Ecofys BV
P.O. Box 8408
NL-3503 RK Utrecht
Kanaalweg 16-G
NL-3526 KL Utrecht
The Netherlands
www.ecofys.com

T +31 (0)30 280 83 00
F +31 (0)30 280 83 01
E info@ecofys.com

TRANSFERS OF CO_2 UNDER THE EU EMISSIONS TRADING SCHEME

- FINAL -

Mirjam Harmelink
Rogier Coenraads

15 April 2005

ECS04102

By order of the Netherlands Ministry of Housing, Spatial Planning and the Environment, The Hague.

Summary

CO_2 transfers: one of the 'loose ends' under the ETS.
At January 1 2005 the first trading period of the European Emissions Trading Scheme (ETS) took off. This ETS still holds several 'loose ends' that have not been settled yet under the Directive of emission trading, and the accompanying monitoring and reporting guidelines. One of these 'loose ends' is the transfer of CO_2 from one installation to another installation in order to be used in other production processes or to be stored in products or the underground. These transfers may cause leakage of CO_2 emissions from the ETS, thus sending wrong signals to companies, in case CO_2 is transferred to installations that currently do not take part in the ETS.

Current CO_2 transfers in the Netherlands amount to ~3 Mton.
An overview of current and future transfers of CO_2 in the Netherlands is shown in Figure S1. Currently the most important transfer (> 2400 kton) is the transfer of CO_2 coming from the steel production sector to the electricity production sector. The second largest transfer (~650 kton) is CO_2 coming from the fertiliser industry, which is being supplied to a great variety of applications, some of them abroad. Currently only one stream (from an electricity production installation to greenhouse growers) involves a transfer from an ETS participant to a non-ETS participant.

Future CO_2 transfers will increase substantially with the OCAP project in place and through carbon capture and storage projects.
An important future transfer, that will be established on the short term, is the transfer of CO_2 from the Shell refinery to the horticultural sector of ~300 kton within the so-called OCAP project. This involves the transfer from an ETS to a non-ETS sector. On the medium term transfers of CO_2 for storage in the underground such as empty gas fields can be of significant importance.

