



IEA Information Paper

Combined Heat & Power and Emissions Trading: Options for Policy Makers

July 2008

International Energy Agency

The International Energy Agency (IEA) is an autonomous body which was established in November 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme. It carries out a comprehensive programme of energy co-operation among twenty-seven of the OECD thirty member countries. The basic aims of the IEA are:

- To maintain and improve systems for coping with oil supply disruptions.
- To promote rational energy policies in a global context through co-operative relations with non-member countries, industry and international organisations.
- To operate a permanent information system on the international oil market.
- To improve the world’s energy supply and demand structure by developing alternative energy sources and increasing the efficiency of energy use.
- To promote international collaboration on energy technology.
- To assist in the integration of environmental and energy policies.

The IEA member countries are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Republic of Korea, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States. Poland is expected to become a member in 2008. The European Commission also participates in the work of the IEA.

Organisation for Economic Co-operation and Development

The OECD is a unique forum where the governments of thirty democracies work together to address the economic, social and environmental challenges of globalisation. The OECD is also at the forefront of efforts to understand and to help governments respond to new developments and concerns, such as corporate governance, the information economy and the challenges of an ageing population. The Organisation provides a setting where governments can compare policy experiences, seek answers to common problems, identify good practice and work to co-ordinate domestic and international policies.

The OECD member countries are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Republic of Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States. The European Commission takes part in the work of the OECD.

© OECD/IEA, 2008

International Energy Agency (IEA)
9, rue de la Fédération
75739 Paris Cedex 15
France
<http://www.iea.org/index.asp>

Please note that this publication is subject to specific restrictions that limit its use and distribution. The terms and conditions are available online at <http://www.iea.org/Textbase/about/copyright.asp>

Table of Contents

Acknowledgements	4
Foreword	5
Executive Summary	6
Introduction	7
Climate change and the GHG Policy Response	7
What is Emissions Trading?	7
Why is the Treatment of CHP important for ETS design?	8
What is CHP?	10
What are the key challenges for incorporating CHP into an ETS?	12
ETS design and operational issues	14
Allocation Methodology	14
CHP bonus allocation	18
Reducing the Compliance Factor for CHP	18
A separate CHP sector	19
New Entrant Reserve	19
CHP efficiency requirements	19
ETS experience to date	20
Terminology	26
End notes	27

Acknowledgements

This paper was prepared by Tom Kerr. The author would like to thank Ingrid Barnsley, Julia Reinaud, Barbara Buchner, Pieter Boot, Richard Baron, and Luke Nickerman at the IEA for their review and insightful comments. Partners and Collaborators in the IEA's International CHP/DHC Collaborative also offered important input. This paper was prepared with the analytical and drafting support of the consulting firm Delta Energy & Environment.

Questions and comments should be sent to:

Tom Kerr
9, rue de la Fédération
75739 Paris CEDEX 15
France
Email tom.kerr@iea.org

Foreword

The aim of this IEA Information Paper is to help policy makers and other stakeholders understand the challenges facing the incorporation of high efficiency combined heat and power (CHP) into greenhouse gas (GHG) Emissions Trading Schemes (ETSs) – and to propose options for overcoming them.

Experience has shown that CHP (and related applications like District Heating and Cooling (DHC)), which span energy supply and demand, and which generate both electricity and heat, do not always fit easily into the overall design framework of an ETS. Yet these approaches are highly efficient compared to separate heat and power generation, bringing the potential for substantial global GHG emissions reductions. If ETS design unwittingly penalises rather than incentivises CHP, this potential could be lost. Further, some policy makers may wish to utilise ETS as a tool for expanding the use of CHP and DHC.

This Paper therefore:

- Presents an overview of the key challenges to incorporating CHP into ETSs;
- Assesses lessons learned from international ETS experience to date;
- Outlines the key ETS design features that could be considered by policymakers; and
- Proposes options and recommendations on approaches that can be used to ensure a fair and supportive treatment for CHP.

Executive Summary

Combined Heat and Power and District Heating and Cooling have been identified as an important tool available to policymakers for bringing about significant reductions in carbon emissions from the energy sector. Potential for carbon emissions reductions from these technologies are significant¹.

Cap-and-trade emissions trading systems are becoming an increasingly popular policy tool for addressing climate change, and may in time become the dominant policy mechanism for emissions reduction. It is therefore of high importance that ETS designers ensure that CHP is not inadvertently penalised within an ETS. ETS designers should ensure that the scheme does not deter the entry of new CHP, or cause existing CHP owners to reduce their CHP utilisation. There is also scope within the ETS to support CHP as a carbon reduction measure, and to target specific incentives at those CHP plants that bring about the greatest emission reductions.

The main challenge facing CHP in ETS design is that, with CHP, onsite emissions increase, even though overall global emissions decrease. This paper concludes that using a “double benchmarking” approach to allowance allocation represents the most effective mechanism for ensuring that ETS design gives due recognition to the emissions reducing benefits of CHP. An equivalent measure can be used for supporting CHP when allowances are auctioned.

Other measures include:

- A low Compliance Factor
- The award of bonus allowances for CHP production
- The establishment of a specific CHP Sector for allocation
- Keeping allowances aside for CHP in the New Entrants Reserve

Auctioning of ETS allowances will likely become increasingly important in the future. There are a range of options available to ETS designers to ensure that the onsite emissions increase that occurs with CHP does not result in compliance cost increases for CHP plants. Some policy makers may wish to pursue full support for CHP via double benchmarking with free allowances equivalent to either heat or electricity output; others may wish to provide other forms of support. This paper outlines the menu of options that are available to them.

Introduction

Climate Change and the GHG Policy Response

There is now unequivocal evidence that human-induced climate change is taking place. Increasing global air and ocean temperatures, widespread melting of snow and ice and rising global sea levels have been dramatic in the last few decades. The IPCC reports that these changes are very likely to have been exacerbated by anthropogenic greenhouse gas (GHG) emissions².

To date, the most important international and legally binding agreement aimed at tackling climate change has been the Kyoto Protocol, which came into force on 16 February 2005. 180 countries have ratified the treaty, which sets binding targets to reduce GHG emissions. One of the main features of the Kyoto Protocol is its establishment of the basis for the introduction of three market-based mechanisms through which to meet their targets: Joint Implementation, the Clean Development Mechanism and International Emissions Trading³. The United States has not ratified the Kyoto Protocol. However, there are a number of proposed GHG ETS schemes under consideration at the US federal, state and regional levels. In addition, the US has both many years of experience with national and regional ETS for non-GHG air pollutants. This paper will also be of use to policy makers in these jurisdictions who wish to assess the role of CHP.

What is Emissions Trading?

The development and design of emissions trading schemes is driven by their scope to bring about emissions reductions at the least cost. Emissions trading effectively caps emissions and creates scarcity, thereby putting a price on emissions through the creation of an emissions market.

