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Study on free allocation of emission allowances for district heating production under ETS for the period 2013-2020 based on benchmarking principles

24.4.2009

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Contents

1 Introduction

The European Commission is currently preparing revised rules for the allocation of emission allowances for the post-Kyoto period 2013-2020. EU has chosen cap-and-trade system for CO2-emissions as the main instrument to limit greenhouse gas emissions. This Emissions Trading Scheme (ETS) system has been practised during Phase I in 2005-2007 and is now in Phase II during the Kyoto-period 2008-2012. Member States have made national allocations of emissions allowances that have been approved by the European Commission.

The rules of allocations of emission allowances will now be harmonised Community-wide. The basis for the new rules for the allocation is the EU Emissions Trading Scheme Directive[1]. The Directive will be revised in order to improve and extend the greenhouse gas emission allowance trading system[2]. The final decisions will be made after data collection and further work of consultants as well as stakeholder consultation. The Commission shall adopt the new allocation measures by the end of 2010.

According to the proposed revised ETS Directive, the initial free allocation of allowances will be based on Community-wide *ex ante* benchmarks. The objective is to give incentives for both emissions reductions and the use of energy efficient techniques. In addition, the revised rules should take into account substitutes, alternative production processes, high efficiency cogeneration, efficient energy recovery of waste gases, use of biomass, and capture and storage of carbon dioxide.

The revised benchmarks shall be calculated for products rather than for input of fuel or raw materials. The purpose is to maximise greenhouse gas emissions reductions and energy efficiency savings throughout all production processes. The benchmarks will be separate for all industrial sectors and therefore also for district heat. Initial free allocation is unlikely to cover all emissions in any sector. The basic principle is that free allocation in 2013 will be 80% of historical emissions in 2005-2007. After that, the free allocation will decrease each year. In 2020 the free allocation will be around 30 % and there will be no free allocation by 2027.

Tentatively, no free allocation shall be given to electricity production. However, free allocation shall be given to district heating as well as high efficiency cogeneration for economically justifiable demand, in respect of the production of heating or cooling. High efficiency cogeneration is defined by the CHP Directive (Directive 2004/8/EC).

This study focuses on the initial free allocation of emission allowances for district heating and high efficiency cogeneration. The objective of the study is to compare various benchmarking methods, and show, in practice, how much free allocations would be given to various kinds of district heating plants, if certain benchmarking methods were used. The study covers both benchmarking methods

[1] Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC

[2] Proposal for a Directive of the European Parliament and of the Council amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading system of the Community. Brussels, January 14, 2009.

that have already been utilised in some Member States and methods that are in line with the proposed revised ETS Directive. The study includes separate heat production and cogeneration of heat and power. As the latter one is more complex, more emphasis have been put on cogeneration. Special attention has been paid to two issues: 1) how to divide emission between heat and electricity in cogeneration and 2) how to define the benchmark for free allowances. The approach used is based on case studies of real-life case examples of modern district heating plants with various technology and fuel options in Finland. By using real-life examples, more concrete overview of the effects of benchmarking can be achieved.

The study also covers the allowance allocation in selected Member States for the emission trading period 2008-2012. The analysis is made on the basis of the national allocation plans (NAPs) for district heating or cogeneration. The countries studied in detail were Sweden, Denmark, UK, Germany, Austria, Estonia, Latvia, Lithuania, Slovakia and Poland.

This study has been made for the Ministry of Employment and the Economy as part of the national preparations for the post-Kyoto period. The study has been made by Gaia Consulting Oy.

2 District heating and cogeneration

2.1 District heating system

2.1.1 Overview

District heating system provides centrally generated heat to meet customer heat demand in various locations. The system consists of a heat distribution system and typically large heat generating plants. The district heating system can combine many demand points and production units. A larger system creates benefits for the resource use, although the losses from distribution reduce the benefits of centralized heat production in scarcely populated areas. It is also possible to use generated heat for district cooling. Figure 2.1 presents a simplified overview of a district heating system.

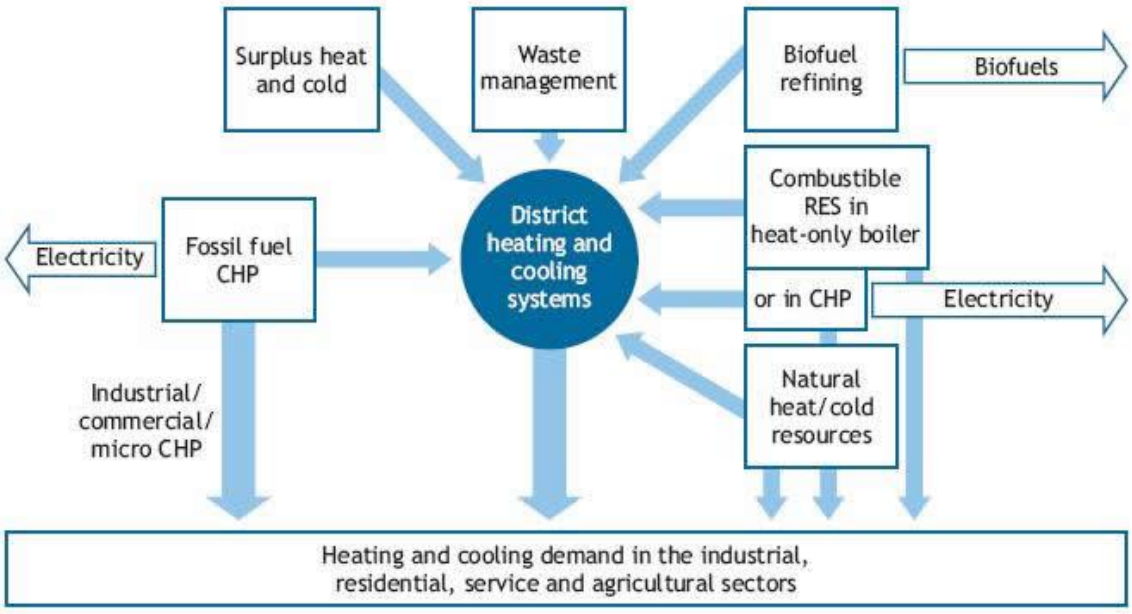

Figure 2.1. District heating system.[3]

The most common ways to produce heat to district heating system are:

- separate production of heat in heat boilers
- combined heat and power production (CHP)
- utilising surplus heat sources, e.g. secondary heat from industry

In the following Chapters, these production types are presented in more detail in order to create better understanding on the effect of various production types and technologies and their implications to allocation of free emission allowances for district heating.

2.1.2 Separate production of heat

The simplest way to produce district heat is the separate production of heat in a boiler plant. Separate heat production is relatively simple and can use most types of fuels without technical limitations. The efficiency of separate production of heat is fuel dependent. Table 2.1 lists harmonised efficiency reference values for various fuels in separate production of heat. The best efficiency can be achieved with natural gas, followed by refinery gases, hydrogen, oil, and liquid biofuels. The worst efficiencies are generally associated with various wastes either in solid, liquid or gaseous form.

[3] IEA, www.iea.org, referenced 7 Apr 2009.

Table 2.1. *Harmonised efficiency reference values for various fuels in separate production of heat*[4].

	Type of fuel	***Efficiency***
Solid	Hard coal/coke	88 %
	Lignite/lignite briquettes	86 %
	Peat/peat briquettes	86 %
	Wood fuels	86 %
	Agricultural biomass	80 %
	Biodegradeable (municipal) waste	80 %
	Non-renewable (municipal and industrial) waste	80 %
	Oil shale	86 %
Liquid	Oil (gas oil + residual fuel oil), LPG	89 %
	Biofuels	89 %
	Biodegradeable waste	80 %
	Non-renewable waste	80 %
Gaseous	Natural gas	90 %
	Refinery gas/hydrogen	89 %
	Biogas	70 %
	Coke oven gas, blast furnace gas + other waste gases	80 %

As free emission allowances are allocated for district heating, the most important question in separate production of heat is: What is the efficiency value used for heat production calculation? Is it the harmonised efficiency reference value for each fuel or is the best reference value (90 %) for all fuels or something else?

2.1.3 Surplus heat use

Many industrial processes use heat and steam that needs to be generated on-site. There are several reasons why excess heat from these industrial sites is beneficial to use in district heating. The industrial processes typically also consume electricity. Therefore the benefits of cogeneration are also available in industrial sites (see previous section). However, a feasible sized combined heat and power plant can end up generating too much heat for the process needs in the industry site.

Heavy industrial processes that require heat generation typically work all-year round in steady shifts. In district heating networks, temperature dependent variations affect the heating load. However, the hot water demand is rather stable all-year round. A combination of industrial load and hot water load can result in a feasible production facility.

Energy efficiency developments and industrial production variations can result in the reduction of the heat loads in the industrial processes over time. However, the production units have been planned to cover the original loads.

2.2 Cogeneration of heat and power

Cogeneration of heat and power uses less primary energy resources compared to generation of corresponding amount of heat and power in separate production facilities. Electricity generation in

[4] Commission Decision of 21 Dec 2006, Official Journal of the European Union, 2007/74/EC.

combustion plants generates always also heat. The main idea of combined heat and power (CHP) production is to take advantage of this heat in district heat or industrial applications.

Heat demand usually determines how a cogeneration plant is operated. In district heating, the demand for heating and hot water determines how much heat needs to be generated. In industrial processes, the process heat requirements are set by the industrial process. The cogeneration plants are typically large units. They are typically preferred in heat production over separate heat generation because of the value of electricity generated.

There are various technologies that can be utilised in cogeneration. The most common cogeneration technologies are:

- Combined cycle gas turbine with heat recovery
- Steam backpressure turbine
- Steam condensing extraction turbine
- Gas turbine with heat recovery
- Internal combustion engine

In addition to these conventional technologies, the CHP directive names some other new technologies[5]. These include micro turbines, Stirling engines, fuel cells, steam engines and Organic Rankine Cycles.

The emissions from cogeneration depend primarily on the fuel mix and secondarily on the efficiency of the production process. Table 2.2 gives an overview of various technologies and their suitability for various fuels. More detailed list of various solid, liquid and gaseous fuels are give in Table 2.1.

Table 2.2. *Various cogeneration technologies and their suitability for fuel types.*

Technology	***Solid***	***Liquid***	***Gaseous***
(a) Combined cycle gas turbine with heat recovery	no	yes	yes
(b) Steam backpressure turbine	yes	yes	yes
(c) Steam condensing extraction turbine	yes	yes	yes
(d) Gas turbine with heat recovery	no	yes	yes
(e) Internal combustion engine	no	yes	yes
(f) Microturbines	no	yes	yes
(g) Stirling engines	yes	yes	yes
(h) Fuel cells	no	no	yes
(i) Steam engines	yes	yes	yes

The choice of cogeneration technology affects also how much electricity can be generated for a certain heat load. The total energy efficiency of modern cogeneration technologies varies only modestly in district heating applications. The efficiency including both electricity and heat is typically around 90 %. However, the power to heat ratio of the technologies varies significantly. Typical values of power to heat ratio, based on the technologies mentioned in CHP Directive, are given in Table 2.3.