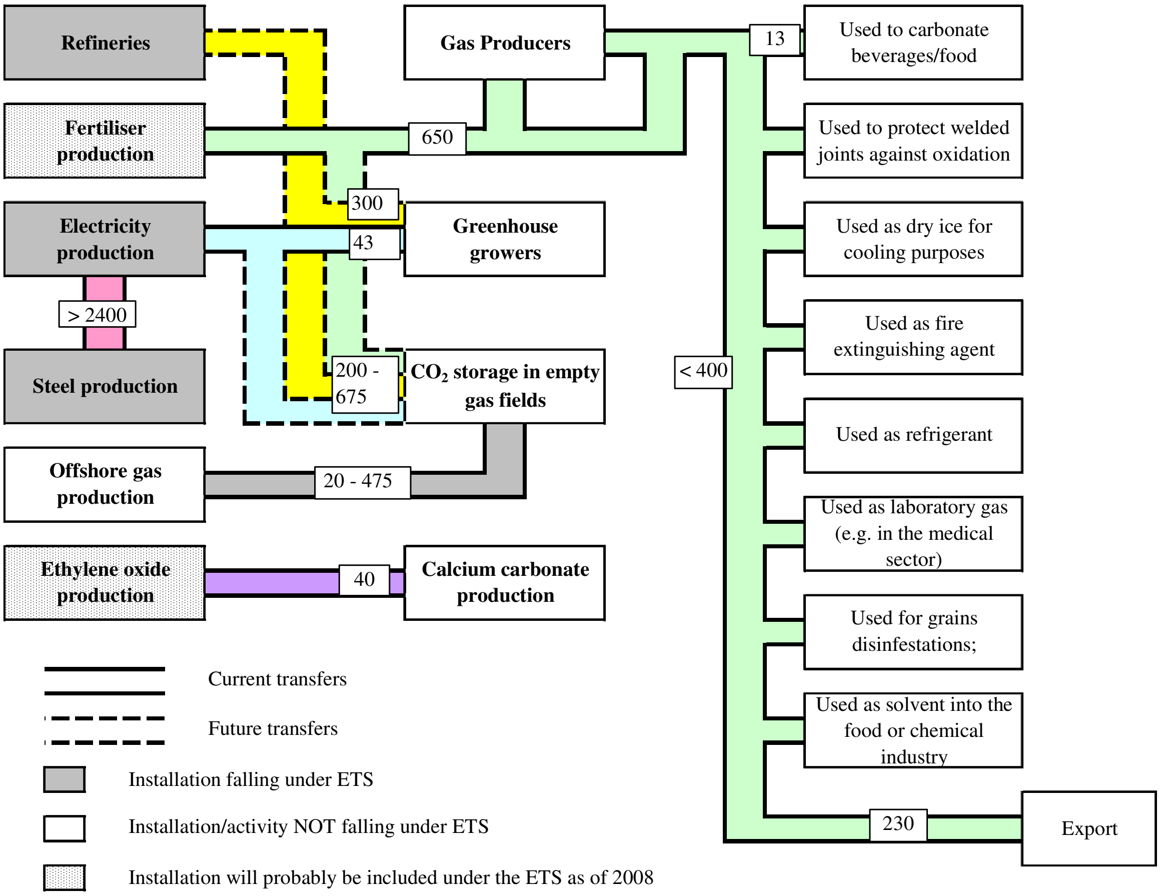

Figure S1 Quantitative overview of most important current and estimated future transfers of CO_2 in the Netherlands

Almost all physically transferred CO_2 is emitted further down the production chain, but does often lead to a decrease in energy use.

With the exception of storage of CO_2 in the underground all physically transferred CO_2 is emitted again at either the direct buyer of the CO_2 or otherwise further down the chain at the moment when produced products are consumed. However, CO_2 transfers often do lead to a decrease in fossil energy use and CO_2 associated emissions. Whether transfers of CO_2 lead to a decrease in fossil energy use or not, depends on the assumption with respect to the reference situation, which is defined as the situation that would have occurred in the absence of CO_2 transfers.

CO_2 transfers are currently not properly accounted for in the national emission inventories.

Under the inventory guidelines in place as of 2005 no provisions are included to properly account for all transfers of CO_2. In order to establish correct CO_2 emissions on national and sector level CO_2 transfers should be reported as separate item in the national inventory report. With the exception of exports of pure CO_2, which require introducing a new category in the national inventory report, all other transfers do not require any changes to the current guidelines.

Carbon capture and storage can either be treated as a sink or an emission reduction option in the national emission inventories.
Under the current IPCC emission inventory guidelines carbon capture and storage (CCS) can be treated as an emission reduction by adapting the emission factor for fuel combustion or industrial process emissions. In this case the reductions achieved through CCS are accounted for by decreasing the combustion or industrial emissions. In order to be transparent this would require proper measurement of exported and the injected amount of CO_2 and the seepage of CO_2 from the storage site in order to account for fugitive emissions occurring in the carbon capture and storage chain. Another option is to treat CCS as a sink under the IPCC guidelines. This only requires monitoring of the injected amount of CO_2 and the seepage of CO_2 from the storage site. This approach however requires amendments to the IPCC guidelines by including a new category to account for storage.

The transfer of CO_2 from ETS to non-ETS sectors is a potential leakage of CO_2 from the ETS system.
The current guidelines to monitor emissions under the ETS state that "CO_2 which is not emitted from the installation but transferred out of the installation as a pure substance, as a component of fuels or directly used as a feedstock in the chemical or paper industry, shall be subtracted from the calculated level of emissions". This means that CO_2 transfers can be directly subtracted from the level of CO_2 emissions calculated/measured for the installation from which the CO_2 is transferred, and from the installation point of view can be considered as a reduction. This is illustrated in figure S2 for the OCAP project.

CO_2 transfers to the horticultural sector are currently the most important leakage source.
On the short term the most important potential leakage is related to the transfer of CO_2 from a refinery to the horticultural sector, which could lead to an increase in CO_2 emissions. If in the second trading period the ammonia industry is included under the ETS, CO_2 transfers from this industry sector are a large potential source of CO_2 leakage from the ETS as well.

