enhance the 'environmental and other benefits' of CHP.

8 Each scheme will be required to:

- Apply for Registration.
- Install appropriate metering systems and maintain appropriate records.
- Conduct a Quality Assessment, self-assessed, and reported to the programme.
- Provide access to operational data on a confidential basis to support the Assessment.
- Comply with Verification and Audit obligations.

9 The Quality Assessment will be based on a Quality Index (QI). Where electricity and thermal energy are supplied from independent sources, the power is 'harder won' than the heat: electrical power is currently generated at 30-50% efficiency (GCV) before transmission and distribution losses, whereas steam or hot water is produced in boilers of typically 65-80% efficiency (GCV). Thus when valuing the separate outputs of electricity and heat from a CHP scheme through the Quality Index, a higher weighting is given to the electrical output than to the heat. A suite of definitions is being developed to cover the whole range of scheme applications, sizes, technologies, and fuels. Definitions for the most common types of plant are included in Table 2.

10 ***CHP*QA** requirements will vary with the size of the scheme. More frequent reporting will be required for larger plant. Simpler arrangements are proposed for packaged CHP schemes rated up to 1 MW_e.

11 The outputs from the programme will include:

- Quality Assessment and Certification of participating CHP schemes. It is envisaged that, for an estimated 90% of existing schemes, Certification as 'Good Quality' would give full access to benefits for the whole capacity and output. For the remaining schemes, Certification for an element of the capacity (CHP Equivalent Capability) and output (CHP Equivalent Generation Limit) will allow benefits in proportion to the 'environmental and other' benefits delivered by the scheme.
- Reporting of aggregated data, for example, in order to measure progress towards UK CHP targets; for production of statistics (e.g. the DTI's annual Digest of UK Energy Statistics) or to support further policy analysis.
- An Audit capability where necessary for Government, e.g. for Customs and Excise as part of the operation of the Climate Change Levy exemption for CHP.

12 Following completion of this consultation, the timetable for implementation of the programme is tight. In order to apply for the benefit of exemption from Climate Change Levy at the earliest opportunity, CHP schemes will need to have completed and reported an Assessment, and to have been verified and given appropriate Certification, before April 2001.

13 This is without doubt the most exciting time for developers and users of CHP since privatisation of the electricity industry. A clear method for assessing CHP according to its quality can only assist in developing policy to encourage further uptake.

A Quality Assurance programme for Combined Heat and Power

Part A
This Consultation

1 Purpose and Aims

The Need for a Quality Assurance Programme

> *"The Quality Assurance programme will help equip CHP to take full advantage of the new arrangements, such as exemption from the Levy . . . With this to underpin a new target and strategy, we will have a framework in which CHP can prosper for the next decade and beyond."*
>
> Michael Meacher MP, Minister for the Environment
> CHPA conference 25 November 1999

1.1 CHP is the simultaneous generation of heat and power (usually electricity) in a single process. Most large conventional power stations currently generate electricity at 30-50% efficiency (GCV) [1], before transmission and distribution losses, and therefore throw away most of the heat generated in the process. CHP generates electricity and puts waste heat to good use, for instance in industry or in community heating. CHP schemes are typically much smaller than conventional power stations, and sized to meet customers heat demands. Schemes vary from tens of kW to hundreds of MW electrical capacity, and can be found in building such as hospitals and universities, or on industrial sites, for example in the paper and chemicals sectors. CHP typically achieves efficiencies of 60-80% or more (GCV), and makes significant fuel savings, and thus cost and emissions savings, over conventional forms of electricity generation and heat-only boilers.

1.2 The UK has around 4,000 MW_e of CHP installed at the present time, which is estimated to save around 3.5 MtC (million tonnes of carbon) and around £650 million per year.

1.3 The Government's *Climate Change Consultation Paper* estimated that CHP could save up to a further 6 MtC per year by 2010, as well as saving around a further £1 billion per year. It provides one of the most cost-effective approaches for reducing CO_2 emissions and will play a crucial role in the UK Climate Change programme. CHP capacity is anticipated to reach 5,000 MW_e within the next two years, and the UK Government is working towards a target of at least 10,000 MW_e by 2010.

1.4 The Government will consult early in the new year on a strategy for CHP for the next decade, setting out the regulatory, fiscal and other measures to encourage the uptake of CHP. These measures include exemption for 'Good Quality' CHP under the Climate Change Levy (CCL), and a proposal for Enhanced Capital Allowances (ECA) for a range of energy efficient technologies, both announced by the Chancellor in his Pre-Budget Report [2].

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1 All figures in this paper are in Gross Calorific Value (GCV), since the performance of a scheme will be assessed using measured fuel use, electricity generated and heat supplied over a full year. UK Energy statistics are reported in GCV terms. The Power Generation industry invariably quotes net calorific value (NCV) efficiency data, which inflates the headline efficiency figure by some 5-15% higher depending on fuel.

2 *Stability and Steady Growth for Britain* Pre Budget Report, November 1999. Cm 4479. Available from HMSO or from **http://www.hm-treasury.gov.uk/prebudget/Nov99/report/cm4479.htm**. See paragraphs 6.32-6.50.

1.5 This consultation paper from the Department of the Environment, Transport and the Regions (DETR) was prepared in consultation with other Government Departments and with the Devolved Administrations. It was foreshadowed in the technical papers on the Climate Change Levy and the exemption for 'Good Quality' CHP published by Customs and Excise alongside the Pre-Budget Report [3].

1.6 The ***CHP*QA** programme will be available to schemes in the whole of the UK including Northern Ireland. However, given the developing roles of the Devolved Administrations and their Agencies across the UK, the benefits available to CHP schemes may be different across the UK.

1.7 The ***CHP*QA** programme has two main aims:

- First, to provide a practical, determinate, and reliable method for Quality Assessment and monitoring of the various types and sizes of CHP scheme. This is based on the energy efficiency and environmental performance of CHP plant compared to good alternative energy supply options. This Quality Assessment will determine the eligibility of schemes for CCL exemption and for ECA. ***CHP*QA** is designed to be relevant to the operation of any further regulatory or fiscal measures affecting CHP, where the level of quality is relevant to entitlement.
- Second, to improve the quality of CHP schemes, in order to enhance the 'environmental and other benefits' achieved by CHP over equivalent, alternative electricity-only and heat-only generation.

The Purpose of this Consultation

1.8 This paper sets out and invites comment on proposals for a ***CHP*QA** programme for existing and future CHP schemes. The aim of this process is to consult on the technical detail of how the programme will be implemented. Particular issues are listed in paragraphs 1.35-1.41 below. This is not a consultation paper on either exemption from the Climate Change Levy or the proposed Enhanced Capital Allowances. The first was discussed widely before the announcement, and the implementation of the second is the subject of a separate consultation from DETR and Treasury [4]. However, since the programme will be used in the implementation of these measures, a short summary of each is included (paras1.18-1.33).

A Summary of this Consultation

> *"Clearly we will need practical definitions and workable procedures for assessment in order to implement Climate Change Levy exemptions. We intend that schemes will be assessed under a Quality Assurance programme with specific arrangements to cover all types of CHP."*
> Michael Meacher MP, Minister for the Environment
> CHPA conference 25 November 1999

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3 See Technical Briefing number 2, part of the papers following the Chancellor's pre-Budget Report on the Customs and Excise Website. **http://www.hmce.gov.gov.uk/bus/excise/ccl-tec2.htm**.

4 The consultation paper is available at **http://www.detr.gov.uk/consult.htm**. Views should be expressed to the Energy Efficiency Consultation Team, Department of the Environment Transport and the Regions, 6/F5 Ashdown House, 123 Victoria Street, London SW1P 3DE by Friday 4th of February

1.9 CHP plant seeking the benefits of CCL exemption, ECA (and potentially other future regulatory or fiscal mechanisms benefitting CHP) will be required to comply with the ***CHP*QA** programme, including Registration and Auditing requirements. Schemes may, of course, choose not to apply for regulatory and fiscal benefits available to qualifying CHP schemes, in which case they would have no need to take part in this programme.

1.10 The Quality Assessment will be based on the Quality Index (QI). A suite of definitions is being developed to cover the whole range of scheme applications, sizes, technologies, and fuels. Definitions for the most common types of plant are included in paragraph 2.11 and Table 2 below.

1.11 Most of the CHP schemes currently operating in the UK would achieve a Quality Index (QI) of at least 110, and many more would exceed the threshold of 100 in operation and be deemed 'Good Quality' CHP for their entire capacity and output. All new schemes would normally be designed to achieve a Quality Index of at least 110 (QI>110). This would deliver very significant environmental and other benefits over the best available energy supply alternatives. However, even at a QI of 100 there are significant environmental and other benefits over good modern alternatives.

1.12 Some schemes which generate power and also supply heat may not achieve a QI of 100 in operation. Such plant, in general, also has 'environmental and other benefits' compared to conventional electricity-only and heat-only energy supply. Where schemes deliver these benefits, the Government believes that it would be appropriate for them to receive recognition in proportion to the benefits delivered, and proposals are included under the ***CHP*QA** programme. This approach has two advantages:

- Schemes that fall below a QI of 100 in operation, owing to temporary operational difficulties, or changes in market conditions which affect heat loads, will not suffer complete loss of benefit. (If the loss of benefit for such schemes were dramatic rather than gradual, the economic consequences for the site of short-term operational difficulties could otherwise be disproportionate.)