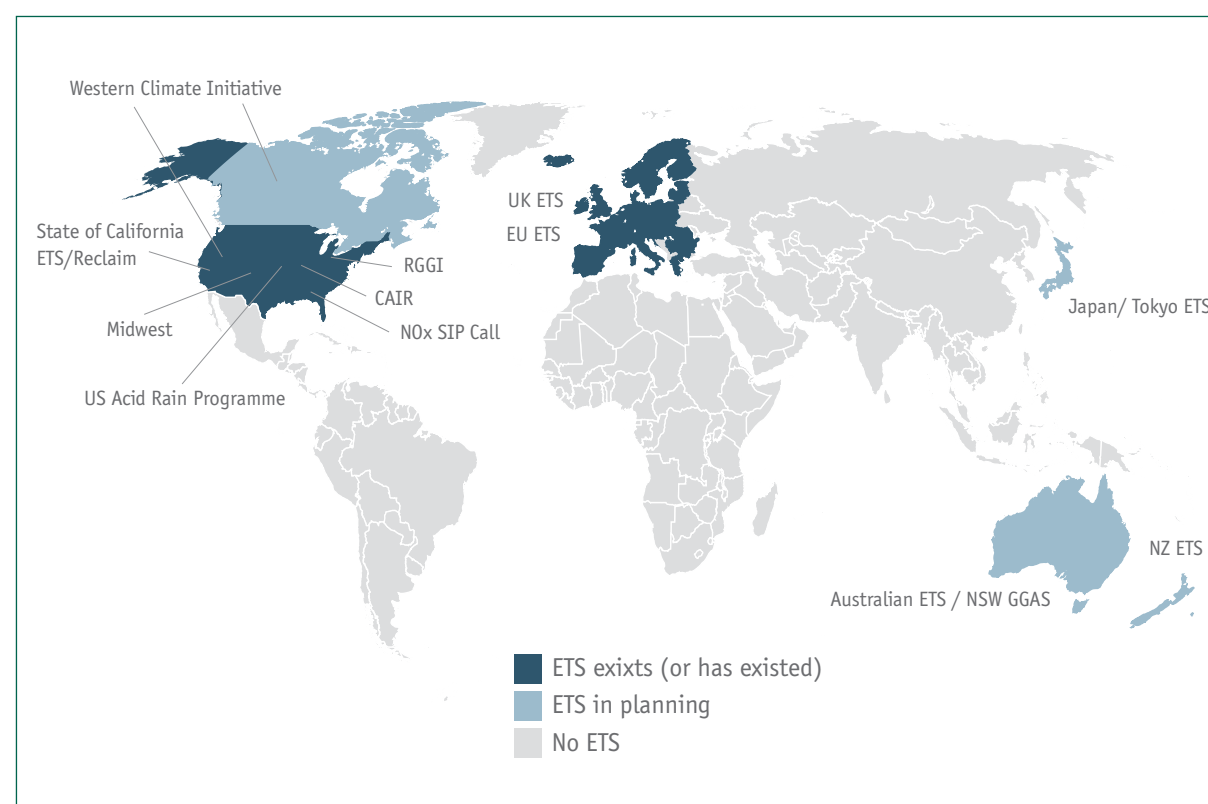
In cap-and-trade schemes, a cap (or limit) is set on the total volume of emissions allowed by facilities in a particular jurisdiction, and a finite number of emissions allowances are available that reflect the cap (e.g. one allowance permits the emission of 1 tonne of CO₂). The total emissions cap is reduced on a year-by-year or phase-by-phase basis, typically increasing the stringency of the scheme gradually. The steepness of this ‘ratcheting down’ trajectory (also known as a ‘glide path’) may vary depending on the sector in which the facility falls. Allowances are distributed, or allocated, to emitters, enabling participants to sell surplus (unused) allowances to those with a deficit. Trading schemes can involve individual installations, groups of emitting sectors of the economy, or whole countries⁴.

Emissions Trading Schemes started to gain popularity in the US in the 1990s with trading of traditional air pollutants such as oxides of nitrogen (NO_x) and sulphur (SO_x). Europe was the first region to begin a mandatory CO₂ cap-and-trade scheme, known as the EU ETS. The EU ETS has been operating since 2005 and is now the largest multi-country, multi-sector GHG emission trading scheme in the world. Phase I (2005–07) has now ended and Phase II (2008–2012) has begun. The design of Phase III (2013–2020) is now under negotiation among the EU Institutions.

Outside Europe, GHG trading schemes are at various stages of development, including the Regional Greenhouse Gas Initiative in the north-eastern United States and the US / Canadian Western Climate Initiative. Other schemes are being established in Asia and Australasia.

Some emerging economies, including China and India, support market based instruments like ETS and favour in particular relative rather than absolute targets that are linked to economic growth. This type of scheme is known as performance-based cap-and-trade.

FIGURE 1: EMISSIONS TRADING EXPERIENCE TO DATE



Source: IEA Analysis

Why is the Treatment of CHP important for ETS design?

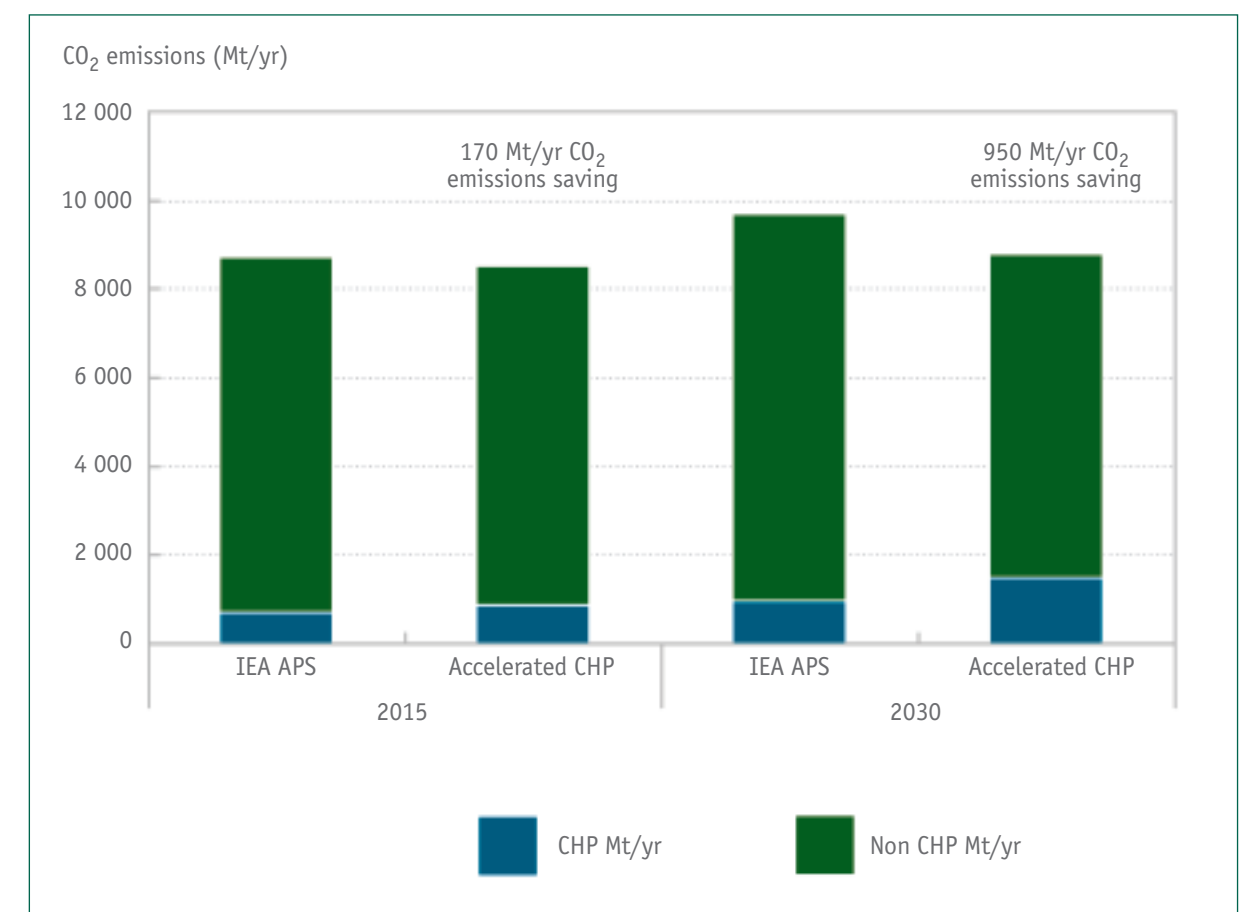
Greenhouse gas emissions trading is a central tool in the global response to climate change, as is evidenced by the emergence of emerging trading schemes. In time, it may become the dominant policy mechanism, with the existence of a global market for GHG emissions allowances and the participation of all the major economies worldwide.