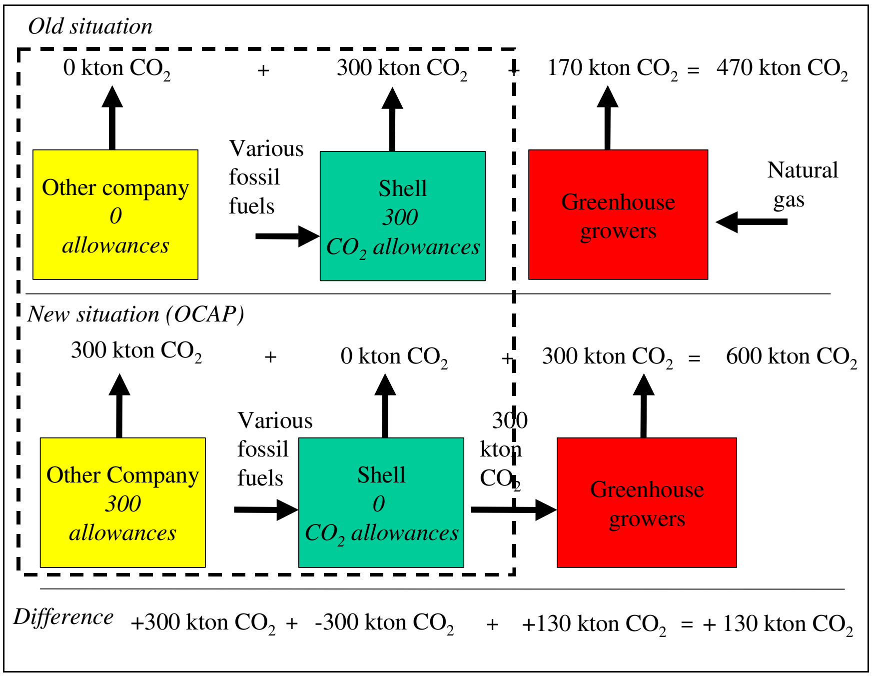

Figure S2. Outline of emissions in the old situation (before CO_2 is transferred) and in the new situation (OCAP project). The dashed lines indicate the boundaries of the ETS system[1].

The integrity of the ETS can be ensured through……

(i) ….proper monitoring.

At least ensuring proper monitoring and accounting of the transferred CO_2. By measuring the amount of transferred CO_2, giving full account on where the CO_2 is going to and where it is emitted again, and accounting of the transfers in the national inventory report.

(ii) ….treating CO_2 transfers as emissions.

Treat CO_2 which is transferred to non-ETS sectors, and which is not permanently stored as an emission. This means that the allowances linked to this transferred CO_2 need to be handed in with the emission authority and cannot be brought on the market. This would require small amendments to the monitoring guidelines by including that "*only in case the physically transferred CO_2 is permanently stored*" CO_2 transfers are immediately deductible from the level of CO_2 emissions. Drawback of this approach is that the 'chimney approach', which is the starting point of the monitoring guidelines, is partly abandoned.

[1] In the old situation the amount of allowances for Shell is equal to the amount of CO_2 emitted by Shell (300 kton). In the new situation Shell emits 300 kton of CO_2 less through her chimney but this is almost completely emitted by the greenhouse growers. Due to the transfer greenhouse growers use less natural gas (leading to a reduction of 170 kton), but because they supply more CO_2 to their crops, compared to the situation in which they used their own boiler, the emission of the greenhouse growers exceeds the old emission level with 130 kton.

(iii) …including customers of the CO_2 under the ETS.

By including the customers of the CO_2 under the ETS as well. In this way transferred CO_2 will stay within the ETS system. Depending on the sector this requires amendments to the Directives on ETS (extending the lists of activities covered by the ETS) and the accompanying monitoring guidelines. Including more sectors may however present insurmountable obstacles because a lot of small installations/consumers would need to be included under the ETS, where there is currently discussion whether small emitters should be excluded from the ETS.

Table of contents

1 Introduction

1.1 Background

At the first of January 2005 the European Emissions Trading Scheme (ETS) took off. From that date CO_2 emissions of installations participating in the ETS have to stay under the CO_2 cap laid down in the national allocation plans (NAP). The ETS that took off at the first of January still holds several 'loose ends' that have not been settled yet under the Directive of emission trading (EC, 2003)[2] and the accompanying monitoring and reporting guidelines (EC, 2004)[3]. Some of these 'loose ends' could affect the environmental integrity of the ETS, because it may cause leakage of CO_2 emissions and send wrong signals to companies.

One of these 'loose ends' is the transfer of CO_2 out of the installations in order to be used in other production processes or stored in products or the underground. This report will show that CO_2 transfers from installations falling under the ETS to installations/activities currently not participating in the ETS potentially form a leakage of CO_2 emissions out of the ETS, which can harm the environmental integrity of the system. The Ministry of VROM therefore commissioned Ecofys to explore this issue of CO_2 transfers in more detail.

1.2 Objectives

The objectives of the project are

- To assess if it is necessary to adapt current rules under the ETS and the guidelines for national greenhouse gas emission inventories in order to ensure that CO_2 transfers are properly accounted for.
- To provide concrete recommendations for amendments and additions to the current rules and guidelines.
- To draw up a report that can serve as a starting point for further discussions on CO_2 transfers with several target groups such as companies that participate in the ETS, policy makers at the national and European level, non-governmental organisations, and scientific institutes involved in emission inventories.