- It offers an appropriate level of reward for a scheme with some heat recovery yet with a QI below 100 and provides an incentive to further improve heat recovery.

Are there particular cases or circumstances in which a CHP scheme that generates both heat and electricity does not bring benefits over conventional generation? If so, what would be the appropriate treatment of these schemes?

1.13 ***CHP*QA** is being implemented under the Government's UK-wide Energy Efficiency Best Practice Programme as the latest in a series of initiatives to encourage the uptake of, and best practice in, Combined Heat and Power. The programme will carry out a range of functions on behalf of Government. Participation in the programme is entirely voluntary.

1.14 Each scheme will be required to:

- Apply for Registration.

- Install appropriate metering systems and maintain appropriate records.

- Conduct a Quality Assessment, self-assessed, and reported to the programme.

- Provide access to operational data on a confidential basis to support the Assessment.

- Comply with Verification and Audit obligations.

1.15 The outputs from the programme will include:

- Quality Assessment and Certification of participating CHP schemes. It is envisaged that, for an estimated 90% of existing schemes, Certification as 'Good Quality' will give full access to benefits for the whole capacity and output. For the remaining schemes, Certification for an element of the capacity ('CHP Equivalent Capability' set out in paragraphs 3.15-3.17 below) and output ('CHP Equivalent Generation Limit', set out in paragraphs 3.7-3.14) will allow benefits in proportion to the 'environmental and other' benefits delivered by the scheme.

- Reporting of aggregated data, for example, in order to measure progress towards UK CHP targets; for production of statistics (e.g. the DTI's annual Digest of UK Energy Statistics) or to support further policy analysis.

- An Audit capability where necessary for Government, e.g. for Customs and Excise as part of the operation of the Climate Change Levy exemption for CHP.

1.16 Under the Best Practice Programme, publications to support self-assessment will be developed including the associated regulations, definitions, guidance, worked examples, and standard *pro-forma* for Registration and Assessment. The Best Practice Programme already offers support for users and potential users of CHP towards improving the performance of schemes, for example through Best Practice publications; site-specific advice; business-to-business support, internet forum, Champions networks, and other ways of sharing experience of installing and operating the technology.

1.17 The objective is therefore to offer much more than simply a registration service, but a programme which continues to support the uptake of, and best practice in, Combined Heat and Power.

Specific Uses for the Programme

1.18 The programme will be used in the first instance for Certifying Climate Change Levy exemption, evaluating eligibility for Enhanced Capital Allowances, and to support assessment of Negotiated Agreements.

Climate Change Levy

1.19 The Chancellor announced further details on the design of the climate change levy in the Pre-Budget Report, following an extensive consultation exercise. Details included:

- A levy rate of 0.15 p/kWh for coal and gas and 0.43 p/kWh for electricity.

- An exemption from the levy for electricity generated from renewable sources of energy and 'Good Quality' Combined Heat and Power schemes.

- An 80 per cent discount for energy intensive sectors that sign Negotiated Agreements on energy efficiency.

- A trebling of support for energy efficiency measures under the levy package to around £150m in 2001-02, to allow for the introduction of a system of Enhanced Capital Allowances for energy saving investments.

1.20 All CHP schemes assessed under the programme will be exempt from levy payments on the fuel input, and on the heat supplied.

1.21 Electricity supplied from CHP schemes which achieve ‘Good Quality’ status for their entire capacity and output (a QI of at least 100 in operation) will be exempt from the levy, where that electricity is consumed onsite or sold direct to other customers. Electricity sold via a licensed supplier will attract CCL at the appropriate rate. The appropriate rate will depend, *inter alia*, on whether the purchaser is party to a negotiated agreement and therefore qualifies for a reduced rate.

1.22 For schemes with a QI < 100, and which achieve ‘Good Quality’ status for an element of their capacity and output, electricity up to the Equivalent Generation Limit (CHP_{EGL}) will be exempt from the levy, where such electricity is consumed onsite or sold direct to other customers. Electricity supply above the level of CHP_{EGL}, whether used on-site or off-site, will be subject to CCL at the appropriate rate. There will be some cases therefore, where the CHP scheme will be responsible for collection of Climate Change Levy on the electricity so supplied.

1.23 At the same time, therefore, it is worth noting two related and important issues for such schemes:

- The DTI have published a Consultation paper, *Electricity (Class exemptions from the requirement for a license) Order 1997: Proposed Amendments for proposed changes to Supply and Generation license regimes* [5].
- Further proposals will be brought forward early in 2000 to clarify the definition and treatment under the Climate Change Levy, of auto-generation which is neither based on CHP nor renewable generation.

1.24 It is proposed that each CHP scheme will be Registered and issued with appropriate Certification via the ***CHP*QA** programme. The Certificate will enable levy exemption by the fuel supplier for the scheme, and hence will provide the site details necessary to facilitate this, such as meter serial numbers.

1.25 Whilst the programme will be voluntary, the resulting Certificates will enable schemes to gain significant financial benefits through the tax system. In line with other tax exemptions, applicants who are found to have abused the exemption will be subject to the normal penalty arrangements enforced by HM Customs and Excise.

1.26 The exemption from the Climate Change Levy for CHP is estimated to be worth around £60 million per year for the current installed capacity. This takes into account the fuel used in CHP in 1998; allows for scaling-back of CHP_{EGL}; and assumes that around half of CHP capacity operates on sites that succeed in gaining an 80% exemption from CCL because of negotiated agreements. Clearly this saving will make new CHP capacity more cost-effective, and the value of the exemption, as CHP expands, is likely to go up, rather than down, in future years.

Enhanced Capital Allowances

1.27 In his November Pre-Budget Report (PBR), the Chancellor announced that, in light of the responses received to the consultation exercise on the Climate Change Levy, he was minded to treble the support for energy efficiency measures and renewables under the Climate Change Levy package. Thus the £50m announced in the March Budget for 2001-02 would rise to £150m.

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5 Electricity (Class exemptions from the requirement for a license) Order 1997 Proposed Amendments, Consultation Paper issued 25th November, available at **http://www.dti.gov.uk/energy/propamend.htm**. Responses should have been with DTI (Dr Graham Bryce, Deputy Director, Energy Utilities Directorate, DTI) by 31st December 1999.

1.28 This would allow for the introduction of a system of 100 per cent first year Enhanced Capital Allowances (ECAs) scheme for firms making energy saving investments. This would be introduced alongside the £50m "energy efficiency" fund announced in the March Budget. Both measures could come on stream in 2001-02 alongside the Climate Change Levy. Depending on take-up, the scheme might cost up to £100 million in the first year of its operation. The £100 million will be available for 100% first-year ECAs, allowing some or all of the investment to be set against income or corporation tax, in the first year, for a range of energy efficient technologies. This effectively reduces the cost of borrowing capital.

1.29 The PBR also announced the Government's intention to consult business on exactly which energy efficient products and technologies might qualify for the enhanced capital allowances. This is now the subject of the separate Government consultation paper [6], but may include for example, 'Good Quality' CHP, and high efficiency boilers, motors and lighting.

1.30 For CHP a range of criteria may be used to determine the level of benefits, if any, that a particular scheme should receive. It is proposed that, amongst other criteria, eligible CHP should have a QI > 110. A higher threshold is required to recognise two issues. Firstly, in operation the performance of some schemes may not reach the original design specification. Secondly new plants will be in operation for 10-15 years or more, hence the threshold should be set at a higher level to guarantee long term environmental benefits.

Negotiated Agreements

1.31 A range of industrial sectors are developing proposals for Negotiated Agreements with DETR. Following the Chancellor's announcements, industry sectors can negotiate an 80% reduction in Climate Change Levy in return for a commitment to reduce energy use or carbon emissions to a given target level.

1.32 In many sectors CHP represents the largest and most cost-effective opportunity to make savings which may contribute to Negotiated Agreements.

1.33 Sites which are part of a Negotiated Agreement might have a CHP scheme which exports electricity and or heat to other sites. Where there is no opportunity for CHP, sites may choose to buy heat and or power from a nearby CHP scheme. In such cases, the fuel use, emissions and thus savings will need to be allocated between sites. An Assessment under the ***CHP*QA** programme will act as Certification for the sector in its negotiations and validation process.

Timetable for Implementation

1.34 Following the close of this consultation, the timetable for implementation of the programme is tight (Table 1). In order to apply for the benefit of exemption from Climate Change Levy at the earliest opportunity, CHP schemes will need to have completed and reported an Assessment, and to have been verified and issued appropriate Certification, before April 2001. The scheme will have to be implemented in just over 12 months.

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6 This consultation paper is available at **http://www.detr.gov.uk/consult.htm**. Views should be expressed to the Energy Efficiency Consultation Team, Department of the Environment Transport and the Regions, 6/F5 Ashdown House, 123 Victoria Street, London SW1P 3DE by Friday 4th February.