Meanwhile, the potential for CHP (and applications such as District Heating and Cooling) to bring about significant emissions reductions is increasingly well understood. The IEA has recently analyzed this capability; its 'Accelerated CHP' scenario (illustrated in figure 2) brings about a 10% emission reduction beyond that achieved by the IEA's low-carbon Alternative Policy Scenario.

It is therefore important to ensure that evolving ETS design takes account of CHP's unique position in the energy delivery chain and, if desired, incentivises the development of high-efficiency CHP systems alongside other carbon mitigation solutions. At the very least, ETS programmes should not penalise CHP.

FIGURE 2: GLOBAL ENERGY-RELATED CO₂ EMISSIONS

(APS – Alternative Policy Scenario)



Source: IEA, *Combined Heat and Power: Evaluating the Benefits of Greater Global Investment* (2008).

What is CHP?

CHP represents a series of technologies used for the simultaneous generation of useful heat and electricity in a single process, at or near the point of use. A CHP plant will usually be scaled to meet industrial, commercial, city-wide (via DHC) or domestic heat demand. CHP can run on fossil and renewable fuels.

HIGH EFFICIENCY: It is the high efficiency of CHP that underpins its emissions benefits. CHP is a more efficient use of fuel than conventional centralized electricity generation with separate heat production (see figure 3). CHP plants typically convert 75-80% of the fuel source into useful energy. In contrast, in conventional separate electricity and heat generation, overall efficiency is only around 60%. While boilers can be <90% efficient, conventional electricity generation processes can waste around two-thirds of the primary energy input as 'waste' heat. In addition, CHP reduces the energy losses occurring through the transmission and distribution of electricity from a centralized power plant to the point of use. CHP plants can avoid these losses, which can account for 9% of net generation, because they are sited at, or near, the location where the energy output is to be used.

FIGURE 3: ENERGY FLOWS FOR SEPARATE AND COMBINED HEAT AND POWER GENERATION

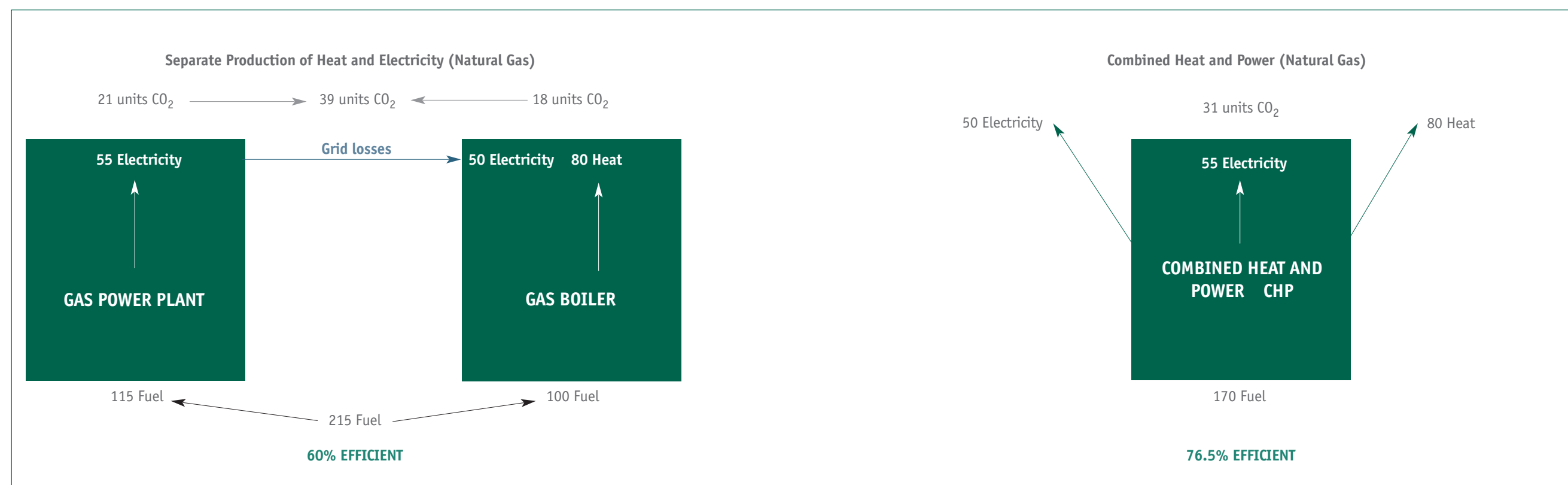


Figure 3 illustrates comparative efficiencies of combined and separate generation of heat and power using example plants run on natural gas (though CHP can be run on a variety of fuels including natural gas). Quoted efficiencies are based on low heating values.

WHAT DOES 'HIGH EFFICIENCY' MEAN? One way of ensuring that incentives target the most efficient CHP systems is to set qualifying thresholds that benefit the plants that reduce fuel use – and emissions – the to the greatest extent. In this way, an ETS can be implemented to target the best-performing plants. The definition of CHP in the EU CHP Directive and the UK CHP Quality Assurance scheme are both pioneering mechanisms for achieving this.

APPLICATIONS OF CHP: The scale of CHP unit depends on its application. The range of applications includes:

- > **District Heating and Cooling** – DHC systems can use CHP to supply heat or cooling to a network of pipes that carry heat or chilled water to buildings in towns and campus settings.
- > **Industrial** – CHP up to 500 MWe or more in size supply heat and steam to industrial processes, including oil refining, pulp & paper & other manufacturing processes.
- > **Commercial** – Medium-scale systems may serve a small business, school, hospital, or university campus.
- > **Domestic** – emerging kW-scale micro-CHP technologies can replace a boiler in individual households.