[5] Directive 2004/8/EC on the promotion of cogeneration based on a useful heat demand in the internal energy market

Table 2.3. *Typical power to heat ratios of the most common cogeneration technologies.*[6]

Type of the unit	Default power to heat ratio, C
Combined cycle gas turbine with heat recovery	0,95
Steam backpressure turbine	0,45
Steam condensing extraction turbine	0,45
Gas turbine with heat recovery	0,55
Internal combustion engine	0,75

The power to heat ratio tells how many units of power are produced per unit of heat produced. If one unit of heat is produced, electricity production is 0.45 units in a typical steam backpressure turbine. In combined cycle gas turbine, electricity production is 0.95.

Figure 2.2 illustrates the effect of cogeneration technology choices to heat production in two cases. The amount of heat generated in a cogeneration facility can be determined by the primary energy efficiency and the power to heat ratio of the facility. If the primary energy efficiency is 90 %, the losses of the plants are 10 %. This means that 100 units of fuel are converted to 90 units of usable energy in the form of heat and electricity. The power to heat ratio determines how the energy is divided between heat and electricity. In steam backpressure turbine 100 units of fuel is converted into 62 units of heat and in combined cycle gas turbine into 46 units of heat.

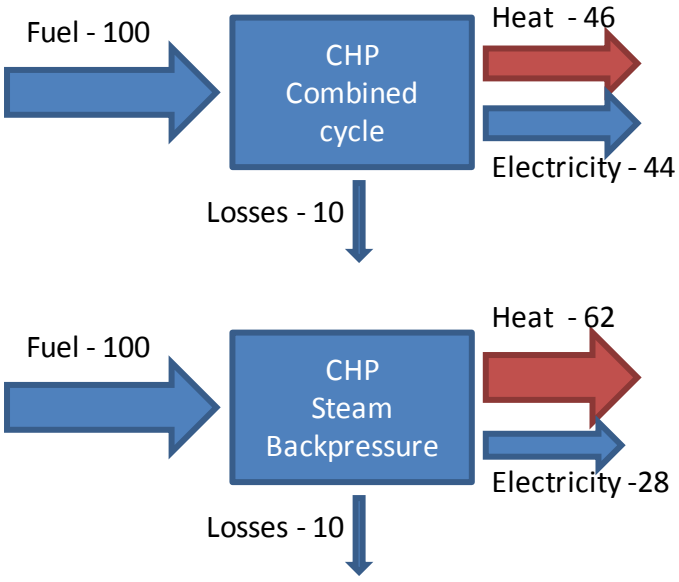

Figure 2.2. *Production of heat and power in combined cycle gas turbine and steam backpressure turbine.*

As a summary, there are various cogeneration technologies but only certain fuels can be used with certain technologies. Because the availability of various fuels is limited geographically, there is actu-

[6] Directive 2004/8/EC on the promotion of cogeneration based on a useful heat demand in the internal energy market.

ally no free choice of fuel and technology, but the selection depends on local conditions. The power to heat ratio of different technologies varies significantly. This means that distribution of emission between heat and power can have significant effect on benchmarking of free allowances, and thus, the competitiveness of different technologies in district heating.

2.3 Distribution of CHP emissions to heat and power

Cogeneration uses the same fuel input to produce two products: heat and power. The emissions from cogeneration depend on fuel use. The treatment of power production will be different from the treatment of heat production in the revised initial allocation rules. Therefore, there is a need to divide the emissions between heat and power. There are several ways to make the division. Some of the methods that have been used are:

- *Alternative heat procurement method*, in which emission distributed to heat are set equal to the emissions from alternative heat procurement source. The alternative is usually a separate production of heat with the same fuel. The rest of emissions are allocated to electricity.
- *Alternative electricity procurement method*, in which emissions of alternative electricity procurement are subtracted and the rest is allocated to heat.
- *Benefit sharing method* that distributes the emissions on the basis of the fuel use of alternative production sources. The benefits of cogeneration are given to both heat and power production.
- *Energy method*, in which emissions are divided between heat and power according to produced amount of energy.
- *Price method*, in which emissions are distributed to heat and electricity based on their market value.
- *Ex-ante dividing method, such as "Swedish 2/7 method"* that distributes 2/7 of the total emissions to heat and 5/7 of the total emissions to electricity.

The method used to divide emissions between heat and power affects the amount of emissions for district heating in benchmarking. Figure 2.3 illustrates this effect in the case of extraction steam turbine plant that produces electricity, district heat and process heat. The alternative heat procurement model associates the most of the emissions to heat production. The share of heat production is the least with the Swedish 2/7 method. The other methods are in between these two extremes in this particular facility.

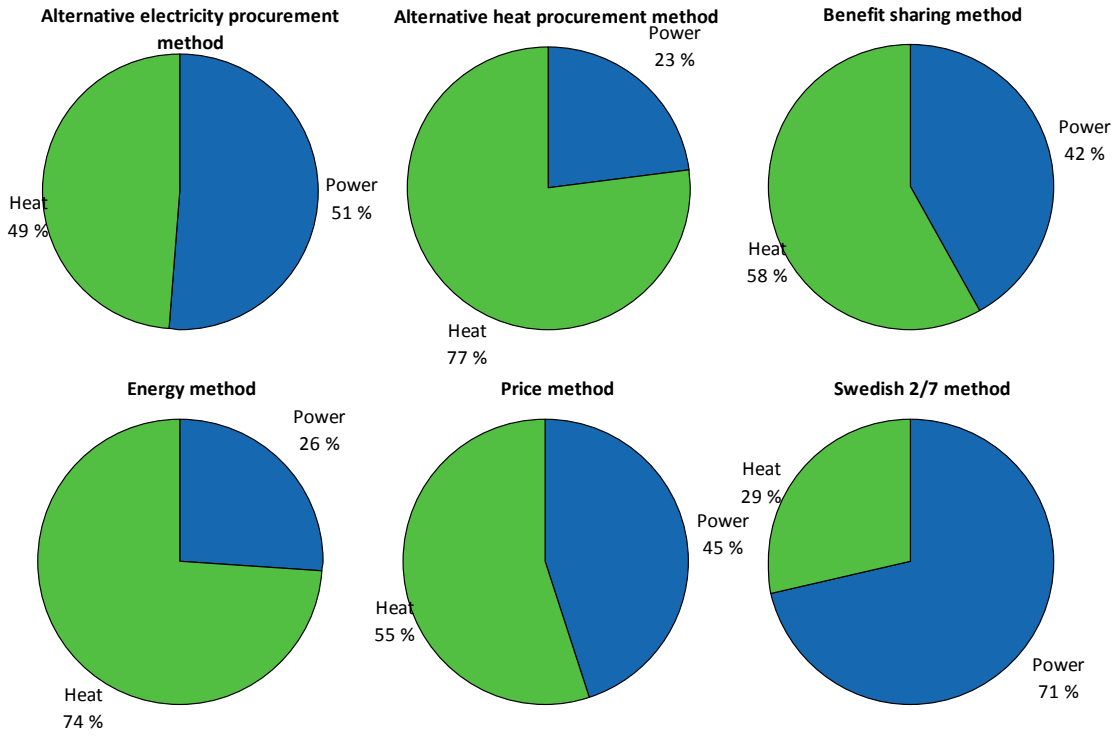

Figure 2.3. *Distribution of emissions between heat and power in a cogeneration plant with various distribution methods*[7]*.*

Furthermore, the emission distributed for district heat compared to total emissions of the plant depends also heavily on technology. In order to clarify this issue, Figure 2.4 presents an example of two distribution methods and two technology choices. The combined cycle gas turbine (CCGT) plant generates more electricity per unit of heat than the steam turbine backpressure plant (ST). Therefore, both alternative heat procurement and benefit sharing method allocate more emissions to power in the CCGT plant than in the ST plant. If the Swedish 2/7 rule is used, the share of heat is around 29 % in both plants.

[7] Finnish Ministry of Trade and Industry, Division of emissions from combined heat and power production (*in Finnish*), 1999. The plant in question uses extraction steam turbine to generate electricity, district heat, and process heat.

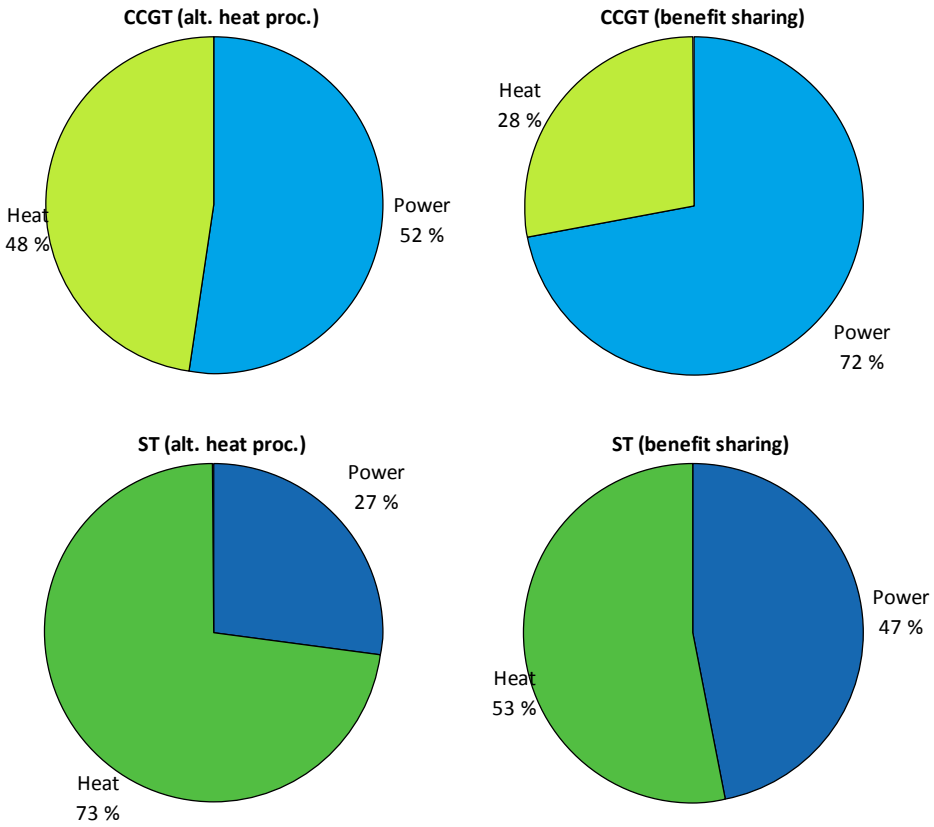

Figure 2.4. *Distribution of emissions between heat and power in a combined cycle gas turbine (CCGT) and a steam turbine backpressure (ST) plant with the alternative heat procurement method and the benefit sharing method*[8].