Table 1 Indicative timetable for implementation of the *CHP*QA programme

Date	Government actions	CHP Users actions
Jan 2000	Consultation paper on *CHP*QA published.	
Jan-Feb 2000	Responses to consultation received and studied.	Respond to *CHP*QA Consultation Paper.
Mar-June 2000	Levy introduced in Finance Act and associated Statutory Instruments. QI definitions finalised. *CHP*QA programme launched. Applications for Registration begin.	Ensure appropriate metering and data management systems are in place. Register CHP scheme and complete Quality Assessment.
July-Dec 2000	Verification, Registration, and Audits begin.	
Jan-Mar 2001	Registration completed and Certification issued.	Confirm Certification to Fuel Supplier.
April 2001	Climate Change Levy introduced from April 2001.	Pay Climate Change Levy on non-CHP fuel use and non- exempt electricity from April 2001.
Ongoing	Manage the programme.	Maintain monitoring systems in readiness for Audit. Maintain Registration and Certification.

Key Issues for Consultation

1.35 A number of proposals are made in this paper, and comment is invited on a range of issues. Responses are welcome both on the issues of principle and on points of detail. For ease of analysis, respondents should include a reference to the relevant paragraph numbers in their response.

1.36 With regard to the Quality Index, issues on which responses would be particularly welcome include:

- Is the principle of valuing power more than heat appropriate (paragraphs 2.1-2.8)?
- Are the definitions proposed for different sizes, technologies and fuels appropriate (paragraphs 2.9-2.12 and Table 2)?
- In order to encourage a certain class of scheme to be upgraded, is it appropriate to include a separate definition of QI for a particular class of scheme for a fixed period? For example, a QI definition is proposed for existing steam turbine plant for the first three years (paragraph 2.13 and Table 2).
- Is it appropriate to allow a commissioning period for new plant, during which a more relaxed QI may be deemed sufficient for a plant to be eligible for full benefits? If so, for how long, and at what level (paragraph 2.13)?

- Non-conventional schemes pose particular difficulties. They include alternative and renewable fuels, high temperature applications, horticulture and community heating, though this list may not be exhaustive. Most such plant will deliver significant 'environmental and other benefits' over equivalent electricity-only and heat-only generation. Is it appropriate for different definitions of QI in each of these areas, and if so, what should they be? Other types of scheme may be considered as special cases. Examples of these with full scheme details, along with a justification for special treatment would be welcome (paragraphs 2.14-2.18).
- Are the proposals for deciding what is included and excluded from the definition of a scheme appropriate (paragraphs 2.19-2.31)?
- Should schemes which include a combination of plant which gives a very high heat to power ratio be capped, with only a portion of the scheme counted as CHP, and benefits available for only a portion of the fuel input (paragraphs 2.25 and 2.26)?
- There are important general issues with regard to metering arrangements. Comments from industry would be welcome on appropriate tolerance conditions (paragraph 2.30).

1.37 For a similar electrical efficiency, a scheme that recovers some heat is more efficient than a scheme that does not. Is it appropriate therefore, that schemes that do not achieve a particular threshold level still achieve some reward for recovering and supplying useful heat, and some incentive to improve heat recovery? Are the proposals for scaling back the scheme to an Equivalent Generation Limit (CHP_{EGL}) and Equivalent Capability (CHP_{EC}) both appropriate and workable? (paragraphs 3.1-3.17).

1.38 An effective Audit regime is essential where benefits are awarded to CHP. How might Registration, Reporting, Verification and Auditing obligations best be implemented (paragraphs 5.1-5.11)?

1.39 Are there sufficient safeguards for commercial confidentiality of data (paragraph 5.9)?

1.40 Are there sufficient penalties for abuse of the benefits (paragraph 5.10)?

1.41 Is it appropriate, for example, that reporting obligations should vary with size? Is it appropriate to consider Product Type-Approval for package schemes, and how might such products be tested for approval (paragraphs 6.1-6.10)?

1.42 This is without doubt, the most exciting time for developers and users of CHP since privatisation of the electricity industry. A clear method of assessing CHP according to its quality can only assist in developing policy to encourage further uptake.

> *"CHP already brings considerable energy cost savings to business, but levy exemption means even bigger savings. And, of course, this also means greater reductions in emissions of carbon dioxide through CHP.* ***Put plainly, there has never been a better time for business to consider CHP****."*
> Michael Meacher MP, Minister for the Environment
> CHPA conference 25 November 1999

Responding to this Consultation

1.43 Responses, both on issues of principle and points of detail, are invited from interested parties including for example, developers, consultants, energy suppliers, finance companies, users, trade associations, professional bodies etc. Responses should be sent to:

Tiwalola Fadina
CHPQA Consultation Paper
DETR
Ashdown House
123 Victoria Street
London SW1E 6DE

Telephone enquiries	0171 890 6681
Fax	0171 890 6679
Email	Tiwalola_Fadina@detr.gsi.gov.uk

(NB whilst responses can be faxed or emailed, please confirm these with a postal copy to ensure that they are taken into account).

The deadline for responses is Tuesday 29th February 2000.

For technical clarification of the proposals, please contact the Environment and Energy Helpline directly:

Telephone	**0800 585794**
Email	**etbppenvhelp@aeat.co.uk**
Website	**www.energy-efficiency.gov.uk**

1.44 Respondents should explain who they are, and who they represent. This will ensure that the views of both CHP users and developers are taken into account, and that responses from representative bodies are properly weighted.

1.45 A response to the consultation will be published before final decisions are taken on implementation of the ***CHP*QA** programme. It is normal practice to publish or make available the responses to consultation documents, unless a respondent has specifically requested confidentiality.

1.46 Given the nature of this consultation, quantitative examples of schemes would be extremely useful in finalising the programme. ***Because of the extreme commercial sensitivity of such information, absolute confidentiality of individual responses is, and will be, respected***.

CHP QA

A Quality Assurance programme for Combined Heat and Power

Part B
The Proposed Programme

BEST PRACTICE PROGRAMME

ENERGY EFFICIENCY

About the Energy Efficiency Best Practice Programme

The Energy Efficiency Best Practice Programme (EEBPP) covers industry, transport and buildings, and operates across Great Britain and Northern Ireland. The Programme is managed by ETSU and BRECSU on behalf of Government, and offers a range of general information and more tailored advice, from publications, seminars, a helpline, and site specific advice.

Publications include:

- Energy Consumption Guides: which compare energy use in specific process, operations, plant and building types.
- Good Practice Guides and Good Practice Case Studies: promote proven energy efficient technologies.
- New Practice Case Studies: monitor first commercial applications of new energy efficient measures.
- Future Practice Reports: publications on joint R&D ventures into new energy efficient technologies.
- General Information Reports: describe concepts and approaches yet to be fully established as good practice.

The Environment and Energy Helpline provides a single contact point for all energy and environment advice.

Telephone: 0800 585794
Email: etbppenvhelp@aeat.co.uk
Website: www.energy-efficiency.gov.uk

The proposed ***CHP*QA** programme will be implemented under the EEBPP.

2 Defining 'Good Quality' CHP: The Quality Index

2.1 CHP is defined as the 'simultaneous generation of heat and power (usually electricity) in a single process'. Power outputs include mechanical power. Heat outputs can include steam or hot water for process heating, space heating or absorption chilling, or hot air, e.g. for direct drying.

2.2 The 1998 White Paper, *Conclusions of the Review of Energy Sources in Power Generation*, noted that "gas-fired CHP often attains efficiencies well in excess of 70%" (on an NCV basis, equivalent to around 64% GCV where natural gas is the fuel). However, simple efficiency (heat plus power) being greater than a certain threshold is not the best indicator of a scheme's environmental performance compared with alternative electricity-only and heat-only supply.

2.3 The White Paper concluded that for 'Good Quality' CHP, amongst other criteria, efficiency, averaged over a year, should be significantly higher than that achievable with the same fuel source in a power-only unit (paragraph 10.50).

2.4 Where electricity and thermal energy are supplied from independent sources, the power is 'harder won' than the heat - electrical power is currently generated at 30-50% efficiency (GCV) before transmission and distribution losses, whereas hot water or steam is raised in boilers of typically 65-80% efficiency (GCV). Thus when valuing the separate outputs of electricity and heat from a CHP scheme, a higher weighting needs to be given to the electrical output than to the heat.

2.5 Regardless of the electrical efficiency of a project, a scheme that recovers heat will generally be more efficient than one that does not. Thus for example, a modern high electrical efficiency Combined Cycle Gas Turbine (CCGT) which recovers otherwise waste heat for supply (say for use on an industrial site) will be more efficient than a similar project that does not. Similarly, an embedded gas turbine which recovers heat for community heating will be more efficient than one that does not.

2.6 The Quality Index (QI) methodology reflects and develops these concepts. It is built on the rationale that electricity supplied is more valuable than heat supplied. It compares CHP to separate electricity-only and heat-only alternatives. The QI therefore offers scope for a major improvement over conventional approaches based simply on overall efficiency.