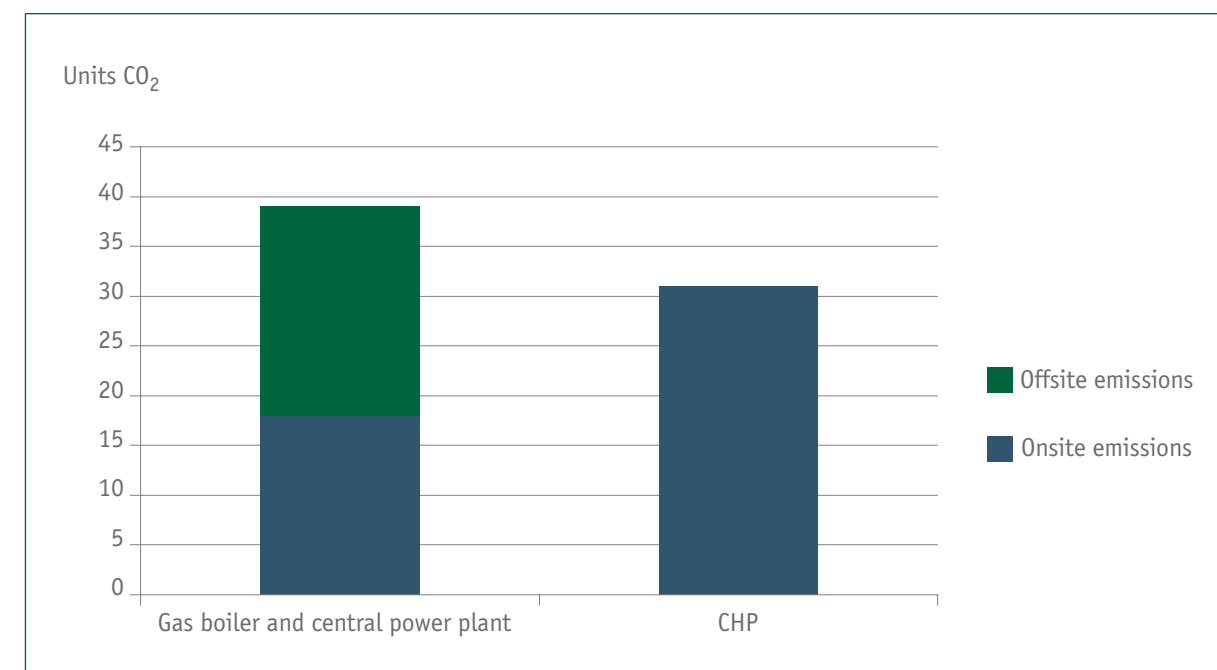
What are the key challenges for incorporating CHP into an ETS?

Based on current experience, there are three important areas to be addressed in incorporating CHP into an ETS.

1. With CHP, onsite emissions go up while global emissions go down

While CHP reduces overall emissions, onsite emissions go up. Figure 4, which is based on the example data from figure 3, shows how overall emissions are 21% lower with CHP than with separate electricity and heat generation. Onsite emissions, however, are up 70%. This is an issue for CHP in a source-based ETS that requires a site to directly account for the emissions it generates (rather than the end-user being accountable). This has the potential to penalise an owner or potential investor in CHP by requiring them to hold – and pay for – additional CO₂ allowances.

**FIGURE 4: ACCOUNTABILITY FOR EMISSIONS:
CHP VS CONVENTIONAL SEPARATE GENERATION OF ELECTRICITY AND HEAT**



Source: IEA Analysis

In theory, this issue can be avoided if the price of imported grid electricity to a site without CHP includes, in full, the carbon cost of that electricity. In practice, however, the electricity price paid by a heat consumer does not include the full carbon cost of the generation that CHP displaces, primarily because integrated utilities can spread the carbon costs of their fossil and non-fossil generation. Equally, evidence to date in the EU suggests that the anticipated upward impact of an ETS on power prices, which would normally be a driver for CHP investment, has not yet made a discernible impression on CHP market growth. As a result, most EU countries have provided some special provision for CHP within their EU ETS allocation plans⁵.

2. Which sector does CHP belong to?

Emissions trading schemes often distinguish between different sectors of the economy. This enables ETS designers to impose stricter targets on some sectors than on others, or to limit the impact of ETS on sectors vulnerable to international competition. CHP generates both electricity and heat. Therefore, a question arises about whether it should be part of the electricity sector or the heat-consuming sector (usually an industrial sector). If it is seen to be in both sectors, then the additional question arises of how to allocate emissions allowances between electrical output and heat output.

Differences in sector caps can make a significant impact on CHP. For example, experience to date with the EU ETS suggests that if a plant is part of a sector that is capped in a significant way, the economic performance of an existing CHP project, as well as the viability of new CHP investment in that sector, can be significantly diminished.

3. Defining the boundaries for inclusion of CHP in an ETS

ETS frameworks will usually set boundaries on what size of installation is included – and this can lead to more efficient CHP and district energy being placed at a competitive disadvantage. Although the electricity market is mostly covered by ETSs, the heat market is only 10-20% covered. This means that CHP and DHC are often above the threshold for inclusion, while separate conventional generators of heat and electricity avoid inclusion.

- **The issue for DHC** – Under ETS frameworks, larger district energy plants which are above the threshold for ETS inclusion may be forced to compete with individual smaller boilers serving the same heat load, but which individually fall below the threshold and avoid being included in the ETS. Therefore, an ETS can provide a sufficient incentive not to invest in a more-efficient district energy scheme (with or without associated electricity generation).

- **The issue for medium-to-small CHP plants** – the issue is similar. For example, the qualifying threshold for the EU ETS is 20 MW thermal input. There are many sites that currently do not qualify for the EU ETS that would do so if they were to invest in CHP, since on-site fuel use increases (though global fuel use decreases). This demonstrates the importance of getting the policies right for CHP in ETS.

ETS design and operational issues

In theory, a well-designed ETS would incentivise investment in all cost-effective carbon reduction options, including CHP. However, there is no clear evidence to date that this is the case.

This section looks at some of the options that exist for policymakers to ensure that carbon savings from CHP can be incentivised within the scope of an ETS by paying particular attention to the way in which allowances are allocated.

Allocation methodology

A key issue at the ETS design stage is how to allocate allowances to affected GHG emitters. If allowances are allocated for free, then one of two basic methodologies can be used:

- Grandfathering – using the historic emissions of an existing site as a proxy for the number of allowances a site will need; and
- Benchmarking – using absolute technology benchmarks to determine how many allowances a site should receive.

If allowances are to be paid for, the main allocation mechanism is:

- Auctioning – where both existing and new installations are required to purchase allowances.

In all cases, year-on-year emission reductions can be achieved by reducing the total number of allowances available each year. Each of these options offers opportunities for ETS policymakers to recognise the emissions saving benefits of CHP. These are summarised below.