In practice, the method to distribute emissions between heat and power affects 1) the setting of the benchmark level and 2) the internal bookkeeping of the cogeneration plant owner. The previous one means that the level of benchmark is higher, if we use a method that divides emission relatively more for heat than electricity (e.g. alternative heat procurement method compared to benefit sharing method, see Fig. 2.4.). The latter one means that cogeneration plant owner must divide overall emission allowance costs for heat and electricity, and in this calculation, the emission distribution must be taken into account.

It must be also noted, that the emissions that are not associated to heat will burden the electricity generation. Thus, for a cogeneration plant owner, it is therefore always better, if a high share of heat is used in benchmarking, because electricity does not receive any initial free allowances.

[8] Finnish Ministry of Trade and Industry, Division of emissions from combined heat and power production (*in Finnish*), 1999. The plant in question uses extraction steam turbine to generate electricity, district heat, and process heat.

3 Benchmarking in district heating production

3.1 Benchmarking in earlier National Allocation Plans

Many member states have used benchmarking already during the first and second phase of the Emissions Trading Scheme (ETS). Mostly benchmarking has been used to define the allocation for new entrants. In their National Allocation Plans (NAPs), member states define the allocation of emission allowances to energy in general, and heat and electricity in particular. There has been a general tendency in many NAPs to favour efficient cogeneration installations. As there are no allowances granted for electricity production for 2013-20 emission trading period, the allocation methods in second phase NAPs are not directly comparable.

The allocation methods and benchmarking models used in the second phase NAPs of selected member states are described in more detail in Appendix A. The comparison of selected countries in terms of benchmarking methods and allocation of emission allowances to CHP plants are summarised in Table 3.1.

Table 3.1. *Comparison of benchmarking methods and allowances to CHP in selected countries.*

Country	Benchmarking	Allocation in CHP plants
Sweden	For new entrants allocation	Allocation to new entrants is based on defined benchmarks for electricity and heat. When defining the benchmarks, the division of emissions for heat and electricity in a CHP plant was based on multiplying the electricity emissions with a factor of 2.5 whereas the factor for heat is 1.0. No allowances will be given for free for existing installations.
Denmark	For new entrants allocation	In CHP production, the calculation is based on distribution of fuels between electricity and heat using a heat efficiency of 125%.
UK	For new entrants and for existing large electricity producers	Based on historical emissions for existing plants and benchmarks for new entrants. New CHP installations get 100% allocation compared to the estimated need whereas other sectors get less than required.
Germany	Benchmarks are used in the allocation for existing energy sector installations and new entrants. The benchmark defined for heat production is 345 gCO2/kWh and 225 gCO2/kWh if gas can be used as a fuel and for electricity production 750 gCO2/kWh and 365 gCO2/kWh if gas can be used as a fuel, for CHP allocation based on a double benchmark	Allocation based on both production of heat and electricity which results in more generous allocation as for separate production
Austria	For existing electricity and CHP installations, a benchmark approach is used in defining an efficiency factor for the sector. For new entrants benchmarking is used.	A special bonus given to CHP producers if primary energy savings of at least 10% have been realised.
Estonia	No benchmarking	Not discussed separately

Latvia	Set benchmarks for suggested efficiency coefficients for new entrants	For existing plants based on historical emissions. For new entrants based on forecast emissions and efficiency coefficients (benchmarks may be used if no other data available)
Lithuania	No benchmarks used	Special rules for the allocation for existing CHP plants and new entrants
Slovakia	No benchmarking	Not discussed separately
Poland	Benchmarking is used directly in the installation level allocation of heating plants. In addition, the sector level allocation is based on defined average emissions for certain production.	A cogeneration bonus given for the sector as a total. Exact allocation method based on an agreed algorithm not given in the NAP.

In the German NAP for the second trading period, the benchmarking is done on the basis of fuel specific emission factors given for heat and electricity production. The allocation for CHP producers is done so that they get allowances for both heat and power production. Therefore they get on average a bigger share of their historical emissions covered by free allocation compared to separate production. The fuel specific benchmarks are defined so that the benchmark of production with natural gas is used if gas is available. Only if it is not possible to use natural gas as a fuel, the benchmark for other fuels is used. The benchmark for other fuels is on a higher level than the benchmark for natural gas. The benchmarks are based on best available technology.

In the second NAP of UK, the benchmarks used in district heating production are based on the production technology. For small heating units, the benchmarks are based on a defined capacity use factor and an efficiency benchmark. For new CHP plants, there are different benchmarks set for load factors and efficiencies of the following technologies: Gas engine CHP, Back pressure ST (steam cycle only), Pass out / condensing ST (steam cycle only), Simple cycle gas turbine and Combined cycle gas turbine.

In Swedish NAP for the second period, free allowances are only given to new entrants that are highly-efficient co-generation plants as defined in the CHP Directive[9]. The purpose is to favour establishment of cogeneration plants compared to less energy efficient alternatives. There are benchmark levels for both heat and electricity production. These benchmark levels have been defined on the basis of the average CO2 emissions in Swedish heat and electricity production in 2000-2004. The division between heat and power emissions during the benchmark definition was made using the 2/7 rule, i.e. 2/7 of the emissions are allocated to heat.

In the Danish NAP, a production capacity based approach has been used for benchmarking. Allocation for new entrants is based on the electric and heat capacity of the installation to be built. There are different benchmarks for CHP and heat only production. Assumed use of installations is over 3000 hours per year. If the planned use is less than that, the amount of allowances granted for free is reduced.

[9] Directive 2004/8/EC on the promotion of cogeneration based on a useful heat demand in the internal energy market

3.2 Proposed approach on the basis of the revised ETS directive

3.2.1 General guidelines for allocating of allowances

According to the proposed revised ETS Directive, the Commission shall publish the absolute community-wide quantity of allowances for 2013 by 30 June 2010. The total quantity of allowances is set on the basis of the total quantities of allowances issued or to be issued by the member states in accordance with the Commission Decisions on their national allocation plans for the period 2008 to 2012. The quantity of allowances issued each year starting in 2013 shall decrease in a linear factor of 1.74% compared to the average annual total quantity in 2008 to 2012 period.

Of the total quantity of allowances, only part will be given in the initial free allocation and the most of the allowances will be auctioned. Free allocations will be given to certain industrial sectors and district heating. According to the proposed ETS Directive, free allocation is determined on the basis of the emissions in 2005 to 2007 period. In 2013 the free allocation would be 80% of the amount that corresponded to the percentage of the overall community-wide emissions throughout the period 2005 to 2007 that those installations emitted as a proportion of the annual community-wide total quantity of allowances. Thereafter, the free allocation should decrease each year by equal amounts resulting in 30% free allocation in 2020, with a view to reaching no free allocation in 2027.

The allocation of allowances will be based on *community-wide ex ante benchmarks*. According to revised ETS Directive, the benchmark shall be calculated for products rather than for inputs. The target is to maximise greenhouse gas emissions reductions and energy efficiency savings throughout each production process of the sector or the sub-sector concerned. In defining the principles for setting ex-ante benchmarks in individual sectors or subsectors, the starting point shall be the *average performance of the 10% most efficient installations* in a sector or sub-sector in the Community in the years 2007-2008.

3.2.2 Probable implications of benchmarking

The revised ETS directive defines the principles how the allocation will be carried out in the ETS sectors. There is no free allocation for electricity production. The initial allocation for electricity is done by auctioning. For district heating and industries, the initial free allocation is made on the basis of benchmarks. The revised ETS directive gives general level guidelines on how the benchmarks are defined. Specific details are still open in district heating and cogeneration of heat and power.

The overall principle is that the benchmarks are set for products. This means that district heat should be treated in the same manner regardless of the technology and fuel it is produced with. It also means that cogeneration and separate heat production should be treated in the same manner. To remain comparable, the emissions from CHP need to be divided between heat and power with the alternative heat procurement method (see Chapter 2.3).

The actual benchmark figure is only one factor in the allocation formula. Allocation is defined by the capacity of the installation, capacity use factor for the installation, the product specific benchmark, and possible adjustment factor for the sector or sub-sector. A simplified formula for the allocation can therefore be written as:

*Allocation = Benchmark * Activity level * Adjustment factor*

Focus of this study is on how the benchmark level is set, but the effects of the other factors are also touched briefly in the following.

The proposed revised ETS directive states that the benchmark levels will be determined on the basis of the average performance of the 10 % most efficient installations in a sector or sub-sector in the EU. The final benchmark determination can include also other considerations. Most efficient techniques, substitutes, and other factor will be taken into account when the final benchmark levels are set.

There is no exact data on what is the average performance of the 10 % most efficient installations. If biomass and other renewable sources account for the 10 % of installations, the emissions benchmark is simply zero. The next most efficient production form that is widely available is high-efficiency natural gas fired production. Together these two most likely cover the 10 % most efficient installations. The benchmark will therefore be between the performance of the high performance natural gas plant, i.e. around 215-220 gCO/kWh, and the performance of renewable generation, i.e. 0 gCO2/kWh.

According to the revised ETS directive, the allocation shall be made using the *ex ante* principle, i.e. the amounts of emissions allowances allocated to the installations are defined beforehand. Emissions relate to the activity level, i.e. to the production volumes, of the installations. Hence, the upcoming production volumes need to be estimated in advance. The estimation can be done e.g. by using historical values for existing installations. For new entrants, the estimation can be made using verified capacities and capacity use factors estimated on the basis of the average use in the sector.

Benchmark based allocation does not guarantee that the total emissions of the sector will be reduced. Increased emissions from new installations and changes in production volumes or fuel mix can more than compensate the intended *ex ante* reductions. Also, it is possible that some sectors will receive higher overall allocation than the other sectors. Therefore it is possible, that sector specific adjustment factors will be used. In addition, the free allocation will be reduced gradually during the period from 2013-2020 on the basis of the directive.

3.2.3 Open issues

Establishment of the 10 % average performance within EU is no trivial exercise. The number of installations within the EU ETS systems is large, and the time frame and resources for the study are limited. There have been three alternatives in the discussion[10]:

1. Full bottom-up data collection covering all installations
2. Benchmark levels set on the basis of literature review and expert view
3. Benchmark levels set on the basis of literature review and expert view and a limited data collection exercise from a representative sample.

The data on which installations should be included in benchmarking might also be somewhat unclear. Normally only installations with over 20 MW thermal capacity are included in the ETS. However, in

[10] European Commission, DG Environment, TWG on benchmarks, presentation, 13 Feb 2009.

Finland and Sweden, also some smaller installations are currently within ETS, because of the so-called opt-in method.