2.7 The proposed methodology is designed both to reward existing and future 'Good Quality' CHP schemes and to provide an incentive for scheme performance to be improved. The rewards and challenges need to be offered to all sizes and types of CHP technology, hence a suite of QI definitions have been developed and tested, based around a simple general form.

2.8 The general form of the QI calculation is

$$QI = X \text{ x Efficiency}_{power} + Y \text{ x Efficiency}_{heat}$$

Where:

$\text{Efficiency}_{power}$ = annual power supply (MWh_e)/annual fuel use (MWh)

Efficiency_{heat} = annual heat supply (MWh_{th})/annual fuel use (MWh)

X is a coefficient for power, related to alternative electricity supply options. Similarly *Y* is a coefficient for heat generation, related to alternative heat generation options. These coefficients vary to reflect conditions affecting particular classes of CHP plant. For a scheme which supplies electricity only, Efficiency_{heat} is zero. For a scheme which supplies heat only, $\text{Efficiency}_{power}$ is zero.

Efficiencies are expressed in terms of Gross Calorific Value (GCV), since the proposed regime will use metered values for fuel use, electricity generation and heat supplied.

Annual heat supply is the useful heat supplied by the scheme which displaces heat which would otherwise have to be supplied by boilers or by direct heating.

Treatment of Different Plant

2.9 The generalised QI expression provides for flexibility in the selection of the coefficient for power '*X*' and the heat coefficient '*Y*'. This ensures the validity of the QI methodology across a broad spectrum of CHP plant and applications. The methodology reflects the technical factors affecting the selection of CHP plant in different applications and circumstances. These factors include:

- Alternative power supply options to CHP, taking account of the generating technology that would be employed.
- The improvement in generating efficiency that can be achieved with increasing scale.
- Reduced transmission and distribution (T&D) losses for smaller embedded generating plant, as compared to larger, grid connected generating plant.
- Different alternative heat supply options. In industrial applications CHP will typically displace boilers across a range of sizes, fuels, and thermal efficiencies. In community heating, communal boilers, electric heating, and small individual boilers are displaced by heat from CHP.

2.10 In addition to the technical factors above it is essential to ensure that under all circumstances the following objectives are met:

- CHP provides significant 'environmental and other benefits' compared to the best available energy supply alternatives.
- The QI provides a challenging target for all CHP schemes.

It is especially important that the coefficient *X* is, and remains, challenging.

Proposed Quality Index Definitions

2.11 In order to be designated 'Good Quality' CHP, schemes should achieve a QI of 110 in design, and at least 100 in operation using the proposed definitions shown in Table 2. Schemes with a QI less than 100 may be eligible for a proportion of benefits (see paragraphs 3.1-3.17). These criteria will be operated using a series of definitions outlined below (paragraphs 2.19-2.31) so that it is clear what is, and is not, defined as part of the scheme and eligible for benefits.

Table 2 **Proposed QI Definitions (*X* and *Y*)**

The general form	QI =	X	$Efficiency_{power}$	+	Y	$Efficiency_{heat}$
Reciprocating engines						
All sizes	QI =	200	$Efficiency_{power}$	+	130	$Efficiency_{heat}$
All other technologies						
> 500 MW_e	QI =	160	$Efficiency_{power}$	+	125	$Efficiency_{heat}$
> 200 to ≤ 500 MW_e	QI =	170	$Efficiency_{power}$	+	125	$Efficiency_{heat}$
> 100 - ≤ 200 MW_e	QI =	180	$Efficiency_{power}$	+	125	$Efficiency_{heat}$
> 50 - ≤ 100 MW_e	QI =	185	$Efficiency_{power}$	+	125	$Efficiency_{heat}$
> 25 - ≤ 50 MW_e	QI =	190	$Efficiency_{power}$	+	125	$Efficiency_{heat}$
> 10 - ≤ 25 MW_e	QI =	205	$Efficiency_{power}$	+	125	$Efficiency_{heat}$
> 1 - ≤ 10 MW_e	QI =	220	$Efficiency_{power}$	+	125	$Efficiency_{heat}$
≤ 1 MW_e	QI =	230	$Efficiency_{power}$	+	130	$Efficiency_{heat}$
Transitional arrangements for existing (pre 1998) steam turbines						
≤ 100 MW_e	QI =	240	$Efficiency_{power}$	+	130	$Efficiency_{heat}$
Alternative fuels						
Biogas/Waste Gas	QI =	300	$Efficiency_{power}$	+	140	$Efficiency_{heat}$
Biomass/Solid Waste	QI =	400	$Efficiency_{power}$	+	140	$Efficiency_{heat}$

2.12 Final definitions of QI will be published following consultation, and will include definitions for a range of special cases outlined below. The definitions of QI will be revised from time to time to take into account, for instance, improvements in existing technologies (e.g. turbine technology) and the introduction of entirely new technologies (e.g. fuel cells, or triple cycle generation). A drive towards continuous improvement will be maintained.

2.13 There are a range of issues which may need to be addressed in applying these definitions. *Views would be welcome on the following*:

- In order to encourage a certain class of scheme to be upgraded, is it appropriate to include a separate definition of QI for a particular class of scheme for a fixed period? For example, a QI definition is proposed for existing steam turbine plant for the first three years (Table 2).
- Is it appropriate to allow a commissioning period for new plant (for, say one year), during which a lower QI may be deemed sufficient for a plant to receive full benefits. In order to prevent abuse, the projected QI will need to be estimated, then the actual performance monitored through the commissioning period. If estimated levels are not met at the end of the period, it is proposed that a proportion of the benefits must be repaid. *How long, and at what level, should such a Commissioning period operate*?

Special Cases

2.14 The vast majority of CHP schemes will utilise conventional energy technologies, such as gas turbines, steam turbines and reciprocating engines, and burn conventional fossil fuels. However, a proportion of plant uses alternative fuels or technologies, or demonstrates an unusual mode of operation. In such cases the coefficients used to define the QI may vary from those used to assess conventional CHP plant. Appropriate coefficients for power (*X*) and heat (*Y*) will be developed for a range of special cases. The following paragraphs illustrate a few applications which have special features which may merit different treatment.

2.15 Non-conventional fuels include industrial wastes, process gases (e.g. refinery gases, blast furnace gases), Volatile Organic Compounds (VOCs), refuse-derived fuel (RDF), and bio-fuels (bio-mass such as sewage or animal matter or other waste, either in solid form or processed to produce gas). Non-conventional fuels may be used with conventional fuels to co-fire CHP schemes. In such cases, a weighted average of QI definitions for gas and Non-conventional fuels could be used. For process gases the scheme could be treated as if it were two separate schemes. An alternative approach would be to analyse the scheme on a CO_2-equivalent basis. *Proposals from industry would be welcome*.

2.16 Non-conventional applications include high temperature industries. Normally heat from electricity generation is higher grade than that required in most industrial or community heating and the heat from electricity generation can be put to good use. However, in high temperature industries, very high-grade heat (above 1200°C) is needed (whereas electrical generation technologies exhaust heat up to around 600°C). In some cases, hot exhausts from CHP systems (gas turbines or engines) can be used in pre-heating process combustion air or raw materials, but often, the exhaust heat from power generation is not sufficiently high grade to be useful. In some cases the heat (as well as the chemical by-products) from high temperature applications can be used as an *input* into electricity generation. It is proposed that the scheme be treated as two different schemes, one, based on the waste heat and waste product input, and one based on the fossil fuel input, with outputs allocated in appropriate proportions to the equivalent thermal input. Views from industry are welcome.

2.17 In other applications, useful outputs are not just heat and power. Some schemes produce mechanical power to drive compressors or pumps. Others use heat in absorption chilling and replace compression refrigeration. In many such cases, conventionally-supplied electricity is displaced as the energy source. Other schemes may include elements that need to be valued separately. For example, CHP in horticulture (greenhouses), utilises CO_2 exhaust emissions to promote crop growth. There may be a range of factors to be taken into account which may require an equation of the form:

$$QI = X \times \text{Efficiency}_{power} + Y \times \text{Efficiency}_{heat} + N \times \text{Efficiency}_{Other}$$

2.18 Community heating schemes will need particular attention. Schemes that supply heat to domestic dwellings displace a mix of existing electric heating (both peak and off-peak storage heaters), existing community heating boilers, and central heating boilers. In the case of electric heating, to supply 100 units of heat requires (at an average efficiency delivered into the house of 38%) around 260 units of heat in. Thus the value of heat supplied to domestic dwellings may be significantly higher than in industrial applications. As well as the energy and environmental aspects of community heating, the additional benefits of providing affordable warmth merits the use of a QI definition tailored to the special characteristics of these schemes.

Definitions for CHP Quality Assessment

2.19 A scheme consists of one or more prime movers (e.g. gas turbine, steam turbine or reciprocating engine), and some means of recovering what would otherwise be waste heat exhausted to the atmosphere (such as a waste heat recovery boiler, connection to a heat or steam system, or direct use of the exhaust heat, for example, in direct drying or in pre-heating).