Grandfathering

Using the historic emissions profile of a site to allocate allowances has been a common allocation methodology in existing ETS schemes. It has been used in most National Allocation Plans (NAPs) in both Phases of the EU ETS, and has been the basis for most of the U.S. conventional pollutant programs. However, using historic emissions can mean that emitters that have already made energy efficiency improvements, including CHP, are penalised.

A plant with an existing CHP facility, for example, could argue that its year-on-year reductions are more costly than a site that has not invested in efficiency. This problem also occurs across phases of ETSs; for example, if a plant makes an improvement during Phase I, it effectively has its allowances reduced in Phase II.

Reducing the Compliance Factor (see page 16) for sites that already have CHP is one option for recognising this early investment in efficient CHP, also called ‘early action’.

Incentives to replace an old plant or update a new plant are also removed, because allowances are based on previous emissions, resulting in reduced allocation for new plants. Double benchmarking solves this issue.

Benchmarking and double benchmarking

BENCHMARKING

Benchmarking is a means of allocating permits that is often favoured by ETS designers. It has been applied in several EU Member States and seems likely to be used in California and other ETSs being developed elsewhere.

With benchmarking, permits are allocated not according to historic or actual emissions, but on the basis of comparison with the emissions of a typical – often a ‘best available technology’ (BAT) – generating plant. For example, a boiler installation in a factory might be allocated the same number of allowances as would be required by a standard high-efficiency boiler to deliver the same heat output. If the factory boiler were less efficient, it would be unlikely to have sufficient allowances to cover its emissions.

DOUBLE BENCHMARKING

When applied to CHP, which generates electrical and heat output, the benchmarking approach is known as *double benchmarking*:

- The allowance allocation for the electrical output is based on the emissions of a conventional fossil-fired power plant (these are typically CCGT plants that do not recover heat, but could also be a fossil-fuel average, or the likely marginal plant that CHP would displace); and
- The allowance allocation for heat output is based on emissions of a conventional boiler or steam plant.

A sample CHP plant is therefore given a twin allocation based on benchmarking against standardised separate electricity and heat generators – one for the heat output (according to a boiler reference) and one for the electrical output (according to a central generation reference). In this way, CHP is provided with allowances that would have been allocated to separate generators to produce the same output. In this context, the reference values that are used to benchmark CHP are of great importance since they have a very strong influence on the final allocation.

In the US, a related approach, output-based allocations, have been employed for CHP in regional NO_x emission trading programs. Here the allocation is based on actual thermal and electric output over a recent historical period which is updated to account for changes in load factor.

Terminology: “Benchmarking” and “Output Based Allocation”

The term ‘benchmarking’ refers to the practise of using a reference emissions level per unit of input or output. In the United States ‘output based allocation’ has been used – for example allocations are made for NO_x under the US Clean Air Interstate rule for each MWh of electricity generated, regardless of generation type. In Europe input based allocation has been more common where benchmarking has been applied in the EU ETS; here generators are given allocations relating to the fuel going into a generating station.

The US phrase most consistent with double benchmarking is ‘output based allocation with thermal credit’ see, e.g., the US Environmental Protection Agency’s website at www.epa.gov/CHP/state_policy/output.html.

WHY DOUBLE BENCHMARKING?

The main benefits of double benchmarking are as follows:

- Double benchmarking is perhaps the most logical solution to the problem of increased onsite emissions at a CHP site: the CHP site is allocated carbon allowances as if it sourced heat and electricity separately, so the possible distortion is removed.
- CHP efficiency is also rewarded in direct relation to the carbon savings that it generates compared to separate central generators and boilers.
- Flexibility – double benchmarking can be used both for new and existing CHP plants.

EXAMPLES

In the EU ETS, several countries used double benchmarking for CHP in Phase I, including Germany and the Netherlands, with further adoption by other countries in Phase II. The electricity and heat reference efficiencies (LHV) in the Netherlands in Phase I reflect the BATs for separate electricity and heat production:

- For electricity (gas fired), the benchmark is 50% efficiency.
- For heat, it is 90% efficiency.

CONSIDERATION FOR CHP LOAD (CAPACITY) FACTORS

A decision to use double benchmarking as a means of recognising the carbon saving benefits of CHP is a clear option for policymakers. However, there is another issue that will need to be taken into account as the calculations are made.

To enable an overall cap on emissions to be applied when using benchmarking, an ETS designer will, quite legitimately, need to make assumptions on the annual hours of operation of CHP and other plants (also known as the load (capacity) factor). Once this is done, the actual number of allowances issued for a given period can be calculated. Simply put, if this assumed load factor is lower than the normal operating hours of a CHP plant, the plant will not receive sufficient allowances.

In the EU ETS, there are examples of double benchmarking approaches being partly undone by specifying insufficient load factors. These include certain German industrial sectors. If, for example, a load factor of 0.8 is used for industrial CHP (in other words it is assumed that the plant will run for no more than 80% of the year) but the actual operational load factor is 0.9, then the CHP site would be significantly short of allowances.

Auctioning

Selling permits via auction may be an elegant economic solution to the challenges of free allocation (for example, it avoids questions of how to allocate permits when there is incomplete historical emissions data). However, it can amplify the issue of increased onsite emissions arising from CHP.

There has been very little experience of using auctions for allowance allocation. In the EU ETS, no countries have yet used auctioning as a primary allocation methodology for a significant proportion of allowances.

However, it is likely that auctioning will play a significant part in the EU ETS in the future— the European Commission has proposed it for Phase III after 2012. In time, it appears as if auctioning is likely to be the rule rather than the exception as cap-and-trade ETSs become more common.

THE CHALLENGE FOR CHP WITHIN AN AUCTIONING SYSTEM

The key challenge for CHP associated with the use of auctioning is that onsite emissions go up as a consequence of investment in CHP (as discussed in section 1.4). Therefore, a site with CHP must purchase more allowances than a site with no CHP (although the CHP causes global emissions to go down).

METHODS OF ADJUSTING AN AUCTIONING SYSTEM TO DEAL FAIRLY WITH CHP

If a decision to auction some or all allowances is taken, policymakers have a number of possible options for overcoming this potential penalty. These options are summarised below; the figures used in the examples relate to the carbon emissions from the hypothetical CHP plant in figure 3 (see pages 8-9 above), which cuts emissions by 8 units of carbon dioxide(21%). The onsite and offsite emissions are presented for reference in table 1.