The data on fuels and technologies used in district heat production are not readily available. The share of renewables was 9 % and the share of natural gas 39 % of all CHP production in the EU-27 in 2005[11]. However, almost half of the CHP fuels are used in the industry[12]. The share of renewables can be higher in some industrial sectors than in the district heating sector, like pulp and paper production. Also, the figures do not include separate heat production. Therefore the share of renewables used in district heating can be higher or lower than the 9 % for the whole CHP production. Also, the share of production does not equal the share in the number of installations as the capacities of the installations vary. In addition, some installations can use renewables as part of a fuel mix with fossil fuels.

The 10 % most efficient percentile is said to be defined on the basis of the number of installations. As discussed above, this level is not necessarily very straightforward to determine. Also, the role of very small installations becomes then dominant, and consideration needs to be done for example for the opt-in method. More straightforward statistics would be available on the production capacity and historical production volumes of the installations.

The division of cogeneration emissions between heat and power will also affect the definition of the benchmark level. If the alternative heat procurement method is used, cogeneration of heat and separate heat production receive a similar treatment in benchmarking. If some other method is used, the share of heat emissions from cogeneration will be smaller. This will lead to a lower benchmark level than with the alternative heat procurement method.

The proposed directive does not explicitly state what is included in the product specific benchmark. This can affect the treatment of district heat and simultaneous generation of process heat. However, it is probably safe to assume that process heat used in the industry will be included in the industry specific allocation. For existing installations, the actual district heat production can be verified. For new entrants, the definition of *ex ante* heat capacity can become problematic, as the heat can be directed to many applications.

According to the CHP directive, the efficient cogeneration should be advanced within EU. However, under the revised ETS directive the benchmarking is intended to be product-wise. This makes it challenging to create benefits for efficient CHP compared to separate district heating.

[11] EEA, Energy and environment report 2008.

[12] Eurostat, Statistics in Focus, Environment and Energy, 3/2006.

4 Effects of benchmarking

4.1 Real world case studies

The effects of benchmarking to CHP plants are studied through real life case studies. The cases are descriptive of modern CHP facilities built recently or now under construction in Finland. The case-studies are used to make the effects of benchmarking tangible. Three CHP-plants have been selected for the case-studies with varying technology, capacity and fuel mix.

The first example facility, Plant A, is a modern combined cycle gas turbine (CCGT) with heat recovery. The plant is used to generate electricity and district heat. Electricity is generated both in a gas turbine, 172 MWe, and in a steam turbine, 66 MWe. The total power output is 238 MWe. Excess heat is used to produce district heat at 214 MWth. The main fuel of the plant is natural gas. The total fuel efficiency of the plant is 91 %.

Plant B uses straightforward steam backpressure turbine technology to generate electricity and district heat. The power output is 20 MWe and the district heat output 50 MWth. Main fuels are peat and wood or other renewable biomasses. The plant has total efficiency of around 88 %. Plant B is the only one that is not located near the natural gas pipeline network.

Plant C is a steam condensing extraction turbine. The plant generates electricity and heat to both industrial use and district heating. Process heat of 130 MWth is extracted from the turbine. Turbine generates electricity at maximum of 60 MWe. The steam that goes through the turbine is directed to heat exchangers that generate district heat at maximum of 110 MWth. Alternatively, the steam can be used for additional condensing power generation at the maximum of 50 MWe. The fuel sources of the plant are 1) bark and other wood, for example logging residues, stumps, and small wood from thinnings 2) peat and 3) natural gas. The total fuel efficiency of the plant is around 91 %. More precise numerical values for the cogeneration installations are given in Table 4.1. It should be noted that the amount of heat generation and the condensing power production do not affect the benchmark level calculations made with the alternative heat procurement method.

Table 4.1. *The key characteristics of case study examples.*

	Technology	Fuel mix	Heat output	Power output	Total efficiency
Plant A	Combined cycle gas turbine	Nat. gas 99 % Oil 1 %	214 MW district	238 MW	91 %
Plant B	Steam backpressure turbine	Peat 53 % Biomass 47 %	50 MW district	20 MW	88 %
Plant C	Steam condensing extraction turbine	Peat 30 % Biomass 67 % Nat. gas 3 %	130 MW process 110 MW district	60 MW + 50 MW cond.	91 %

With the parameters described above, it is possible to roughly calculate the total emissions from the power plants. In the first calculations, the emissions are divided between heat and power with the alternative heat procurement model. Table 4.2 presents the results of the calculations. Because the focus is now on heat benchmarks, the emissions figures are given in units of grams of CO2 emitted per kilowatt-hour of heat produced. Therefore, the power emissions and total emissions are not very descriptive but are given for completeness. Plant A produces comparably more power and less heat than the other installations. The calculatory total emissions per heat unit produced are thus higher for Plant A than Plant B. The emissions for Plant C are the lowest because of the high share of renewables.

Table 4.2. *Calculatory emissions from the case study installations. Emissions are given in units of CO2 per produced unit of heat. Alternative heat procurement model is used for dividing emissions between heat and power.*

	Technology	Fuel mix	Heat emissions	Power emissions	Total emissions
Plant A	Combined cycle gas turbine	Nat. gas 99 % Oil 1 %	221 gCO2/kWh$_{th}$	242 gCO2/kWh$_{th}$	463 gCO2/kWh$_{th}$
Plant B	Steam backpressure turbine	Peat 53 % Biomass 47 %	226 gCO2/kWh$_{th}$	85 gCO2/kWh$_{th}$	311 gCO2/kWh$_{th}$
Plant C	Steam condensing extraction turbine	Peat 30 % Biomass 67 % Nat. gas 3 %	129 gCO2/kWh$_{th}$	57 gCO2/kWh$_{th}$	186 gCO2/kWh$_{th}$

4.2 Assumed effects of benchmarking

The nature of benchmarking requires that the level that sets the benchmarking is quantified. As describe in Chapter 2.3.3, data to precisely determine the benchmark level for district heating does not exist. Biomass or waste fired cogeneration and high efficiency natural gas plants will most likely dominate the top 10 % efficient installations. In the case the benchmark level is calculated on the basis of natural gas fired combined gas cycle plant, the benchmark level will be around 215-220 gCO2/kWh. In the case biomass or waste fired production is used, the benchmark level will be 0 gCO2/kWh.

In the calculations below, the high efficiency natural gas plant is used as a benchmark value. The exact value used is 220 gCO2/kWh. This value is used to calculate the initial free allocation to the district heating plants. This is likely to represent the upper level for the actual benchmark for all EU installations that produce district heat. It corresponds to the emissions from a separate natural gas fired heat production with efficiency of 90 %.

Figure 4.1 compares the assumed benchmark allocation to the calculatory emissions from the case study plants. If the calculatory emissions are higher than the benchmark level, then the plant owner

is required to purchase additional allowances to meet its obligations. If the calculatory emissions are lower than the benchmark level, the plant owner can sell the additional allowances to the markets (assuming that the activity level is unchanged and the adjustment factor is 1).

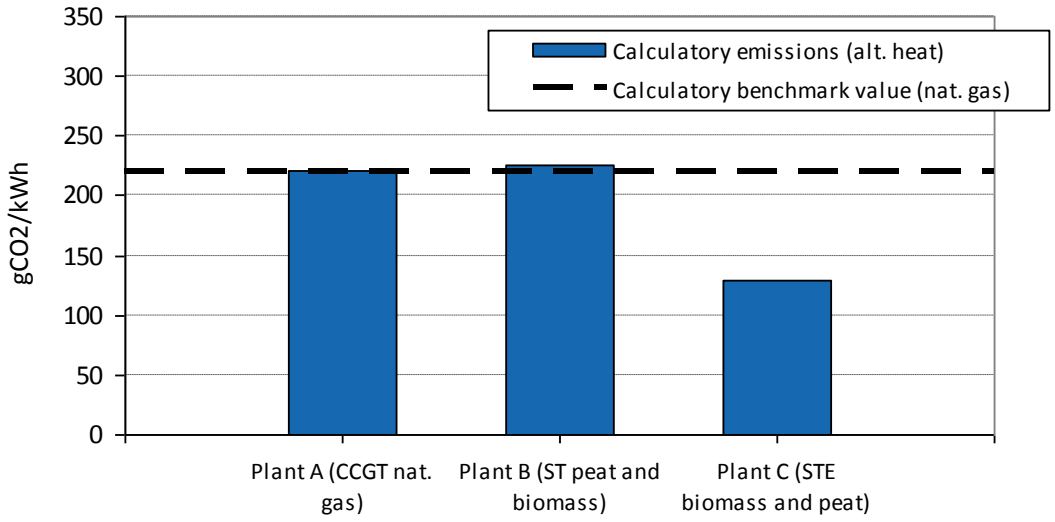

Figure 4.1. *Calculatory emissions of the case study plants and calculatory natural gas based benchmark level (without any reduction factors).*

Plant A is a modern combined cycle gas turbine that uses natural gas. It is very similar to the assumed natural gas fired benchmark installation. The only difference in these calculations comes from the 1 % oil share in the fuel mix of Plant A that results in slightly higher emissions. Plant B is a simple steam turbine unit that uses roughly half peat and half renewables as its fuel source. The resulting emissions happen to be very close to the benchmark level, if the emissions between heat and power are divided by the alternative heat procurement method. Plant C has the lowest emissions. It is an extraction steam turbine that uses roughly 2/3 renewables as fuel, the rest being peat and natural gas.

4.3 Supplementary analysis of benchmarking

4.3.1 The effect of heat and power division

As discussed above, the way how emissions of a CHP plant are divided between heat and power has an effect on benchmarking. Figure 4.2 illustrates the effect of various division methods to calculatory heat emissions of the case study plants. The division methods studied are alternative heat procurement method, benefit sharing method (see Chapter 2.3) and Swedish 2/7 division method (see Chapter 3.1). The units are in emissions per heat produced. Note that the total emissions of the whole plant remain the same regardless of which division method is used.