2.20 A scheme can consist of a number of prime movers connected in series (for example, a gas turbine in combined cycle mode, where the heat is used to produce steam which feeds into a steam turbine) or in parallel (for example, a number of reciprocating engines connected to a common steam main; or a number of steam turbines and gas turbines with suitable heat recovery steam generators connected to a common steam system (possibly supplying steam at several pressures). If these units are connected by a common heat or steam connection, they should be treated as one scheme. Quality Assessment and Auditing arrangements would normally be determined on the basis of the cumulative rated capacity.

2.21 The choice of definition to determine QI for any given scheme is based on the rated electrical capacity under conditions related to maximum electrical generation. (For a scheme which includes a pass-out steam turbine, electrical output declines as steam extraction increases. Thus for a scheme which, in electricity-only mode is rated at 220 MW_e, and which generates an annual average of 185 MW_e given the range of heat recovery levels over the year, the rated capacity in electricity-only mode should be used to determine the relevant definition for QI.)

2.22 For the purpose of Assessment, heat supply to site and to off-site customers must be metered as part of the scheme, including steam supplied and condensate returned.

2.23 Heat supplied on-site or to off-site customers must be used in genuine applications, (i.e. where heat-only boilers would otherwise have provided a service) and not merely providing an alternative to dumping in a condenser, or supplied elsewhere and used solely for power generation.

2.24 Some schemes incorporate supplementary firing, where excess oxygen in the exhaust gas of a prime mover is combusted with additional fuel. Fossil fuels used in supplementary firing will normally be considered to be part of the qualifying scheme only if no excess air for combustion is introduced during firing.

2.25 Schemes may include small gas turbines used to fire large boilers with additional firing facilities. In such cases the heat supplied from the gas turbine cannot be measured, and will be capped as a proportion of the total fuel input to the turbine. The heat supplied from an additional burner which introduces oxygen as part of this firing, and does not generate electricity, will not be considered to be part of the CHP scheme.

2.26 Schemes may include large boilers feeding small steam turbines. For the purpose of calculating benefits, the ratio of heat supplied to electricity generated will be capped. A cap of 3.3:1 is proposed. Thus, using the definitions in Table 2, for an existing steam turbine to achieve a QI of more than 100 would require a minimum electrical efficiency of 15% and heat supply efficiency of at least 49% (GCV). Thus, if the electricity generated is less than 15% of the fuel input, the fuel input deemed to be part of the CHP is scaled-back to this level. The remainder of the fuel input will not be considered to be part of the CHP scheme, and will not, for example, be exempt from Climate Change Levy. Some schemes however, will be burning bio-fuels, industrial or domestic wastes and will be subject to appropriate analysis.

2.27 Fuel used in auxiliary or back-up boilers to supply heat directly into the site distribution system, will not be considered part of the CHP scheme and will not attract any benefits.

2.28 Schemes may include large electrical generation capacity with a small amount of heat recovery. Additional calculations must be made for determining benefits in these cases (paragraphs 3.1-3.17).

2.29 A site will need to meter, and keep records of the following [7]:

- Fuel use in the CHP scheme separately from other fuel uses. For most schemes this will be gas. Larger schemes may use oil as a back-up fuel, and possibly other fuels. All fuel inputs need to metered and accounted for separately.
- Any fuels used in supplementary firing need to be metered separately.
- Electricity generated, supplied on site, and exported.
- Electricity purchased.
- Heat supplied and any condensate returned in the heat network (in other words the net heat supplied by the CHP).
- Heat-only boilers or auxiliary firing.
- Direct heat or electricity supplies. Direct heat or electricity customers supplied by the scheme will need to be a part of the Assessment regime, and have the same arrangements for metering electricity and heat supplied. Direct customers so supplied will thus benefit from, for example, Certification for the purposes of Negotiated Agreements.

2.30 There are important general issues with regard to metering arrangements. Definitions of capacity are name plate rated capacity and not Declared Net Capacity, and should be metered as such. Meter positions and serial numbers will need to be recorded, and meters will need to be calibrated. Gas and steam meters have inherent inaccuracies given the effects of temperature and pressure on volume. For some fuels calorific value is difficult to determine or variable (especially waste gases and refuse derived fuels where both chemical composition and moisture content can vary). All these factors introduce the need for compliance with a tolerance limit (e.g. to be able to say that fuel use for a given scheme is 100 ± 0.1 units) for any given calculation, which will affect assessment against the QI definitions. *Comments would be welcome on appropriate tolerance conditions*.

2.31 Many other issues will need to be clarified in order to make the system operational. The objective will be to develop a fair, determinate and reliable system of assessing CHP schemes based on the energy efficiency and environmental performance of CHP plant compared to good alternative energy supply options. *Developers and users alike are invited to submit particular issues of concern in response to this consultation paper*.

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7 All units will need to be converted to MWh.

3 Schemes with a Quality Index of less than 100

3.1 Most of the CHP schemes currently operating in the UK would achieve a Quality Index of 110, and many more would achieve a QI above 100 and be deemed 'Good Quality' CHP for their entire capacity and output. However, some schemes which generate power and also recover heat may not achieve a QI of 100 in operation. Such plant, in general, has environmental and other benefits compared to electricity-only and heat only-energy supply. Where schemes deliver these benefits, the Government believes that it would be appropriate for them to receive recognition in proportion to the benefits delivered.

The Range of Schemes with QI < 100

3.2 There are several groups of schemes which may in operation achieve a QI <100, these include:

- A scheme whose main purpose is electricity generation, but which offers limited steam sales. There are only a handful of such schemes in the UK. Most of these are CCGT based CHP, plus a couple of older steam turbine CHP schemes.
- Schemes where a newer system is being brought on-line and run alongside an existing older scheme for some years, before the older scheme is retired. Both schemes may operate below full steam supply design conditions over the year. There are only a handful of such schemes in the UK.
- The scheme may once have been good CHP, but heat use has declined on site. Such sites are typically steam turbine schemes on well-established industrial sites (e.g. in the chemicals or paper sectors) where a portion of the site has closed. Often these schemes are complex and utilise waste or by-product fuels, and appropriate treatment will be required for such fuels in calculation of QI (see paragraph 2.15). There are around 70 steam turbine CHP schemes in the UK. Of these:
    - Around 12 utilise waste or by-product fuels
    - Around 10 are under development as CCGT CHP, and
    - Around 5 are expected to close in the near future as a consequence of industrial restructuring.

3.3 Taking all the types of CHP scheme discussed above it is estimated that there are perhaps 40 of these larger schemes which may have a Quality Index below 100.

3.4 Most smaller, conventional CHP based on reciprocating engine, gas turbine and smaller combined cycle gas turbine based schemes will achieve a QI of around 110. There may be some smaller schemes, where sizing has focused more on electrical generating capacity (for example to provide a secure electrical supply to a site) rather than just overall efficiency. As a result these schemes may not achieve a QI of 100 in operation. Insufficient details are available on how many such schemes may exist - a best estimate based on current data is that there may be another 100 such schemes.

3.5 Thus an estimated 140 out of 1,400 existing CHP schemes (or around 10%) may have a QI<100.

3.6 In all likelihood the number of schemes with QI <100 could be expected to decline, partly as a result of the natural replacement cycle, and due to the incentive to qualify for 'Good Quality' status on their entire output and capacity.

CHP Equivalent Generation Limit

3.7 Government, through the Energy Efficiency Best Practice Programme, has for many years promoted the idea that in order to maximise efficiency, schemes should be sized to supply onsite or nearby heat loads. The proposed method for calculating the appropriate level of benefit for schemes with QI<100 follows this approach.

3.8 The CHP Equivalent Generation Limit is the annual electrical generation (MWhe) from a scheme that *would have achieved* a QI of 110 given the actual annual heat supply. This can best be illustrated using an example (see Figure 1). A 10 MW_e reciprocating gas engine scheme running 5,000 hours a year would generate 50 GWh of electricity a year. If it supplied 5 MW of steam to a heat user for 5,000 hours it would supply 25 GWh of heat over a year. If Best Practice advice were followed to size a CHP scheme to meet this heat demand, the resulting scheme would be much smaller than 10 MW_e.

3.9 The proposed CHP Equivalent Generation Limit (CHP_{EGL}) would depend on the heat to power ratio of the prime mover. For the reciprocating gas engine example above, with a typical heat to power ratio of 1:1, then for 25 GWh of usable heat, a CHP_{EGL} of 25/1 = 25 GWh p.a. could be justified as shown in Figure 1.