TABLE 1: ONSITE AND OFFSITE EMISSIONS WITH AND WITHOUT CHP (BASED ON FIGURE 3)

	Separate production of heat and electricity	CHP
Offsite CO ₂ Emissions	21	No offsite emissions
Onsite CO ₂ Emissions	18	31

Source: IEA Analysis

- **Giving CHP free allocation of permits equivalent to the carbon savings from the CHP.** In this approach, CHP is required to submit permits for all of its emissions, but is given a free allocation equivalent to the carbon emissions saved. For example, based on the numbers in figure 3, the CHP owner would buy 23 allowances and be freely allocated 8. This solution would reward CHP directly for its emissions savings, but the CHP plant would still face an increase in the number of required allowances compared to separate heat and power.
- **Giving CHP free allocation of permits equating to its electrical output.** Here, CHP is required to buy allowances that it would be liable for in a pre-CHP situation using only an onsite boiler. So in effect there would be no increase in carbon liability arising from onsite CHP. Based on the figures in figure 3, the CHP owner would buy 18 allowances and be freely allocated 13.
- **Giving CHP free allocation of permits equating to its heat output.** Here, CHP is required to buy allowances equating to its electrical output but given free allocation equivalent to the heat output. Using the numbers in figure 3, the CHP installation would be allocated 18 allowances and buy 13. This may be necessary where an equivalent boiler might get free allocations (due to boundary issues, or free allocation to sectors facing international competition) while electricity sector allocations are auctioned. The use of this principle to ensure that CHP is not penalised relative to separate heat and electricity production has been recognised by the European Commission in a proposed amendment to the EU ETS Directive⁶.

- **Giving CHP plants 100% free permits.** There is some precedent for freely allocating permits; for example, in its NAP for the EU ETS Phase II; Sweden has imposed auctioning for all new generation plants except CHP for the period 2008 – 2012⁷. This solution would provide a stronger incentive to CHP by removing all carbon liability.

AUCTION REVENUES

As the use of auctioning expands, allowance sales could generate significant new revenues for governments. Some ETS designers are proposing that some or all of these funds be used to promote climate change policy objectives and incentivise new technology.

There is therefore scope for incentivising high-efficiency CHP, and other low-carbon solutions, through the use of auction revenues. This approach has the potential to become widely adopted. For example, the European Commission has indicated that some revenues from national auctions in Phase III of the EU ETS should be redistributed from rich countries to poor countries to ‘strengthen their financial capacity to invest in climate friendly technologies’⁸.

CHP bonus allocation

A CHP bonus allocation provides an additional allocation to CHP plants for each unit of electricity when compared with conventional power plants. As with free allocation in an auction situation, the level of bonus can be set at a level to remove any disincentives for CHP, or to specifically incentivise CHP in relation to its carbon savings. A CHP bonus can be applied to CHP regardless of whether allowances are initially distributed for free or at auction.

In Germany, for example, existing CHP plants in Phase I of the EU ETS benefited from an additional allowance of 27 tonnes of CO₂ / GWh of electricity production. This represents a bonus of approximately 6% for a gas-fired 40 MWe CHP emitting around 470t CO₂ / GWh. New CHP plants in Germany are allocated allowances according to a double benchmarking methodology⁹.

Reducing the Compliance Factor for CHP

One straightforward means of addressing the challenges to CHP is to enable qualifying plants to reduce their emissions more slowly over time than conventional installations. The speed with which annual reductions in emissions are required to take place in a cap-and-trade scheme is sometimes known as a Compliance Factor. It is similar to the concept of the ‘glide rate’ for particular technologies or industries where emissions reductions are increased year on year.

The Compliance Factor, which can be used for both free allocation and auctioning, is therefore the principal means of ensuring downward pressure on emissions – if it is set at one, there would be no requirement to reduce emissions; if set at less than one, there is a requirement to reduce emissions each year. By setting the Compliance Factor for existing CHP closer to one than for non-CHP plants the early action of companies installing CHP can be recognised.

There are several examples of the use of reduced Compliance Factors for CHP in the EU ETS. The Netherlands is currently using a compliance factor of 0.995 for CHP plants in the energy sector (requiring a 0.5% reduction) and one of 0.915 for non-CHP plants (requiring an 8.5% reduction). The Greek Phase I NAP, which stated that “it is considered vital to promote and support cogeneration”, has a Compliance Factor of 0.92 for non-CHP plants in some sectors, but a factor of 1 for CHP plants¹⁰.

A separate CHP sector

ETS designers have the opportunity to segment the covered installations into different sectors, including the power sector and various industrial sectors. This segmentation presents an opportunity to establish a specific CHP sector to which pro-CHP measures can be applied that relate to their carbon emission benefits, and which can be applied with both free allocation and auctioning.

Such measures could include:

- A higher Compliance Factor.
- The application of a specific CHP bonus.
- The use of a specific allocation methodology, for example double benchmarking, to reward new and existing CHP in a scenario where most allocation is grandfathered.

For the EU ETS NAP 1, such a system was applied in Finland, Hungary and Poland. For NAP II, the UK has established a specific CHP sector based on a definition of CHP efficiency using the UK CHP Quality Assurance Programme (CHPQA)¹¹.

New Entrant Reserve

A New Entrant Reserve (NER) is a stock of allowances set aside for new emitters entering an ETS after it is established. There are opportunities to incentivise CHP and other energy efficiency improvements through NER design. For example, a proportion of the new allowances can be specifically ring-fenced for CHP and allocated on a double benchmarking basis or, in an auctioning system, applying one of the options mentioned in section 3.2. One example of the use of the NER is Sweden, which proposed that CHP plants should be the only form of fossil generation that received free permits from the NER in Phase I of the EU ETS¹².

CHP efficiency requirements

Policy makers will likely want to ensure that any measures directed to CHP, such as those described above, are awarded only to those CHP plants that are the most efficient—the most effective at reducing emissions. There are tools that exist for them to do this.

The EU Cogeneration Directive (which requires EU Member States to support CHP in various ways) establishes a methodology for calculating carbon savings from a CHP installation. This uses benchmark efficiencies for boilers and for CCGT central generation to calculate ‘primary energy savings’¹³. The carbon savings from the CHP unit can then be rewarded through the EU ETS or other approaches. The UK CHP Quality Assurance scheme is another available mechanism.

ETS experience to date

Table 2 presents a summary of the design features of the major ETSs that are running, or being planned, across the globe. It summarises the main incentives and potential disincentives for CHP. There are a number of other trading schemes where rules and allocation methodologies are yet to be finalised, or where no CHP-specific arrangements have been made. These schemes are outlined below in Table 3.