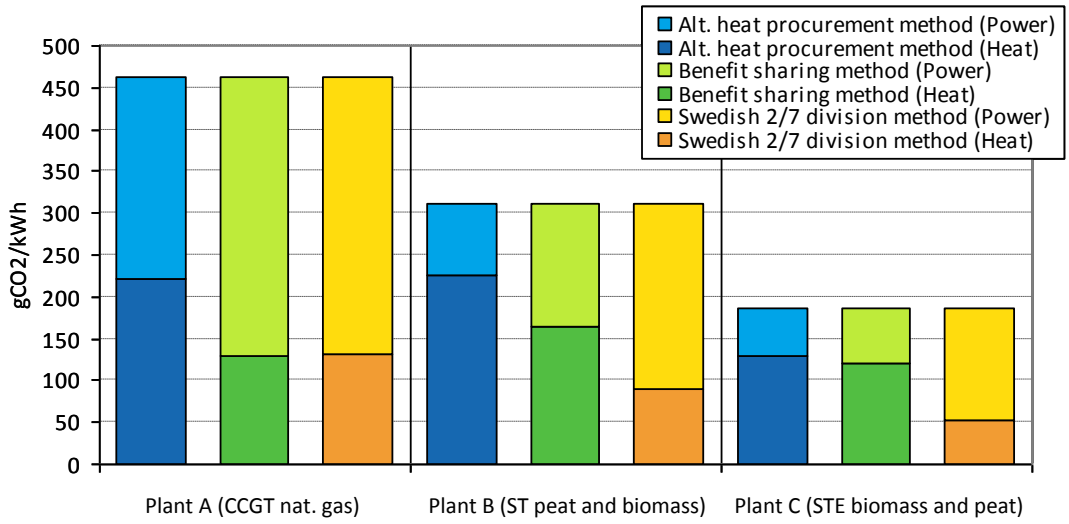

Figure 4.2. *The total emissions from the case plants divided to heat and power with different calculatory methods. Three different methods are alternative heat procurement method (blue bar), benefit sharing method (green), and the Swedish 2/7 method (yellow). Unit is emissions / heat produced.*

Alternative heat procurement method allocates most emissions to heat compared to the other methods in all case plants[13]. Swedish 2/7 division method is simple but allocates very little to heat compared to the other methods. The benefit sharing method is in between these two methods. It also takes into account the power production, i.e. power to heat ratio, which explains the variations between the plants. Thus, Plant A has different characteristics from the other installations. It produces comparably more power and less heat than the other installations. Using the alternative heat procurement method, only around half of the total emissions are distributed to heat. This can be compared with the around 70 % share of heat in Plants B and C.

4.3.2 Fuel dependent benchmarking

The benchmark above is the same for all installations regardless of the fuel mix used. In the second phase of the EU ETS systems, some countries used fuel dependent benchmarking systems. Figure 4.3 presents an illustrative example using the German NAP II model. The German allocation proposal took into account the availability of natural gas. If there is natural gas available, the benchmark level was set to 225 gCO2/kWh. In other case, the benchmark level was set to 345 gCO2/kWh.

[13] This is valid even for a larger subset of CHP division methods. Of all the presented methods, alternative heat procurement method allocates most emissions to heat production.

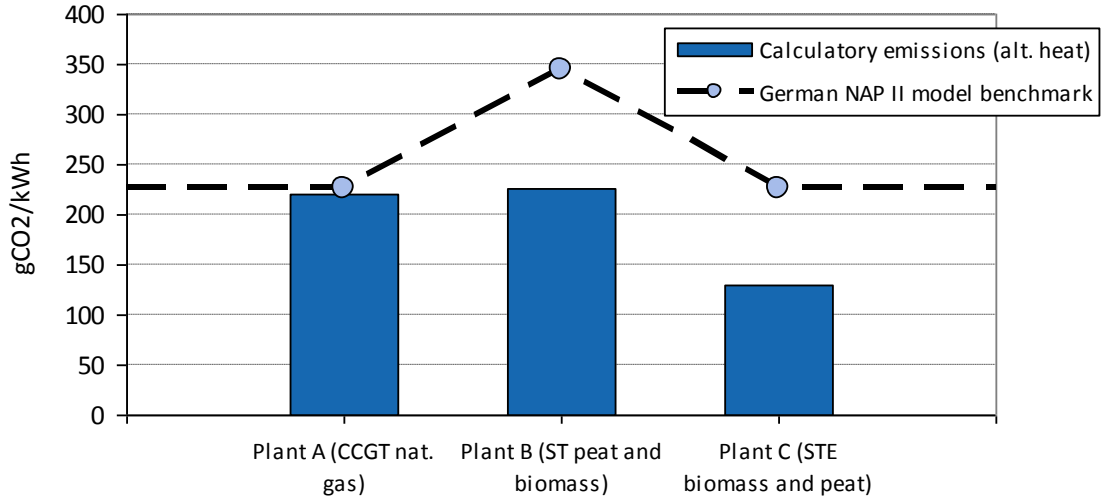

Figure 4.3. *The possible effect of fuel dependent benchmark level to the allocation to the case study plants. An example is made using the German NAP II allocation method as described in the Appendix.*

The allocation to Plants A and C is essentially the same as with the base benchmark model described above. Both plants use natural gas as a part of their fuel mix, and natural gas is therefore available energy source. Plant B is geographically located so that natural gas is not available. Under the illustrative example from the German NAP II proposal, it would have received higher initial free allocation than the other two plants.

An allocation that takes more fuel specific issues into account could be implemented in several ways. One starting point is the solid, liquid, gaseous division (see e.g. Table 2.1). In such a model, each benchmark level of each subgroup would be defined on the basis of the installations that belong to the subgroup. The allocation would also be based on the fuel types, either technically possible or practically available. Because a multi-fuel installation could be counted in many subgroups, this might make it more challenging to establish the benchmark and determine the actual allocation. If the benchmarking is made on the basis of individual fuels used, that would reduce the incentive to invest in renewable generation (as the benchmark level for renewables is zero).

4.3.3 Additional findings on the basis of the calculations

The alternative heat procurement method divide the emissions of CHP plant between heat and power so that the amount of heat the plant produces is equal to heat produced in separate heat production. As a result, the emissions per heat unit produced are not dependent on the actual heat efficiency of the plant. However, if the heat efficiency is low, then the method allocates more emissions to power production, and retains the incentive to reduce total emissions. Also, cogeneration and separate heat generation with the same heat output receive equal allocation.

The calculations above resemble in a general level the *ex ante* methodology that is proposed. Because the focus of this study has been in the benchmark levels, the results are presented using the emissions per heat values. However, the actual allocation needs to be made on tons of CO2 basis. In these calculations, the actual emissions are reflected by the calculatory emissions. The same activity

level has been used both in the benchmark allocation and the calculatory emissions. For existing installations, historical heat production will determine the basis for the initial free allocation. For new entrants, the allocation will be determined by the capacity and capacity use factors. One possible way of promoting cogeneration for new entrants could be to use higher capacity use factors in the benchmark allocation. New installations would therefore receive additional free allowances.

5 Summary and conclusions

The European Commission is currently preparing revised rules for the initial free allocation of emission allowances. According to the proposed revised ETS Directive, the Commission shall, by 31 December 2010, adopt community-wide and fully-harmonised implementing measures for allocating the allowances. The allocation of free allowances will be based on *ex ante* benchmarks. The benchmark shall be calculated for products rather than for input in order to maximise greenhouse gas emissions reductions and energy efficiency throughout each production process of the sector or the sub-sector concerned. In defining the principles for setting *ex ante* benchmarks in individual sectors or subsectors, the starting point shall be the average performance of the 10% most efficient installations in a sector or sub-sector in the Community in the years 2007-2008.

According to proposed revised ETS Directive, no free allowances are given for electricity production. For district heating and industries, the initial free allocation is made on the basis of benchmarks. The revised ETS directive gives general level guidelines on how the benchmarks are defined. Specific details are still open. The objective of this study has been to analyze various benchmarking methods that could be used in defining allocation of free emission allowances to district heating. The two main points studied in this report have been: 1) how to divide emissions of cogeneration between heat and power and 2) how to set the benchmark for allocating the allowances.

There are several methods that have been used to divide emissions between heat and power. The methods studied more detailed in this report have been 1) alternative heat procurement method, 2) benefit sharing method and 3) “Swedish 2/7 method”. The alternative heat procurement method allocates highest amount of emissions to heat. It is also implicitly the basis of the revised ETS Directive as it treats end-product (heat) similarly independent on production method, i.e. separate production heat or cogeneration.

The proposed revised ETS Directive creates a clear incentive to select low-carbon fuels and technologies to produce district heat. According to proposed Directive there is no fuel or technology dependence in benchmarking. As all plants receive the same initial free allocation, the plants with lowest emissions will benefit most. In a similar manner, the proposal creates also an incentive for high heat efficiency in district heating, as initial free allocation is made independent of the plant efficiency.

The revised Directive does not directly support high efficiency cogeneration. This is due to the product based allocation principle. The benchmark level is the same regardless of the production technology. However, the allocation formula allows other means to support new cogeneration. The initial free allocation for new entrants is made on the basis of the benchmark level, capacity, and capacity use factor. High efficiency cogeneration can be supported by setting it a higher capacity use

factor than to separate heat production. This corresponds also to the real life situation at least in Finland, where large cogeneration units mostly provide the baseload heat and smaller separate heat production units produce only during peak times.

The key question for benchmarking is how to define the benchmark level, i.e. the average performance of the 10% most efficient installations. The other interesting question is how to define what the best 10% is and which installation are included in calculation. To follow the principle of the proposed Directive, all emissions and heat production data from all the installations within the Community should be collected and verified. There are however practical restrictions set by the time and resources available for the task. A simpler but less precise alternative is to use literature values and expert views. In a third alternative, a benchmark calculated on the basis of a representative sample of installations is adjusted by expert views and literature values.

The most emission efficient district heating plants use renewable energy sources. If there are enough installations within the Community that use only renewables, the benchmark level will be 0 gCO2/kWh. However, this is unlikely to be the case at the moment but need to be studied more detailed. The next most efficient production form is separate or cogeneration of heat with natural gas. The emissions from a relatively high efficiency natural gas plant are around 220 gCO2/kWh. It seems likely, that the benchmark for free initial allocation of emission allowances will be between 0 to 220 gCO2/kWh.

It should be noted, that initial free allocation is not covering all historical emissions of district heating sector. The basic principle is that the total free allocation in 2013 will be 80% of historical emissions in 2005-2007. After that, the free allocation will decrease each year. In 2020 the free allocation will be around 30 % and there will be no free allocation by 2027. Also, the total number of allowances is reduced each year to reach the emissions reductions targets. In addition, the allocation between the sectors has not yet been fixed.

Product based benchmarking does not support some technology choice over others. Separate heat production and cogeneration plants with various technologies receive similar treatment. This gives the incentive to use the most efficient technologies for heat production. However, it does not necessarily support high-efficiency cogeneration or surplus heat use over separate heat production. For new entrants, this could be supported by setting a higher capacity use factor for high-efficiency cogeneration plants.

The product based benchmark ignores also the fuel mix. However, it is not technically and economically feasible to use all fuels in all geographic locations. Natural gas network covers only parts of Europe and a sustainable supply of renewable fuels might be limited in some locations. A product based benchmarking can therefore put these locations to a disadvantage compared to areas where renewables and/or natural gas are available.