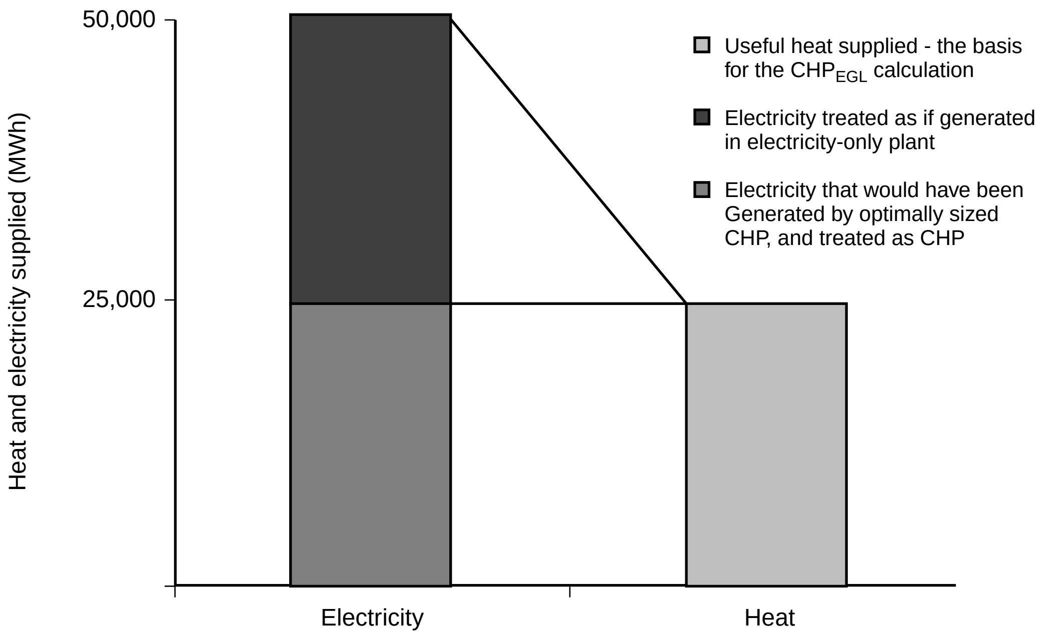

Figure 1 **The CHP Equivalent Generation Limit**

3.10 While this basic principle is simple in theory, two problems arise in practice:

- Electrical efficiency (and heat to power ratio) varies from installation to installation, and
- For schemes which include a pass-out steam turbine, the heat to power ratio varies with the level of steam extracted from the steam turbine, and thus varies over time.

3.11 In order to operate this concept in practice, a more detailed and robust method is needed. For schemes with a QI <100 it is proposed that a scheme is treated as two separate elements.

- First, the CHP_{EGL} is the equivalent annual electrical generation that *would have achieved* a QI of 110 given the actual annual heat supplied, and which is eligible for benefits.
- Second, the remainder is treated as an equivalent electricity-only element and will attract no benefit.

3.12 The treatment of these two separate elements will depend on the purpose and scope of each policy instrument.

- For some benefits the Equivalent Generation Limit (CHP_{EGL}) will enable schemes with a QI < 100 to be eligible for some benefit in proportion to the 'environmental and other benefits' provided (for example, Climate Change Levy Exemption, paragraphs 1.19-1.26)
- For other benefits schemes may only be eligible if they have a QI equal to or over 110 (for example Enhanced Capital Allowances, see paragraphs 1.27-1.30).

3.13 It is proposed that CHP_{EGL} can be determined as follows:

The first stages are as for calculating QI:

- Select the QI definition for the type and size of the plant in question.
- Determine the fuel use, electricity generated and heat used from the scheme over a year.
- Calculate the QI.

For schemes with QI<100, the next step is to calculate the increase in heat recovery that would have enabled the scheme to achieve a QI of 110. For schemes where the prime mover is a reciprocating engine or gas turbine the electrical output is fixed regardless of the amount of heat recovered. For schemes with a back pressure steam turbine the heat to power ratio is fixed. So for these prime movers the calculation of CHP_{EGL} is as follows:

Step 1 - Is to calculate the new heat efficiency needed to reach a Quality Index of 110. For these prime movers the electrical efficiency is fixed regardless of heat recovery, hence the calculation uses the basic definition for the Quality Index:

$$110 = Y \text{ x New Efficiency}_{heat} + X \text{ x Efficiency}_{power}$$

This equation can be rearranged to give:

$$\text{New Efficiency}_{heat} = \frac{(110 - X \text{ x Efficiency}_{power})}{Y}$$

Step 2 - Calculate the equivalent heat to power ratio for the scheme *as if it had achieved* this new level of heat utilisation and hence a Quality Index of 110. This is:

$$\text{Equivalent heat to power ratio} = \frac{\text{New Efficiency}_{heat}}{\text{Efficiency}_{power}}$$

Step 3 - Calculate CHP_{EGL} as follows:

$$CHP_{EGL}\ (MWhe) = \frac{\text{Heat supplied } (MWh_{th})}{\text{Equivalent heat to power ratio}}$$

3.14 For schemes which include a pass-out steam turbine, electrical efficiency will decline as steam extraction increases, so there is a balance between increasing heat recovery and reducing electrical output. This also makes calculations more complex because there are two variables, rather than one, but the basic method is the same.

Step 1 - Calculate the new heat efficiency needed to reach a Quality Index of 110. For a scheme with a pass-out steam turbine the electrical efficiency will fall as the heat used efficiency rises. This ratio of trading between heat and electricity (known as the Z ratio) is explained in more detail in Annex I. The Z ratio can vary from one circumstance to another, but a typical Z ratio is 4.1:1, in other words, for every 4.1 units of steam extracted from the turbine, one unit of electricity will be foregone. Annex I also provides details of the Z ratio for a range of steam turbines. Assuming a fixed Z ratio allows the trade between heat and electricity to be calculated.

$$\text{Change in Efficiency}_{heat} = \frac{\text{Change in QI}}{\left(Y - \frac{X}{\text{Z ratio}}\right)}$$

To calculate the new heat utilisation efficiency add the Change in Efficiency $_{heat}$ needed to achieve a QI of 110 to the measured Efficiency $_{heat}$ to give the total New Efficiency $_{heat}$:

$$\text{New Efficiency}_{heat} = \text{Change in Efficiency}_{heat} + \text{Efficiency}_{heat}$$

As the heat efficiency has increased the corresponding reduction in electrical efficiency is:

$$\text{Change in Efficiency}_{power} = \frac{\text{Change in Efficiency}_{heat}}{\text{Z ratio}}$$

Note that the change in electrical efficiency is negative as this will have fallen, hence to calculate the overall new electrical efficiency:

$$\text{New Efficiency}_{power} = \text{Efficiency}_{power} - \text{Change in Efficiency}_{power}$$

Step 2 - As before, calculate the equivalent heat to power ratio for the scheme as if it had achieved this level of heat efficiency and hence a Quality Index of 110. This is:

$$\text{Equivalent heat to power ratio} = \frac{\text{New Efficiency}_{heat}}{\text{New Efficiency}_{power}}$$

Step 3 - As before, calculate CHP_{EGL} as follows:

$$CHP_{EGL}\ (MWhe) = \frac{\text{Heat supplied } (MWh_{th})}{\text{Equivalent heat to power ratio}}$$

Registered CHP Capacity and CHP Equivalent Capability

3.15 Capacity as well as output is important, for example, for measuring progress against the Governments CHP targets, and design of policy to increase uptake. For schemes with a QI in excess of 100, the Registered CHP Capacity (RCC) will be equal to the rated capacity under normal heat supply conditions.

3.16 For Schemes with a QI less than 100, capacity as well as output needs to be scaled-back. This is the CHP Equivalent Capability (CHP_{EC}). In calculating Equivalent Capability however, the heat supplied is the maximum continuous heat supplied under Normal Operating Conditions. This is effectively the way that CHP capacity is currently counted for progress towards the Governments CHP targets, and for the DTI Digest of UK Energy Statistics.

3.17 The first step is to determine the equivalent heat to power ratio at a QI of 110, as above. Then:

$$CHP_{EC}\ (MW) = \frac{\text{Maximum continuous heat supplied } (MW_{th}) \text{ NOC}}{\text{Equivalent heat to power ratio}}$$

4 Illustrative Quality Index Calculations

4.1 This section contains illustrative examples to cover all cases:

- Typical CHP schemes which achieve a QI of at least 100 in operation, and would therefore attract full benefits. Examples include a 250 MW_e CCGT CHP scheme at an oil refinery, a 49 MW_e gas turbine in a factory, a 5 MW_e gas turbine in a factory, and a 200 kW_e reciprocating engine in a hotel or leisure centre (Table 3).
- Illustrative CHP_{EGL} and CHP_{EC} calculations for schemes where electrical efficiency does not change with increasing heat recovery (Table 4).
- Illustrative CHP_{EGL} and CHP_{EC} calculations for schemes where electrical efficiency does change with increasing heat recovery, which adds increasing complexity (Table 5).

Table 3 Illustrative QI Calculations

Example 1	**A 250 MW_e CCGT at an oil refinery (full year operation)**
1.	The proposed QI calculation for schemes between 200 and 500 MW_e is QI = 170 x P + 125 x H
2.	Over the year the metered fuel use is 4,938,500 MWh, electricity generated 2,125,000 MWh and heat supplied 1,479,000 MWh.
3.	Thus electrical efficiency over the year is (2,125,000/4,938,500) = 43% and heat supplied efficiency is (1479,000/4,938,500) = 30% . Overall efficiency is 73%
4.	**The Quality Index** is = 170 x 43% + 125 x 30%, which **is 110.6**.
Example 2	**A 49 MWe gas turbine at a factory for around 7,000 hours a year**
1.	The proposed QI calculation for schemes between 25 and 50 MW_e is QI = 190 x P + 125 x H
2.	Over the year, the metered fuel use is 952,000 MWh, electricity generated 343,000 MWh and heat supplied 308,000 MWh.
3.	Thus electrical efficiency over the year is (343,000/952,000) = 36% and heat supplied efficiency is (308,000/952,000) = 32% . Overall efficiency is 68%
4.	**The Quality Index** is = 190 x 36% + 125 x 32%, which **is 108.4**.