TABLE 2: EMISSIONS TRADING SCHEMES WITH SOME RECOGNITION OF CHP / DHC

SCHEME	GENERAL BACKGROUND			ALLOCATION METHODOLOGY	TREATMENT OF CHP		
	Dates	Coverage	Type of scheme		Incentives	Disincentives	
US Regional Greenhouse Gas Initiative (RGGI)	Trading starts 1 st Jan 2009.	10 North-East US States	Source-based; mandatory; market-based cap-and-trade for electric generators > 25 MW output.	Allowances distributed to each state based on historic emissions. 100% auctioning proposed. Auction design not yet finalised.	RGGI provides no specific CHP incentives or exemptions. However, RGGI model rules provide flexibility in state models. Some potential CHP benefits are highlighted below which are possible within the RGGI framework, and/or have been included in some states’ ‘pre-proposals’.		✗ Fundamental issue that CHP site emissions will increase has not been addressed.
					Dbl. Bench-marking ✓ Thermal credit for CHP (proposed in Vermont)		
					Set-aside NER ✓ Allowance set-aside for CHP (proposed in Maine, though only for electricity consumed on-site).		
					Exemptions ✓ Exemption for units selling <10% of output to grid		
					Other incentives ✓ Use of auction revenue for promotion of CHP (proposed in Connecticut, NJ, NY, Massachusetts)		
US Acid Rain Programme (SO ₂)	Set up 1995; Phase I (1995-2000); Phase II (2000-)	National program	Cap-and-trade for electric generators > 25 MW output	Grandfathering based on heat input with some fuel-weighting. Auctioning reserve ~2.8% of total allowances for Phase II.	CHP facilities that sell less than 30% of electric output to grid are exempt. “Qualifying” facilities that had a power purchase agreement in place prior to implementation are exempt. No new entrant reserve.		
(A) NO _x Budget Trading/ (B) NO _x SIP Call	(A) began 1999, became (B) in 2003	(A) 13 Northeastern states, (B) 21 Northeastern states	Cap-and-trade for electric generators > 15 MW output and industrial boilers @ 250 MMBtu/hr input	Allocation arranged at state level. Allowances can be bought by any company or member of the public.	Connecticut and Massachusetts applied a double benchmarking (output-based) allocation for CHP. New Jersey provided bonus allowances for CHP.		
Clean Air Interstate Rule	NO _x trading 2009, SO ₂ trading 2010	28 Eastern US States + District of Columbia for electric generators > 25 MW output	Mandatory caps on states; voluntary entry to EPA model scheme	EPA model: NO _x allocation determined at state level. SO ₂ allocation based on acid rain program.	Double Bench-marking ✓ EPA model rule provides extra NO _x allocation for thermal energy from post 2001 CHP >25 MW. Connecticut: allocation for CHP with efficiency >60% based on comparison with conventional system.		✗ Fundamental issue that CHP site emissions increase is not addressed.
					NER ✓ NO _x allowances are periodically reallocated to all units in most states.		
					Exemptions ✓		

continued overleaf

TABLE 2 (CONTINUED): EMISSIONS TRADING SCHEMES WITH SOME RECOGNITION OF CHP / DHC

SCHEME	GENERAL BACKGROUND			ALLOCATION METHODOLOGY	TREATMENT OF CHP	Disincentives
	Dates	Coverage	Type of scheme		Incentives	
EU ETS Phase I (2005-7), Phase II (2008-12) & Phase III (2012-20)	Launched 2005	27 EU States	Mandatory source-based cap-and-trade scheme	Phase I & II - allocation to member states through National Allocation Plans. Majority free allocation – mostly grandfathering, some benchmarking (Germany, Poland, Denmark). Auctioning – limited amount allowed in Phase I (<5%) & Phase II (<10%). Denmark, Hungary and Ireland NAPs I and II used some auctioning. Phase III – greater EU central responsibility for allocation to harmonise allocation rules, eliminate carbon price distortion, and ensure consistency of scope and definitions. 100% auctioning proposed for the power sector <100% for other sectors. Limited free allocation likely – based on robust benchmarking.	Treatment of CHP has not been uniform across member states. CHP generally disregarded, but some exceptions in a few states in Phases I and II. NAPs are highlighted below. Rules not finalised yet for Phase III.	<div>✗ Fundamental issue that CHP site emissions increase is not addressed.</div> <div>✗ Phase I: While robust CHP incentives existed in some NAPs (e.g. Netherlands), in general, most NAPs were not supportive.</div> <div>✗ Over-allocation of free allowances based on grandfathering gave ‘windfall’ revenue to conventional generators without recognition of CHP.</div> <div>✗ In NAPs with no separate CHP sector, treatment varied significantly depending on the industrial sector.</div>
					CHP Sector <div>In Phase I, some NAPs (Finland, Poland, Hungary) used a separate CHP sector, while the UK NAP has introduced this for Phase II.</div>	
					Compliance Factor <div>✓ Reduction of compliance factor often used in NAPs to promote CHP (Germany, Italy, Austria, Belgium, France, Greece and Spain).</div> <div>✓ Greece: a factor of 0.92 is applied to some non-CHP plants in Greece during Phase I, while CHP had a factor of 1 – effectively allocating CHP more allowances.</div> <div>✓ Germany NAP II: existing power plants have a compliance factor of 0.85, while existing CHP plants have a compliance factor of 0.9875. Italy NAP II plans to annually reduce the compliance factor for non-CHP, reaching 0.74 by 2012, while CHP remains on 1.</div>	
					Double Benchmarking <div>✓ Introduced in Phase I in the Netherlands, and then in Phase II in Germany (for new entrants), Denmark and Italy (new entrants). In the Netherlands NAPs I and II, the benchmark is set in comparison to ‘best available technology’ for heat and power. This specifically rewards high-efficiency CHP. CHP generally receives a surplus allocation of allowances, sometimes amounting to <15%.</div>	
					CHP Bonus <div>✓ Some NAPs – E.g. in NAP I: Czech Republic. CHP plants receive a bonus of 430 allowances per GWh of electricity produced; Germany – CHP receives allocations based upon electricity production multiplied by a CHP bonus factor; Poland – CHP installations receive a bonus allocation of 50% of their potential emissions saving.</div>	
					NER <div>✓ Some Phase II NAPs (UK, Poland), set aside allowances for CHP within a New Entrant Reserve. 27.5 million allowances were set aside for “good quality CHP” in the UK. In Phase III, 5% of EU-wide allowances will be set aside for new entrants, but it is not yet clear what share of this, if any, will be ring-fenced for CHP.</div>	

TABLE 3: EMISSIONS TRADING SCHEMES WITHOUT SPECIFIC CHP STRATEGIES PLANNED (AS YET)

SCHEME	DATES	COVERAGE	SCHEME TYPE	DETAILS
US: RECLAIM / California ETS	RECLAIM – set up 1994. California ETS in planning	RECLAIM - southern California ETS – state-wide	RECLAIM – cap-and-trade (NOx & SOx) ETS GHG scheme not yet defined in detail – likely to be source-based cap-and-trade.	RECLAIM - Free allocation through grandfathering. No specific CHP rules. The ETS GHG scheme is in planning. Various options for the scheme design have been proposed (treatment of CHP / proportion of auctioning / sector definitions), but not yet defined. The CPUC published a report that was supportive of CHP, but has not specifically defined CHP rules within the ETS.
Australian ETS / NSW GHG Reduction Scheme	AETS – due 2010 NSW – 2003-2012	Australia / New South Wales	AETS - mandatory cap-and-trade. NSW - credit-and-baseline	Methodologies for the AETS not yet finalised. The NSW GGAS scheme (a credit-and-baseline scheme supportive of CHP) is a pre-cursor to, and will be fully replaced by, the AETS. In the NSW scheme, CHP qualifies as ‘low emissions generation’, and is rewarded with extra ‘abatement certificates’. It is not yet clear how these demand-side abatement certificate incentives for CHP provided in NSW will translate under the AETS in the switch from credit-and-baseline to a cap-and-trade scheme.
New Zealand	Launches 2008	New Zealand	Mandatory cap-and-trade GHG scheme	Final cap & allocation methodology not confirmed yet. No specific CHP rules.
Japan	Launched 2005	Japan	Voluntary cap-and-trade	Japan’s voluntary scheme has no specific CHP rules. A mandatory scheme has been proposed with free allocation through grandfathering – the treatment of CHP is not yet defined.
US Midwest	Design complete Dec 2008.	12 (+) Midwest states	Market-based cap-and-trade	Midwest Regional Greenhouse Gas Reduction Accord still in the early stages of development. Specific rules, including treatment of CHP, yet to be determined.
US / Canada Western Climate Initiative	Design complete August 2008.	7 Western US States + some states in Canada & Mexico	Market-based cap-and-trade	Design so far - mostly auctioning (current recommendation 25-75%, increasing to 100%). Partial free allocation; partner states have flexibility in allocation. Treatment of CHP not explicitly dealt with, but response to consultation suggests possibilities of a CHP sector & a set-aside NER
UK ETS	2002-2006	UK	Source-based; voluntary entry to either cap-and-trade or credit-and-baseline scheme	The UK ETS was established before the EU ETS but was not used as a model for the EU scheme, or for the UK NAP. The scheme was voluntary, the electricity sector was not included and there were no specific incentives for CHP. The UK Government has not been able to identify any new investments in CHP arising from the UK ETS.