Appendix A – Allowance allocation for district heating in national allocation plans (NAPs) of selected EU member states

This appendix reviews the National allocation plans of selected EU member states. The main focus is the allocation for district heating. Main sources of information are the national allocation plans published in the official Emission Trading Scheme web page of European Commission or the translations of the NAPs. The reviewed National Allocation plans are listed below:

- Ministry of Sustainable Development, Sweden's national allocation plan for emission allowances 2008-2012, 2006
- Denmark's National Allocation Plan 2008-12, 2007
- Defra, EU Emissions Trading Scheme, Approved Phase II National Allocation Plan 2008-2012, 2007
- Federal Ministry for the Environment Nature Conservation and Nuclear Safety (BMU), National allocation plan 2008-2012 for the Federal Republic of Germany, 2006
- Federal Ministry of Agriculture, Forestry, Environment and Water Management, National Allocation Plan for Austria pursuant to Sec. 11 of the Austrian Emission Allowances Trading Act (EZG) for the period 2008-2012, 2007
- Ministry of the Environment of the Republic of Estonia, National allocation plan of Estonia for greenhouse gas emission allowances trading for the years 2008-2012
- National Emissions Allowance Allocation Plan 2008–2012, Approved under Cabinet Order No 542 of 4 September 2008 (Latvia)
- Ministry of environment of the republic of Lithuania, Lithuania's National allocation plan for greenhouse gas emission allowances for the period 2008 to 2012, 2006
- Ministry of the Environment of the Slovak Republic Air Protection Department, National Allocation Plan for the 2008 – 2012 period, 2006
- Republic of Poland Ministry of Environment, National Allocation Plan of CO2 Emission Allowances for 2008 – 2012 Settlement Period, 2006

A1.1 Sweden

A1.1.1 General allocation principles

For the emission trading period of 2008-2012, the total allocated amount of emission allowances for Sweden was 22.8 Mtons per year after commission reduction.[14] In Sweden, the existing installations in electricity and district heating will get no allowances for free. [15] For new entrants in energy sector, the allocation is based on benchmarks. The reasoning for the restricted allocation to existing installation in the energy sector is that the sector is not considered to be significantly exposed to competition from other countries outside the European trading scheme. Also, the potential to reduce emissions is greater for fuel-based emissions than for process raw-material related emissions.

The allocation for other sectors is based on historical emissions and the reference period for their allocation is 1998-2001. If there have been some exceptional events during the reference period that have caused the emissions to be more than 10% lower in one year, this year is excluded from the average. All allowances are given to the installations for free. The maximum share of CERs and ERUs to be used at an installation is 10% of the total allocation.

A1.1.2 Allocation for district heating, energy sector as a total and new entrants in the energy sector

Energy sector is treated as one in the Swedish NAP. Existing district heating and power producers are treated equally. No allowances are given for free to existing district heating and power installations. In the electricity and district heating sector, new entrants will not receive any free allowances unless they are highly-efficient co-generation plants. An efficient co-generation plant is defined as in Directive (2004/8/EC) on the promotion of cogeneration based on a useful heat demand in the internal energy market. This implies that no allocation is made to new condensing power plants or new hot water boilers without back-pressure production.

Allocation to new entrants is based on benchmarks of 337 tons of CO2 per GWh electricity and 118 tons of CO2 per GWh heat. The amount of allocation is for the fossil-based share of forecast production. [16] The allocation for new entrants was not reduced after amendments required by the commission.

The benchmarks for allocation to new entrants are based on a study done by Swedish Energy Agency[17]. The basis of the benchmarks is the average CO2 intensity during 2000-2004 in Swedish combustion installations included in the ETS sector. The benchmark for electricity has been calculated on the basis of emissions and production of electricity from condensing power installations and co-

[14] Source: European Commission press release, "Emissions trading: Commission adopts amendment decision on the Slovak National Allocation Plan for 2008 to 2012", Reference: IP/07/1869, 7.12.2007

[15] Source: Förordning (2004:1205) om handel med utsläppsrätter, published12.2.2004, most recent update 2008:711

[16] Source: Förordning (2004:1205) om handel med utsläppsrätter, published12.2.2004, most recent update 2008:711

[17]Statens energimyndighet (ER 2006:16), Bränsleoberoende riktmärken i energisektorn /
Swedish Energy Agency (ER 2006:16), Fuel-independent benchmarks in the energy sector, in Swedish

generation plants. The benchmark for heat is based on emissions and production of heat from heat boilers and co-generation plants. The benchmark calculations are independent of technology and fuel used. The division of emissions to heat and electricity production in a CHP plant is calculated so that the CO2 emissions allocated to electricity are multiplied with a factor 2.5 whereas the factor for heat is 1.0. The factor for electricity is based on Directive (2006/32/EC) on energy end use efficiency and energy services where it is stated that the factor 2.5 may be applied for electricity to calculate the primary energy savings. This means that if a cogeneration installation produces equal quantities of electricity and heat, 5/7 of the emissions have been attributed to the electricity and 2/7 of the emissions to heat.

A1.1.3 Summary of special characteristics

Table A1. *Special characteristics related to benchmarking and allocation for the energy sector in the national allocation plan of Sweden for 2008-2012.*

Reference time period	1998-2001 (used only for existing industrial installations)
Grouping of energy sector	Existing plants: energy sector as one group New entrants: benchmarks for heat and electricity production separately
Allocation method for new entrants	Benchmarks for heat and electricity
Using benchmarking	For new entrants allocation
Allocation in CHP plants	Allocation to new entrants is based on defined benchmarks for electricity and heat. When defining the benchmarks, the division of emissions for heat and electricity in a CHP plant was based on multiplying the electricity emissions with a factor of 2.5 whereas the factor for heat is 1.0. No allowances will be given for free for existing installations.

A1.2 Denmark

A1.2.1 Total allocation

The total allocation of allowances for Denmark is 24.5 Mtons per year, where the share of electricity and heating is 15.8 Mtons per year. There were no amendments required by the commission to the original allocated amount. The allowances are granted for free based on historical emissions. The

allocation is based on the average emissions in 1998-2004 or in 2004 whichever is greater. If there is no demand for all allowances in the new entrants' reserve, the remaining amount may be auctioned.

Installations will receive allowances corresponding to about 87% of fuel-related CO2 emissions and 98% of process-related emissions. However, there is more stringent allocation to electricity and heat production. Heat producers receive allowances corresponding to about 87% of the requirement. Electricity producers receive allowances corresponding to about 57% of the requirement. CERs and ERUs may be used as a percentage of the allocation for each installation maximum 17.01% as stated by the commission.

A1.2.2 Allocation for district heating, energy sector as a total and new entrants in the energy sector

In the Danish NAP, the energy sector is divided to electricity producers and heat producers. In CHP production, the calculation is based on distribution of fuels between electricity and heat using a heat efficiency of 125%.

It is stated in the NAP that allocation based on heat production rather than on historical emissions was examined, but this would have resulted in a significant redistribution of allowances compared to the first period. As a consequence, the consumer prices would have been severely impacted and therefore the decision was made to allocate the allowances based on historical emissions.

For new entrants, the allocation is based on parameters calculated based on best available technology. In addition, the allocated amount is reduced by the same percentage as the allocation to existing installations is reduced from 2005-07 to 2008-12. Allocation is not dependent on fuel type or expected operation hours.

New electricity producers will receive 1185 allowances per MW installed electric capacity and 305 allowances per MW installed heat capacity. If the estimated usage of the installation is less than 3000 hours per year, the allocation will be reduced by 1/3 for each 1000 hours decrease in expected operation hours. New heat only producers will receive 100 allowances per MW of installed capacity. This figure is based on the CO2 emissions from a liquefied natural gas boiler with an annual operating time of 500 hours.

A1.2.3 Summary of special characteristics

Table A2. *Special characteristics related to benchmarking and allocation for the energy sector in the national allocation plan of Denmark for 2008-2012.*

Reference time period	1998-2004 or 2004 whichever higher
Grouping of energy sector	Division to electricity producers and heat producers, more stringent efficiency requirement for electricity producers
Allocation method for new entrants	Benchmarking, for heat only production 100 allowances per MW of installed capacity (based on the CO2 emissions from a liquefied natural gas boiler with an annual operat-

	ing time of 500 hours), in CHP installations for electricity 1185 allowances per MW installed electric capacity and 305 allowances per MW installed heat capacity
Using benchmarking	For new entrants allocation
Allocation in CHP plants	In CHP production, the calculation is based on distribution of fuels between electricity and heat using a heat efficiency of 125%.

A1.3 United Kingdom

A1.3.1 Total allocation

The total allocation for the UK is 246.2 Mtons per year. There were no amendments required by the commission to the original allocation plan. The allowances are granted for free based on historical emissions. The reference period is 2000-2003 from which the lowest year of emissions is dropped. The amount allocated to all other sectors except for large electricity producers is based on historical emissions. Allocation is first done on sector level and then on installation level.

In the sector allocation, a reduction is done from the reference period emissions based on the potential to reduce emissions. In addition, contributions to new entrants reserve and for CHP ring fence are reduced from the total. Large electricity producers will receive the remainder of the national total after allocation to all other sectors and deduction of the amount to be auctioned. From the total number of allowances given for UK, 7% is auctioned as well as any remaining allowances in the new entrants' reserve.

In using CERs and ERUs, the Government has set an 8% limit at an installation level compared to the number of allocated allowances. Because the free allocation is less for large electricity producers, the limit for such installations is 9.3% of their free allocation.

A1.3.2 Allocation for district heating, energy sector as a total and new entrants in the energy sector

There are altogether 19 sectors in the UK national allocation plan. The relevant sectors concerning energy producers are large electricity producers (LEP), other electricity producers, good quality CHP, and services. The service sector includes district heating installations. Good quality combined heat and power was introduced as a new sector to second phase. This sector includes both industrial and district heating. All installations included in the good quality CHP sector in the NAP must be certified under UK's CHP Quality Assurance (CHPQA) programme.

The allocation for existing installations in mainly based on the reference period of 2000-03. However, the reference period for allocation to CHP installations covers only years 2001-2003 as there is no data available from the year 2000 for good quality CHP plants. For large electricity producers, the allocation is based on benchmarks.[18]

The allocation for new entrants is based on benchmarks defined for each sector. New entrants will as a rule receive 95% of the estimated requirement for allowances. As an exception, the good quality CHP plants will get 100%, boilers and other generators will get 90%, and large electricity producers will get 69.7% of their estimated demand. For small heating units, the benchmarks are based on a defined load factor and an efficiency benchmark. The load factor is defined according to the following formula

Load factor = FUtil * FStand * FTemp,

where FUtil = 0.86, FStand = 0.67 and FTemp = 0.6 for space heating, 1.0 for process heating and 0.8 for mixed.

The efficiency (LHV) of a heating boiler is set to be 0.92. In addition, if the heating is used as top-up or back-up for CHP, the allocation is reduced by 50%.

For new CHP plants, certain criteria have to be met for an installation to be qualified as a good quality CHP installation.