Table 3 **Illustrative QI Calculations (cont'd)**

Example 3	**A 5 MW_e gas turbine in a food factory for 6000 hours a year**
1.	The proposed QI calculation for schemes between 1 and 10 MW_e is QI = 220 x P + 125 x H
2.	Over the year, the metered fuel use is 120,000 MWh, electricity generated 30,000 MWh and heat supplied 54,000 MWh.
3.	Thus electrical efficiency over the year is (30,000/120,000) = 25% and heat supplied efficiency is (54,000/120,000) = 45%. Overall efficiency is 70%.
4.	**The Quality Index** is = 220 x 25% + 125 x 45%, which **is 111.3**.
Example 4	**A 200 kW_e reciprocating engine in a hotel for 5000 hours a year**
1.	The proposed QI calculation for reciprocating engines is QI = 200 x P + 130 x H
2.	Over the year, the metered fuel use is 3333 MWh, electricity generated 1000 MWh and heat supplied 1333 MWh.
3.	Thus electrical efficiency over the year is (1000/3,333) = 30% and heat supplied efficiency is (1333/3333) = 40% . Overall efficiency is 70%.
4.	**The Quality Index** is = 200 x 30% + 130 x 40%, which **is 112.0**.

Schemes with QI Less Than 100

4.2 Tables 4 and 5 illustrate schemes with lower levels of heat recovery, and which thus achieve a QI<100, for which only a portion of the capacity and output could be described as 'Good Quality'. Examples include a 49 MW_e Gas Turbine, and a 160 MW_e CCGT CHP scheme.

Table 4 **Illustrative CHP_{EGL} and CHP_{EC} Calculations (simple)**

Example 5	**A 49 MW_e gas turbine at a factory for around 7,000 hours a year**
CHP Equivalent Generation Limit (CHP_{EGL})	
1.	The proposed Quality Index calculation for schemes between 25 and 50 MW_e is QI = 190 x P + 125 x H
2.	Over the year, the metered fuel use is 952,000 MWh, electricity generated 343,000 MWh and heat utilisation is 100,000 MWh.
3.	Thus electrical efficiency over the year is (343,000/952,000) = 36%, and heat utilisation efficiency is (100,000/952,000) = 10.5% . Overall efficiency is 46.5%.
4.	**The Quality Index** is = 190 x 36% + 125 x 10.5%, which **is 81.5**.

5. Since this scheme has a QI <100, further calculations are necessary.

6. For gas turbines, electrical generation efficiency is fixed regardless of heat load.

   So following **Step 1** from the method shown:

$$\text{New Efficiency}_{heat} = \frac{(110 - X \times \text{Efficiency}_{power})}{Y}$$

   This is (110 -190 x 36%) /125 = 33.3%

   Step 2 is to calculate the equivalent heat to power ratio at QI = 110

$$\text{Equivalent heat to power ratio} = \frac{\text{New Efficiency}_{heat}}{\text{Efficiency}_{power}}$$

   So the equivalent heat to power ratio to achieve a QI of 110 is 33.3% / 36% = 0.92

   Step 3 is to calculate CHP_{EGL} which is

$$CHP_{EGL}\ (\text{MWhe}) = \frac{\text{Heat supplied } (\text{MWh}_{th})}{\text{Equivalent heat to power ratio}}$$

   and which is therefore = 100,000 / 0.92 = 108,696 MWh

7. **The annual electricity generation qualifying for benefits is 108,696 MWh**, which represents (108,696 / 343,000 MWh) or 31.7% of the electricity generated.

CHP Equivalent Capability (CHP_{EC})

1. CHP Equivalent Capability is determined on the basis of the maximum continuous heat supplied (MW_{th}) during Normal Operating Conditions. The scheme supplies 100,000 MWh(th) over 7,000 hours, or an annual average of 14.3 MW_{th}. However, the factory has a distinct shift pattern. For 60% of the time it uses 20 MW_{th}, and 40% of the time it only uses 5.8 MW_{th}. For capacity calculations, the relevant figure is therefore 20 MW_{th}.

$$CHP_{EC}\ (MW_e) = \frac{\text{Maximum continuous heat supplied } (\text{MWh}_{th}) \text{ NOC}}{\text{Equivalent heat to power ratio}}$$

$$CHP_{EC}\ (MW_e) = \frac{20}{0.92}$$

2. Thus in this case, **CHP_{EC} (MW_e) = 21.7 MW_e**, which is (21.7/49) or 44% of capacity.

Table 5 **Illustrative CHP_{EGL} and CHP_{EC} Calculations (complex)**

Example 6 **A 250 MW_e CCGT operating 8500 hours a year at an oil refinery**

CHP Equivalent Generation Limit (CHP_{EGL})

1. The proposed Quality Index calculation for schemes between 200 and 500 MW_e is

   QI = 170 x P + 125 x H

2. Over the year, the metered fuel use is 4,938,500 MWh, electricity generated 2,125,000 MWh and heat supplied 500,000 MWh.

3. Thus electrical efficiency over the year is (2,125,000/4,938,500) = 43% and heat utilisation efficiency is (500,000/4,938,500) = 10.1% . Overall efficiency is 53.1%

4. The Quality Index is = 170 x 43% + 125 x 10.1%, which is equal to 85.7.

5. Since this scheme has a QI <100, further calculations are necessary.

6. For schemes which include pass-out steam turbines, electrical generation efficiency declines with increasing heat supply. To calculate QI of 110 both the new electrical and heat efficiency need to be calculated.

7. Annex I Table 7 shows Z ratios for a range of turbine sizes and steam pressures. For a CCGT with a steam turbine rated at 50 MW_e, and a passout pressure of 11.4 bar, the Z ratio is 4.1

   Step 1 the change in heat efficiency is calculated using:

   $$\text{Change in Efficiency}_{heat} = \frac{\text{Change in QI}}{\left(Y - \dfrac{X}{\text{Z ratio}}\right)}$$ with the Z factor for this scheme of 4.1:

   $$\text{Change in Efficiency}_{heat} = \frac{110 - 85.7}{\left(125 - \dfrac{170}{4.1}\right)} = 29.1\%.$$

   Thus the increase in heat efficiency from 10.1% is 29.1%, making a total of 39.2% of the fuel input recovered as useful heat. The corresponding decline in electrical efficiency is

   $$\text{Change in Efficiency}_{power} = \frac{\text{Change in Efficiency}_{heat}}{\text{Z ratio}}$$ which is equal to

   $$\text{Change in Efficiency}_{power} = \frac{29.1\%}{4.1} = 7.1\%.$$

   So the new electrical efficiency at QI =110 is = 43 - 7.1 = 35.9%.

   This gives an overall efficiency of 75.1%, and, to confirm,

   QI = 170 x 35.9% + 125 x 39.2%, which is equal to 110

Table 5 Illustrative CHP_{EGL} and CHP_{EC} Calculations (complex) (cont'd)

Step 2 the equivalent heat to power ratio is 39.2% / 35.9% = 1.09

Step 3 CHP_{EGL} is calculated as before

$$CHP_{EGL}\ (MWhe) = \frac{\text{Heat supplied } (MWh_{th})}{\text{Equivalent heat to power ratio}}$$

CHP_{EGL} is therefore = 500,000 / 1.09 = 458,700 MWh

8. The annual electricity generation qualifying for benefits is 458,700 MWh, which represents (458,700 / 2,125,000 MWh), or 21.5% of the total electricity generated.

CHP Equivalent Capability (CHP_{EC})

1. CHP Equivalent Capability is determined n the basis of the maximum continuous heat supplied (MW_{th}) during Normal Operating Conditions. The scheme supplies 500,000 MWh(th) over 8,500 hours, or an annual average of 58.8 MW_{th}. In this case, the heat load is fairly steady throughout the year, and even under maximum continuous heat supply conditions, the maximum heat supply does not exceed 65 MW_{th}.

$$CHP_{EC}\ (MW_e) = \frac{\text{Maximum continuous heat supplied } (MW_{th}) \text{ NOC}}{\text{Equivalent heat to power ratio}}$$

$$CHP_{EC}\ (MW_e) = \frac{65}{1.09}$$

2. Thus in this case, **CHP_{EC}= 59.6 MW_e**, which is (59.6/250) or 23.8 % of capacity.

5 Organisation of the Programme

Application for Registration

5.1 Schemes wishing to benefit from regulatory and fiscal benefits must apply for Registration to the ***CHP*QA** programme. A standard application form is being developed which will be similar to that currently used for power station consent applications. Basic information will be required including site address and contact details; scheme design including plant layout and installed equipment; typical operating conditions; and metering arrangements for all sites supplied by the scheme.