---

[2] EC (2003). Directive of the European Parliament and the Council of 13 October 2003 establishing a scheme for greenhouse gas allowances trading within the Community (EC/2003/87/EC)

[3] EC (2004). Guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC if the European Parliament and the Council.

1.3 Research questions

In order to fulfil the objectives of the project the following questions will be answered:

1. What is the current and future level of CO_2 transfers in the Netherlands, and in which processes and products is CO_2 used or stored? (Chapter 2)
2. Which part of the transferred CO_2 leads to permanent CO_2 reductions and how can this be determined? (Chapter 3)
3. What is the relationship between transfers of CO_2 and the national system of greenhouse gas emission inventories? (Chapter4)
4. What is the relationship between transfers of CO_2 and rules with respect to trading in CO_2 allowances and the monitoring of CO_2 emissions under the ETS? (Chapter 5)
5. What are desirable and possible complements and revisions to the national system of greenhouse gas emission inventories and the rules for trading and monitoring of CO_2emissions under the ETS? (Chapter 4 and Chapter 5).

2 Volume of CO_2 transfers in the Netherlands

2.1 Overview of transfers of CO_2

This chapter provides an overview of the most important current and future volumes of transfers of pure CO_2 in the Netherlands. Figure 1 gives an overview of the most important CO_2 transfers. In Figure 1 current transfers are indicated with continuous lines and future transfers with non-continuous lines. The overview includes transfers between ETS participants, from ETS participants to non-ETS participants and between non-ETS participants. In Figure 1 ETS participants are marked with grey and non-ETS participants are marked in white cells.

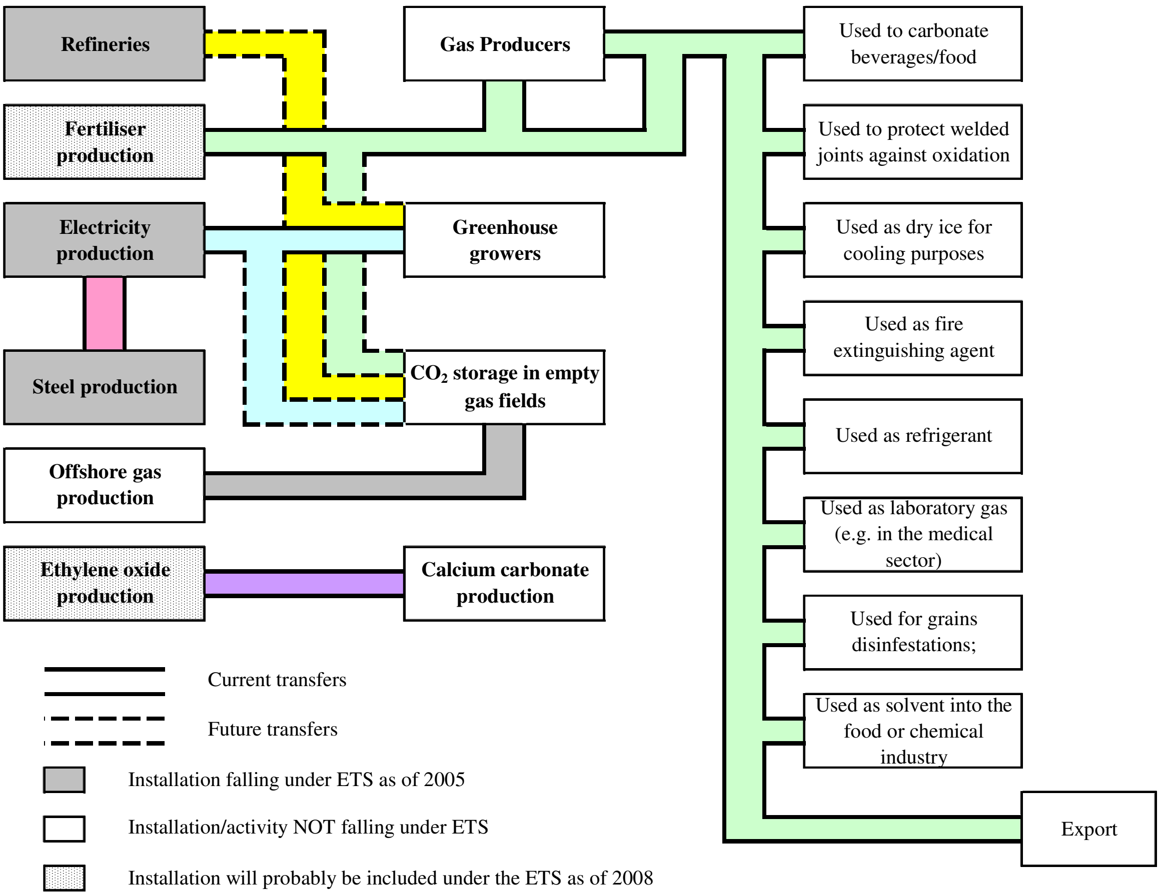

Figure 1 Overview of most important current and estimated future transfers of CO_2 in the Netherlands.