- The power efficiency has to be greater than or equal to 20% and
- the quality index is greater than or equal to 100.[19]

The benchmarks defined for new CHP installations are based on the usage of natural gas in all cases where it is not ruled out by technical characters of the industrial process. The benchmarks are based on the following parameters:

CHP Technology	**Efficiency (LHV)**	**Utilisation (% of year)**
Gas engine CHP	40 %	48 %
Back pressure ST (steam cycle only)	22 %	48 %
Pass out / condensing ST (steam cycle only)	22 %	48 %
Simple cycle gas turbine	29 %	73 %
Combined cycle gas turbine	40 %	73 %

[18] The benchmarks for Large Electricity Producers are the following: Coal 910 tCO2/GWh, Oil 830 tCO2/GWh, Gas 400 tCO2/GWh. These are used in the installation level allocation where also an additional reduction factor for the whole sector applies.

[19] The quality index is defined in the Good Quality CHP criterion. It combines the power and heat efficiencies, adjusted by factors to take into account the size, technology and fuel of the individual scheme. Source: EU Emissions Trading Scheme – Approved UK Phase II National Allocation Plan, Appendix D New Entrants and Closures

Of the total new entrants reserve 6.7% is reserved for good quality CHP installations. It is stated in the UK NAP that the government has a target to increase 10GW the installed good quality CHP capacity by 2010. In order to achieve this, it is necessary to provide incentives for the installation of Good Quality CHP.

A1.3.3 Summary of special characteristics

Table A3. *Special characteristics related to benchmarking and allocation for the energy sector in the national allocation plan of the United Kingdom for 2008-2012.*

Reference time period	2000-2003 but for CHP 2001-2003
Grouping of energy sector	The energy sector is divided to the following: Large Electricity Producers (LEP), Other Electricity Producers, Good Quality CHP, Services (including heating).
Allocation method for new entrants	Based on benchmarks of load factors and efficiency factors.
Using benchmarking	For new entrants and for existing large electricity producers
Allocation in CHP plants	Based on historical emissions for existing plants and benchmarks for new entrants. New CHP installations get 100% allocation compared to the estimated need whereas other sectors get less than required.

A1.4 Germany

A1.4.1 Total allocation

The total allocation in the original German NAP was 482 Mtons per year.[20] This was reduced by commission to 453.1 Mtons and a further reduction requirement was given on the allocation for "additional combustion installations". The allocation is based on historical emission for industrial installations and for energy sector it is based on production volumes and standard emission benchmarks. In addition further reductions will be done based on an efficiency factor. Originally, an efficiency factor for other than energy sector was set to be 98.75% and energy sector would receive the rest of the national total resulting in an efficiency factor of approximately 85%. As the total allocation was cut back, the efficiency factor for energy sector decreased as well. The reference period for

[20] Source: European Commission press release, "Emissions trading: Commission adopts amendment decision on the Slovak National Allocation Plan for 2008 to 2012", Reference: IP/07/1869, 7.12.2007

all sectors is 2000-2005. Of the total amount 8.9%, i.e. 40 Mtons per year will be auctioned. Each installation can use CERs and ERUs maximum 22% of the amount of allocated allowances.[21]

A1.4.2 Allocation for district heating, energy sector as a total and new entrants in the energy sector

The energy sector is treated as one in the German NAP. As an exception, small installations which emit less than 25000 tons CO2 per year and CHP plants have a different treatment. The main difference is that there is no reduction factor used in the allocation for small installations and that CHP installations receive free allowances based on both electricity and heat production separately.

The calculation of allowances given for free to the installations is based on defined benchmarks for heat and electricity production. The benchmark for heat production is 345 gCO2/kWh and 225 gCO2/kWh if gas can be used as a fuel. The benchmark for electricity is 750 gCO2/kWh and 365 gCO2/kWh if gas can be used as a fuel.[21] For new CHP plants, the allocation is based on both benchmarks, i.e. they will receive allowances based on the volume of electricity and heat produced.

The allocation for existing installations is based on their average production in 2000-2005 and an applied efficiency factor, which is 0.85, multiplied with an adjustment factor dependent on the current efficiency of the plant. For new installations, the efficiency factor is always equal to 0.85. In addition, for the new installations the capacity of the installation is taken into account. There are defined load factors that are to be used in defining the amount to be allocated.

A1.4.3 Summary of special characteristics

Table A4. *Special characteristics related to benchmarking and allocation for the energy sector in the national allocation plan of Germany for 2008-2012.*

Reference time period	2000-2005
Grouping of energy sector	Energy sector treated as one, but small installations (which emit less than 25000 tons CO2 per year) and CHP installations as exceptions
Allocation method for new entrants	Benchmarking
Using benchmarking	Benchmarks are used in the allocation for existing energy sector installations and new entrants. The benchmark defined for heat production is 345 gCO2/kWh and 225 gCO2/kWh if gas can be used as a fuel and for electricity production 750 gCO2/kWh and 365 gCO2/kWh if gas can

[21] Gesetz über den nationalen Zuteilungsplan für Treibhausgas-Emissionsberechtigungen in der Zuteilungsperiode 2008 bis 2012(Zuteilungsgesetz 2012 - ZuG 2012), 7.8.2007

	be used as a fuel, for CHP allocation based on a double benchmark
Allocation in CHP plants	Allocation based on both production of heat and electricity which results in more generous allocation as for separate production

A1.5 Austria

A1.5.1 Total allocation

The total allocation for Austria is 28.7 Mtons after commission reduction. In the original NAP, the allocation for energy sector was 11.2 Mtons per year. However, this may have been reduced after commission reduction. Allowances are mainly granted for free, but 0.3% of all allowances are to be auctioned. The allocation is based on historical emissions and the reference period is 2002-2005.

The allocation is done first at sector level where the business as usual development compared to the reference period of 2002-2005 is taken into account. The business as usual development is based on a survey by UBA/IIÖ. From the resulting base level emissions, a share to be auctioned, a share reserved for new entrants and a "climate protection contribution" of the sector is reduced. After sector level allocation, the division is done on sub-sector level and then between installations. The proportion of CERs and ERUs used to cover the emissions may not exceed 10%.

A1.5.2 Allocation for district heating, energy sector as a total and new entrants in the energy sector

Allocation to each sub-sector is based on trend analyses of each sub-sector, potential factor to reduce emissions and a compliance factor used to reduce equally the allocation within the sector to stay within the total amount allocated to it. Energy industry has been divided in the Austrian NAP to electricity production (which includes CHP) and heat production. The compliance factor for electricity producers is 0.826 and for heat producers it is 0.902. The compliance factor of 0.902 is also used for all other sub-sectors. Allocation at installation level is based on the base level emissions, potential factor to reduce emissions and a compliance factor used to reduce equally the allocation within the subsector. In general, the potential factor takes into account process emissions, the CO2 intensity of the fuel used, the use of CHP and the extraction of waste heat for district heating, as well as Best Available Techniques (BAT). For energy sector, a benchmark approach is used.

For electricity production, a potential factor is defined as the share of benchmark based emissions from the actual emissions. The benchmark emissions are based on an emission factor of 350 t CO2/GWh for electricity production and 175 t CO2/GWh for heat produced in CHP production. These benchmarks are based on the use of natural gas. The potential factors are scaled so that there is an upper and lower limit of 0.65 and 1.05.

For pure heat production, the potential factor is defined so that a CO2 emission factor of 110t/GWh will lead to a potential factor of 0.8 and an emission factor of 55.4t/GWh will lead to a potential factor of 0.96. Between these two points, linear interpolation is applied. For CHP production, there is an additional CHP bonus increasing the allocation by 4 percentage points. This can be granted for an

installation, if primary energy savings of at least 10% compared to the separate generation of power and heat has been realised.

The allocation for new entrants is based on historical averages and emission benchmarks based on latest technology. However, there are no exact figures given for the allocation to new entrants. The factors to be taken into account in allocation for new entrants include:

- the authorised capacity of the installation,
- the average capacity utilisation observed, in installations in the sub-sector,
- the capacity utilisation of the installation to be expected during the period, and
- the emissions of the installations to be expected under the assumption that the latest technology is used.

A1.5.3 Summary of special characteristics

Table A5. *Special characteristics related to benchmarking and allocation for the energy sector in the national allocation plan of Austria for 2008-2012.*

Reference time period	2000-2005
Grouping of energy sector	electricity production (which includes CHP) and heat production
Allocation method for new entrants	Benchmarks based on average capacity usage of the sector and latest technology emission benchmarks. The figures are not stated in the NAP.
Using benchmarking	For existing electricity and CHP installations, a benchmark approach is used in defining an efficiency factor for the sector. For new entrants benchmarking is used.
Allocation in CHP plants	A special bonus given to CHP producers if primary energy savings of at least 10% have been realised.

A1.6 Estonia

A1.6.1 Total allocation

The total allocation of Estonia was 24.4 Mtons of which 20.8 Mtons was allocated to energy activities. However, commission reduced the allocation by 11.7 Mtons which amounts in total allocation

of 12.7 Mtons per year.[22] In addition, some reductions were required to be done for one installation not included in the first phase plan. Allocation to installations is based on historical emissions. In addition, there was to be an early action bonus but the commission stated in its decision that the allocation may not go beyond the needs of an installation. No auctioning will be done except for the remaining allowances in the new entrants reserve.

The basic reference period is 2000-2005. Allocation is based on the average emissions during three years with highest emissions. However, for the boiler plants a longer base period, 1995-2005, was chosen.

A1.6.2 Allocation for district heating, energy sector as a total and new entrants in the energy sector

Energy activities are considered as one section in the NAP of Estonia. This includes electricity and heat production as well as enterprises producing heat for their main production technology e.g. petrochemical enterprises, oil terminals and food or peat processing enterprises.

It is stated in the Estonian NAP that the reason for choosing the longer base period of ten years for heating boilers is that their production is highly dependent on weather conditions. By choosing the longer period, especially cold years in the mid 1990s were included in the reference.

In the Estonian NAP, there are no exact rules for the allocation to new entrants. However, the commission decision required clearer rules to be set.[23] It is stated in the NAP that in the energy sector there are some new entrants expected in the market. Those include woodchips and peat fuelled CHP installations and natural gas fuelled CHP plants to balance the electricity production of big number of wind farms.

A1.6.3 Summary of special characteristics

Table A6. *Special characteristics related to benchmarking and allocation for the energy sector in the national allocation plan of Estonia for 2008-2012.*

Reference time period	Mainly 2000-2005, but for thermal boilers 1995-2005 taking the average of three years with most emissions
Grouping of energy sector	Energy sector as one, including electricity, district heat and process heat production Allocation based on bottom-up calculation

[22] Source: European Commission press release, "Emissions trading: Commission adopts amendment decision on the Slovak National Allocation Plan for 2008 to 2012", Reference: IP/07/1869, 7.12.2007

[23] Commission decision of 4 May 2007 concerning the national allocation plan for the allocation of greenhouse gas emission allowances notified by Estonia in accordance with Directive 2003/87/EC of the European Parliament and of the Council

Allocation method for new entrants	Not defined
Using benchmarking	No benchmarking
Allocation in CHP plants	Not discussed separately

A1.7 Latvia

A1.7.1 Total allocation

The original proposed allocation in the Latvian NAP was 7.7 Mtons of which 1.6 Mtons was for energy sector. However, after commission amendment, the total allocation was fixed to 3.4 Mtons.[24] The allowances are granted for free based on historical emissions. The reference period is 2005-2006. There is no sector level allocation. The allocation is done directly at installation level. In addition, the allocation to energy industries is reduced by 20% compared with the base period emissions. The maximum number of CERs and ERUs that an installation may use is 10% of the allowances allocated to them.