5.2 The next stage will be for the scheme to perform a self-assessment using the Quality Index. Help will be available to do this through the EEBPP.

Assessment and Reporting Obligations

5.3 Reporting obligations will be established for CHP schemes that wish to be Registered and Certified. A standard reporting procedure and *Pro-forma* is being developed.

5.4 Records and meter readings will need to be kept in accordance with the definitions in paragraphs 2.19 to 2.31. ISO 9000 provides a useful model of the type of auditing arrangements that may be appropriate (though this will not be a strict requirement). The QI will need to be calculated appropriately. This should be reported to Government via the ***CHP*QA** programme. Access to operational data must be provided on a confidential basis to support the Assessment where necessary.

5.5 Help with appropriate reporting will be available where necessary under the EEBPP.

Verification and Auditing Obligations

5.6 Assessments will need to be Verified, and the right to Audit both the records and the site will be maintained to ensure that operational performance is consistent with reported statements. Verification and Audit will confirm that:

- The definitions for evaluation of the scheme are appropriate.
- Metering arrangements for the site and direct heat and electricity customers are correct.
- Data reporting systems and records are in order.
- Heat uses are genuine (i.e. where heat-only boilers would otherwise have provided a service) and not merely providing an alternative to dumping in a condenser.
- The QI calculation is correct.
- Any necessary CHP_{EGL} and CHP_{EC} calculations are correct.

5.7 Clearly, reporting of actual performance data can only be done retrospectively. However, companies will need to know their future tax liabilities in order to inform both fuel suppliers and potential heat and electricity customers whether CCL is due on inputs or outputs. The Verification and Audit obligations will therefore include two elements : validation, and if necessary reconciliation, of the previous period's fuel use electricity and heat supplied, and therefore tax liability; and preparation of a provisional assessment for the forthcoming period. It may be appropriate for larger schemes to report more regularly than annually.

5.8 Following Verification and Audit, the scheme will be Registered on a database (for reporting aggregated data) and Certified (for exemption from CCL, or Enhanced Capital Allowances as appropriate).

5.9 All information provided by a scheme operator will be treated in the strictest commercial confidence consistent with legislation which covers assessments undertaken for tax purposes.

5.10 At the same time, there is a clear obligation on the part of the scheme operator to provide correct information. Whilst the ***CHP*QA** programme will be voluntary, the resulting Certificates will enable schemes to be eligible for significant financial benefits through the tax system. In line with other tax exemptions, applicants who are found to have abused the exemption will be subject to the normal penalty arrangements enforced by HM Customs and Excise.

5.11 As well as Auditing arrangements, there is the opportunity through the EEBPP to move beyond mere compliance to positive encouragement and support by, for example, options to improve profitability and efficiency through site specific advice.

6 Arrangements for different sizes and categories of scheme

6.1 CHP schemes vary in size from less than 50 kW_e capacity to over 500 MW_e. Schemes less than 1 MW_e account for over 80% of sites, but only 4% of capacity (Table 6). Schemes over 10 MW_e account for 5% of sites and 80% of electrical capacity. It is sensible therefore that obligations under ***CHP*QA** vary with the sizes and category of the scheme (and thus, in the case of Climate Change Levy exemption, the tax revenue foregone). In all cases, the right to conduct unannounced spot-checks will be reserved.

Table 6 CHP installations by capacity size ranges in 1998

Electrical capacity	Number of installations	Share of total (Per cent)	Total electricity capacity (MW_e)	Share of total (Per cent)
Less than 100 kW_e	674	49.0	37.8	1.0
100 kW_e - 999 kW_e	469	34.1	119.6	3.0
1 MW_e - 9.9 MW_e	161	11.7	664.2	16.9
Greater than 10 MW_e	72	5.2	3,107.0	79.1
Total	1,376	100.0	3,928.6	100.0

Large Scale CHP

6.2 Schemes up to 50 MW_e may be subject to annual Audit; schemes over 50 MW_e may be asked to report more frequently.

Small Scale CHP

6.3 There is *prima facie* case that the costs of compliance could be reduced with little loss of revenue, and with a good degree of assurance that the concession would not be abused.

- First, smaller schemes have lower electrical efficiency and higher installed and operating costs. It is generally not economic to generate power at levels of less than 1 MW_e with no heat recovery. The vast majority of schemes within this category will therefore optimise heat recovery.
- Second, whilst schemes below 1 MW_e account for over 80% of CHP installations, they account for only 4% of the total installed CHP capacity (Table 6).

Packaged CHP and Product-type approval

6.4 In packaged CHP units an engine, generator, electrical connections and heat recovery equipment are supplied in a *single integrated package* mounted within a standard enclosure. Often these schemes are operated automatically with remote monitoring by the installer. Most such schemes are below 500 kW_e, though larger schemes are available. These schemes could be given Product-Type Approval.

6.5 Product-Type Approval may be similar to that for products such as gas boilers, i.e. testing of a small number (1-3) of typical standard arrangements which are representative of a larger number of technically identical models. If a product then fails this test, a larger number are tested. The aggregate efficiency must be within a given tolerance. Tests could be carried out either by manufacturers or third parties, for example, approved test houses. In all cases, standard test protocols should apply so that tests can be reproduced by a different tester.

6.6 An alternative arrangement, given the physical size of plant, might be self-assessment by the manufacturer, with the manufacturer the subject of the Audit. In the case of a dispute, independent testing would be carried out by an independent test house.

6.7 Under Product-Type Approval, Registration with the programme would still be required, and site layout and design details supplied. Annual reporting may not be necessary, but the right to carry out Audit at short notice may need to be maintained. Views on the best approach for Product-Type Approval of Packaged CHP schemes would be welcomed.

6.8 In future, small gas turbines operating as burners for large boilers may also be given Product-Type Approval. Fuel used in heat-only burners will not, however, attract CHP benefits.

Bespoke schemes below 1 MW_e

6.9 Some small schemes below 1 MW_e are bespoke installations. Bespoke schemes utilise a variety of fuels and technologies, are operated across a wide range of sites, and with some variation in efficiency. Thus it may be appropriate in such cases to require at least a one off-Audit at commissioning followed by annual self-monitoring reports from the operator. Annual audits may not be necessary, but the right to carry out audits at short notice will be maintained.

6.10 For sites which contain a number of units each below 1 MW_e, but for which the aggregate qualifying capacity of the site exceeds 1 MW_e the site would normally be treated as a single facility, and be subject to appropriate QI definitions and auditing arrangements.

Annex I Equivalent Generation Limit and the Z Ratio

1 As part of the calculation of the CHP Equivalent Generation Limit, the heat recovery necessary to achieve a QI of 110 must be calculated. For schemes which include a pass-out steam turbine, an increase in steam extraction is accompanied by a corresponding decline in electrical efficiency. Thus:

Change in QI = Y x Change in Efficiency $_{heat}$ + X x Change in Efficency $_{power}$

Where X and Y are, again, the coefficients appropriate to the scheme.

2 The trade between heat extraction and electricity for schemes with pass-out steam turbines is known as the *Z* ratio. The *Z* ratio can be derived from actual measurements of the scheme in question, and depend on the temperature and pressure of the steam supplied, Table 7 shows typical *Z* ratios for given steam turbines and steam pressures:

Table 7 Typical Z ratios for given steam turbines and steam pressures

Steam turbine size range	5-10 MW_e	10-25 MW_e	25-50 MW_e	50-100 MW_e	>100 MW_e
Pass-out pressure					
21.7 bar (315 psia)	4.0	4.0	3.9	3.5	3.5
14.8 bar (215 psia)	4.3	4.3	4.2	3.8	3.8
11.4 bar (165 psia)	4.6	4.5	4.5	4.1	4.0
7.9 bar (115 psia)	5.0	4.9	4.8	4.4	4.4
3.8 bar (55 psia)	5.9	5.8	5.7	5.4	5.3

3 For example, a typical CCGT scheme with a steam turbine rated at 60 MW_e with pass-out pressure of 11.4 bar the Z ratio is 4.1:1. This means that for every 4.1 units of steam extracted from the turbine, one unit of electricity will be foregone.

4 Assuming a fixed *Z* ratio allows the trade between heat and electricity to be calculated. Thus the efficiency of power generation can be restated in terms of heat and *Z* ratio (note the minus sign is present because the change in electrical efficiency is a negative change).

$$\text{Change in QI} = Y \text{ x Change in Efficiency}_{heat} - \left(\frac{X \text{ x Change in Efficiency}_{heat}}{\text{Z ratio}} \right)$$

Rearranging this equation gives:

$$\text{Change in QI} = \text{Change in Efficiency}_{heat} \text{ x} \left(Y - \frac{X}{\text{Z ratio}} \right)$$

Rearranging this equation gives:

$$\text{Change in Efficiency}_{heat} = \frac{\text{Change in QI}}{\left(\text{Y} - \frac{\text{X}}{\text{Z ratio}} \right)}$$

5 This is the additional heat recovery necessary for any given scheme to achieve any given change in QI. In calculating CHP_{EGL} the change in QI is equal to 110 minus the QI actually achieved by the scheme.