Terminology

Allowances: Allowances (synonyms are ‘permits’ and ‘emissions rights’) provide the authorization for a facility to emit CO₂ / GHGs. Typically one allowance gives the right to produce 1 tonne of CO₂. A finite number of allowances are distributed, representing the volume of emissions allowed. In theory, this finite number should result in an overall shortage of allowances, promoting trading between participants.

Auctioning: Auctioning is a method of distributing allowances whereby participants purchase the allowances they require rather than being allocated them for free. Price limitations may apply, but prices are not fixed.

Benchmarking: Allocating permits on the basis of those required in ‘reference cases’, for a typical, and often ‘best available technology’ (BAT) plant of the same energy output. Also known as ‘output based allocation’. This rewards those installations with efficiencies exceeding the benchmark. ‘Double Benchmarking’ compares a CHP plant to the separate generation of electricity and heat – thus providing a means of recognising the emissions reducing potential of CHP. Unless stated otherwise, benchmarking in this paper refers to output rather than input or technology benchmarks.

Cap-and-Trade: An aggregate emissions limit (or ‘cap’) is placed on a group of emitters, reflecting an absolute emissions cap. Participants in the scheme (the emitters) can meet their own portion of the cap, and/or are able to trade emissions allowances between themselves in order to meet the aggregate cap.

Compliance Factor: Refers to the factor used to calculate the year-on-year requirement for emissions reduction (‘ratcheting down’). A compliance factor of 1, therefore, requires no emissions reductions; one of 0.9 requires a 10% reduction.

Carbon Leakage: Carbon leakage is where emissions increase in one country as a consequence of strict emissions reduction policies – including ETS – imposed in another country. The issue has been cited as a barrier to the effectiveness of ETSs in reducing global greenhouse gas emissions. The fear is that, pending a global agreement, emissions reductions in regions covered by ETSs will be achieved through simply shifting the high-emissions industries to regions not covered by ETSs.

Credit-and-Baseline: A group of emitters do not have a set ‘cap’, but are awarded credits (sometimes known as ‘abatement certificates’) individually for achieving emissions reductions beneath a set baseline level. For example, a CHP plant may receive credits for emissions reductions achieved relative to an emissions baseline level which would be expected without CHP installed.

Free Allocation: Allowances are allocated free of charge, either through grandfathering or using benchmarks. Where 100% of allowances are free, the total number of available free allowances reflects the total emissions cap – which should create an overall shortage of allowances.

Grandfathering: Allowances allocated based on historic emission values over a specified period of time.

New Entrant Reserve (NER): A set-aside portion of allowances for new installations. A set of these allowances may be earmarked specifically for new CHP.

Performance-Based Scheme: Market-based emissions trading scheme which sets a relative rather than absolute emissions cap, linked to the level of economic growth. This type of scheme is favoured by industrialising nations such as India and China.

Source-Based Scheme: Allowances are required to be obtained at the emissions source – accountability is with the generator rather than the end-user.

End Notes

1. International Energy Agency (2008), *Combined Heat and Power – Evaluating the benefits of greater global investment*. http://www.iea.org/Textbase/Papers/2008/CHP_Report.pdf
2. Intergovernmental Panel on Climate Change (2007), *IPCC 4th Assessment Report: Climate Change 2007*, <http://www.ipcc.ch/ipccreports/assessments-reports.htm> **NAPs**.
3. Joint Implementation (JI) and the Clean Development Mechanism (CDM) are mechanisms that allow countries with Kyoto commitments to make reductions in other countries that do not have commitments.
4. There is also the choice of at what point the ETS is established in the emissions cycle. In the United States, a number of programmes are under consideration that regulate natural gas on an "upstream" basis; i.e., at the level of the producer, processor, or pipeline. Such an approach would increase the price for natural gas, affecting any type of facility that uses gas, without regard to end use or size. As a result, most of the discussions in this paper will not be applicable to an upstream system of GHG regulation.
5. Ellerman, A.D., Buchner, B.K. and C. Carraro (eds.) (2007), *Allocation in the European Emissions Trading Scheme: Rights, Rents and Fairness*. Cambridge University Press.
6. DRAFT REPORT on the proposal for a directive of the European Parliament and of the Council amending Directive 2003/87/EC so as to improve and extend greenhouse gas emission allowance trading system of the Community (2008/0013(COD)). (2008). Amendment 21.
7. Swedish Ministry of Sustainable Development (2006): *Sweden’s National Allocation Plan for Emission Allowances 2008-2012*. Paragraph 3.1.1. <http://www.sweden.gov.se/content/1/c6/06/97/78/9ab84663.pdf>.
8. Europa.eu press release (2008) “Questions and answers on the Commission’s proposal to revise the EU Emissions Trading System”, <http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/08/35&format=HTML&aged=0&language=EN&guiLanguage=en>.
9. Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (2004) *National Allocation Plan for the Federal Republic of Germany 2005 - 2007*. Section 4.3.2 http://www.bmu.de/files/pdfs/allgemein/application/pdf/nap_kabi_en.pdf.
10. See http://ec.europa.eu/environment/climat/emission/nap_2005_2007.htm and http://ec.europa.eu/environment/climat/2nd_phase_ep.htm.
11. See http://ec.europa.eu/environment/climat/emission/nap_2005_2007.htm.
12. Swedish Ministry of Sustainable Development, 2006: *Sweden’s National Allocation Plan for Emission Allowances 2008-2012*. Paragraph 3.1.1. (at <http://www.sweden.gov.se/content/1/c6/06/97/78/9ab84663.pdf>).
13. Directive 2004/8/EC of the European Parliament and of the Council of 11 February 2004 on the promotion of cogeneration based on a useful heat demand in the internal energy market and amending Directive 92/42/EEC. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32004L0008:EN:NOT>.