A1.7.2 Allocation for district heating, energy sector as a total and new entrants in the energy sector

Energy industries are treated as one sector in the Latvian NAP. For existing installations there are in principle no differences in the allocation to heat, electricity and CHP production. For new entrants, the allocation is based on the forecast demand. For heat producers the forecast loss in heating grids is also taken into account. The heating loss cannot be assumed to be more than 10%. If there is no information available about the efficiency of a boiler house to be built, the efficiency coefficient is set to be 0.95 for natural gas or diesel fuel and 0.9 for other fuel types. For new cogeneration plants, the efficiency coefficient is assumed to be 0.8 for coal or peat and 0.85 for natural gas or diesel fuel if there is no data available on the actual coefficient.

Forecast thermal energy production is set for district heating by defined benchmarks for specific thermal energy consumption of buildings. In cogeneration plants, the forecast quantity of electrical energy produced is determined depending on the quantity of thermal energy produced and is confirmed by means of a contract with the electricity consumer.

There is also a restriction that one installation may not be allocated more than 45% (in the case of industrial installations) or 20% (in the case of energy installations) of the total reserve for new entrants.

[24] Source: European Commission press release, "Emissions trading: Commission adopts amendment decision on the Slovak National Allocation Plan for 2008 to 2012", Reference: IP/07/1869, 7.12.2007

A1.7.3 Summary of special characteristics

Table A7. *Special characteristics related to benchmarking and allocation for the energy sector in the national allocation plan of Latvia for 2008-2012.*

Reference time period	2005-2006
Grouping of energy sector	Energy sector as one Allocation based on bottom-up calculation with a 20% reduction compared to the base period
Allocation method for new entrants	Based on forecast production and efficiency benchmarks if no other data on efficiency coefficients available
Using benchmarking	Set benchmarks for suggested efficiency coefficients for new entrants
Allocation in CHP plants	For existing plants based on historical emissions. For new entrants based on forecast emissions and efficiency coefficients (benchmarks may be used if no other data available)

A1.8 Lithuania

A1.8.1 Total allocation

The total allocation in Lithuania was originally suggested to be 16.6 Mtons per year of which 4.1 Mtons was allocated to energy sector. The commission set the allocation to be reduced by 7.7 Mtons per year and in addition some reductions were required for the "additional combustion installations". The resulting total allocation was 8.8 Mtons per year.[25]

The allocation is first done on sector level and then further at installation level. In addition, every sector is appointed a different technical emission reduction and growth potential in compliance with mainstream of the market and possibilities to reduce emissions. Most of the allowances are granted to installations for free based on historical emissions, but 1.6% of the total is auctioned. The reference period is 2002-2005. However, if the emissions in 2005 are greater than the average of the period, then only that year is used as the reference.

As a total, up to 11% of emissions may be covered by CERs and ERUs. However, the number of credits to be used by installations may vary and the maximum amount to be used by operators may not exceed 30% of the allocated allowances.

[25] Source: European Commission press release, "Emissions trading: Commission adopts amendment decision on the Slovak National Allocation Plan for 2008 to 2012", Reference: IP/07/1869, 7.12.2007

A1.8.2 Allocation for district heating, energy sector as a total and new entrants in the energy sector

The allocation for energy sector is based on the average emissions in 2002-2005 and a growth factor of 32.5%. In addition, a reduction of 5% is done for more efficient technology and a 2% reduction for the share to be auctioned. The energy sector is otherwise treated as one, but the cogeneration installations get some additional allowances based on the primary energy savings achieved during the reference period.

There is no comprehensive information in the NAP about allocation to new entrants. It is stated that efficient CHP plants gets more allowances per installed capacity and the allocation is not dependent on the fuel used. The allocation is to be based on a standard number of operating hours. As ordered by the commission, more information needs to be given on how the new entrants will be able to participate in the ETS.

A1.8.3 Summary of special characteristics

Table A8. *Special characteristics related to benchmarking and allocation for the energy sector in the national allocation plan of Lithuania for 2008-2012.*

Reference time period	2002-2005
Grouping of energy sector	Energy sector as one but different treatment for CHP
Allocation method for new entrants	No comprehensive rules given, but efficient CHP plants are to be allocated more allowances.
Using benchmarking	No benchmarks used
Allocation in CHP plants	Special rules for the allocation for existing CHP plants and new entrants

A1.9 Slovakia

A1.9.1 Total allocation

The total allocation to Slovakia for the trading period 2008-2012 was 32.6 Mtons per year after commission reduction[26]. The allocation was done in Slovakia directly for individual plants, i.e. there was no sector allocation first. Also, there is no general reference period set. For big plants whose share of total emissions exceeds 0.5% of the national total, the allocation was based on individual negotiations. For smaller plants, the allocation is based on sector specific formulas. The allocation

[26] Source: European Commission press release, "Emissions trading: Commission adopts amendment decision on the Slovak National Allocation Plan for 2008 to 2012", Reference: IP/07/1869, 7.12.2007

method used for energy sector is further explained in next chapter. All allowances will be given for free to the installations. If there is no demand for all allowances in the new entrants' reserve, the remaining amount may be auctioned.

The limit for CDM and ERU to cover emissions from EU ETS is set to 7% of the total allocation. In Slovakia, the right to use these credits is not set proportionally for each installation but according to the order of the submitted units. When the limit of 7% is reached, no additional CDM or ERU credits will be accepted.

A1.9.2 Allocation for district heating, energy sector as a total and new entrants in the energy sector

In Slovakian NAP the district heating installations are included in "thermal energy" and "the production of electric and thermal energy" groups. For thermal energy producers, the reference period was defined as 1998-2003. The reference is defined to be either the average emissions during the period or during the year 2005, whichever is greater. In addition, a coefficient is used to take into account the increase in the number of housing. The coefficient was defined as 0.4% annually. For electric and thermal energy producers there was no historical reference period defined, but the allocation was stated to be based on the average of the planned energy production. Hence, the allocation would cover all expected emissions. However, as there was a reduction in the national total allocation, the allocated amount for each installation was most likely reduced.

There were no rules specified in the Slovakian NAP on the principles of allocation for new entrants. The commission requested more information to be provided on how new entrants will be able to participate in the emissions trading. [27]

A1.9.3 Summary of special characteristics

Table A9. *Special characteristics related to benchmarking and allocation for the energy sector in the national allocation plan of Slovakia for 2008-2012.*

Reference time period	Varies; for thermal energy producers 1998-2003 and for electric and thermal energy producers not defined
Grouping of energy sector	Allocation not done on sector level; grouping of installations to thermal energy producers and electrical and thermal energy producers
Allocation method for new entrants	Not defined

[27] Commission decision of 29 November 2006 concerning the national allocation plan for the allocation of greenhouse gas emission allowances notified by Slovakia in accordance with Directive 2003/87/EC of the European Parliament and of the Council

Using benchmarking	No benchmarking
Allocation in CHP plants	Not discussed separately

A1.10 Poland

A1.10.1 Total allocation

After commission reduction, the total yearly allocation in Poland was 208.5 Mtons of which some additional reductions will be done that have not been quantified precisely in the commission amendment[28]. Allocation is based on realised emissions in 2005 and the allowances will mainly be granted for free. However, 1% of the total allowances will be auctioned. It is stated in the NAP that the allocation to installations is based on benchmarking and documented development plans. Allocation is first done on sector level and then further on installation level. The maximum share of CERs and ERUs to be used by each installation is 10% as set by commission decision.

A1.10.2 Allocation for district heating, energy sector as a total and new entrants in the energy sector

The energy sector has been divided to the following groups in the NAP:

- Utility power plants
- Combined heat and power plants
- Utility heating plants

Despite the names of the groups, the utility power plant group includes some heat production as well and the utility heating plant group includes some power production. The amount allocated to each sector is based on baseline production, estimated average emissions in base year, forecast production growth, an estimate on emission reduction per production unit and a cogeneration bonus where applicable. The purpose of the cogeneration bonus is to support high energy-efficient production.

For utility power plant sector, the calculated allocation is based on an estimated emission reduction potential of 0.2%, a 1.3% yearly increase in CHP heat generation and an increase in electricity demand equal to half of the national electricity demand growth rate.

For combined heat and power plants, the sector allocation is based on historical production, an assumed growth rate of 1.3% in heat demand and benchmark parameters for emissions. The parameters are stated to be based on BAT:

- 90kg/GJ for heat generated from coal combustion
- 60kg/GJ for heat generated from gas combustion
- 850kg/MWh for electricity generated from coal combustion

[28] Source: European Commission press release, "Emissions trading: Commission adopts amendment decision on the Slovak National Allocation Plan for 2008 to 2012", Reference: IP/07/1869, 7.12.2007

- 430kg/MWh for electricity generated from gas combustion

For heating plants, the allocation is based on production volumes provided by installations and an emission factor of 0.1325 MgCO2/GJ.

Installation level allocation is done for utility power plants so that the power plants having more SO2 emissions per production unit will get fewer allowances. The purpose is to reduce SO2 emissions concurrently. For combined heat and power plants, the division is done for members of PTEZ based on an agreed algorithm. For installations that are not members of PTEZ, the allocation is based on historical emissions and a quotient of CO2 emission indicator of the sector and CO2 emission indicator of the particular installation.

For heating plants, the installation level allocation is based on the following benchmarks:

- 0.1325 Mg/GJ in case of separated heat generation
- 0.125 Mg/GJ in case of combined heat generation
- 0.872 Mg/GJ in case of combined power generation.

As there has been a significant reduction in the total allocation for Poland, it is possible that the allocation rules have been changed after the publication of the original NAP.

Comprehensive information is not given in the NAP on how the allocation is done for new entrants. The commission has requested more information to be given. The allocation for new utility plants is stated to be based on the following benchmarks:

- 0.75 Mg/MWh for hard coal
- 0.85 Mg/MWh for lignite

A1.10.3 Summary of special characteristics

Table A10. *Special characteristics related to benchmarking and allocation for the energy sector in the national allocation plan of Poland for 2008-2012.*

Reference time period	2005
Grouping of energy sector	Utility power plants, Combined heat and power plants, Utility heating plants
Allocation method for new entrants	Not specified comprehensively. Benchmarks used for utility plants.
Using benchmarking	Benchmarking is used directly in the installation level allocation of heating plants. In addition, the sector level allocation is based on defined average emissions for certain production.
Allocation in CHP plants	A cogeneration bonus given for the sector as a total. Exact allocation method based on an agreed algorithm not given in the NAP.

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