Sections 2.2 until 2.5 describe the current transfers of CO_2 in more detail. An estimate and description of the future transfers is given in sections 2.6 until 2.8.

2.2 Current CO_2-transfers from chemical industry and refineries

The *fertilizer industry* is the largest producer of pure CO_2 in the Netherlands. Ammonia, which is the raw material for the production of nitrogen containing fertilizers like urea, is produced from natural gas by means of steam reforming. Steam reforming of natural gas yields a mixture of hydrogen (H_2) and carbon dioxide (CO_2). This CO_2 is removed by means of absorption, leading to a pure CO_2 stream. The remaining hydrogen is used for the synthesis of ammonia from hydrogen and nitrogen via the so-called Haber process. There are two fertilizer producers in the Netherlands (Yara Sluiskil and DSM Agro), which both use the process of steam reforming of natural gas to produce hydrogen as an intermediate for fertilizer production.

- In 2004 Yara Sluiskil produced a total amount of 2.2 Mton (Yara Sluiskil, 2005)[4] of pure CO_2 coming from the ammonia plant. About half of this amount is emitted to the air, while 630 kton of CO_2 is used for the production of urea. The remaining part (approximately 350 kton) of pure CO_2 is transferred to clients outside the company. Yara states that 230 kton of CO_2 is exported to the United Kingdom and Scandinavia, while approximately 120 kton is delivered to breweries, dry ice producers and greenhouses in the Netherlands and Belgium[5].
- In 2004 DSM Agro produced a total amount of 1.2 Mton (DSM Agro, 2005)[6] of CO_2. The production of urea and melamine had an intake of approximately 170 kton of pure CO_2, while approximately 300 kton of CO_2 was delivered to the company Carbolim. Carbolim delivers liquefied CO_2 to several clients in the Netherlands. As far as we know Carbolim does not export any CO_2 to other countries.

It should be noted that process emissions from the fertiliser industry do not fall under the ETS system in the first trading period.

The production of pure CO_2 at *refineries* is also the result from hydrogen production processes. At the Esso refinery steam reforming of natural gas is used to produce hydrogen, providing a pure CO_2 stream. At the Shell Pernis site hydrogen is produced by means of gasification of refinery residues, also resulting in pure CO_2 as a by-product. There are six refineries in the Netherlands, of which five are concentrated around the Rotterdam harbour area (Esso, Kuwait Petroleum, Nerefco, Shell Pernis and Koch HC Partnership), while Vlissingen accommodates the refin-

---

[4] Yara Sluiskil (2005) Communication with Mr J. van Damme d.d. 21 February 2005
[5] Yara Sluiskil (2005) Communication with Mr. J. van Damme d.d. 9 March 2005
[6] DSM Agro (2005) Communication with Mr T. Tolboom d.d. 21 January and 22 February 2005

ery of Total. Only the refineries of Shell Pernis and Esso produce pure CO_2 streams as a by-product of the production of hydrogen. The total amount of pure CO_2 produced by both sites is estimated at 1100 kton in 2004, which was all emitted to the air. These CO_2 emissions fall under the ETS.

The *ethylene oxide plant* of Shell Moerdijk[7] also produces pure CO_2. The production of CO_2 from this plant was 40 kton (Shell Moerdijk, 2005)[8] in 2004. Virtually all CO_2 is transferred to Omya, a manufacturer of calcium carbonate. Calcium carbonate is amongst others used for whitening of paper in the paper industry, resulting in the emission of CO_2 during the whitening process. Under the ETS these emissions are covered as process emissions of the pulp and paper industry. We do not know how much of the calcium carbonate is used in the Netherlands and how much is exported.

Table 1 provides a summary of all large-scale pure CO_2 streams from the chemical industry and the refineries in the Netherlands.

Table 1 Overview of pure CO_2 streams in the Netherlands from the chemical industry and the refineries (between brackets the monitoring year)

	Shell Per+	**Shell Moerdijk**	**Esso**	**Yara**	**DSM Agro**
Location	Pernis	Moerdijk	Rotterdam	Sluiskil	Geleen
Activity	Hydrogen production	Ethylene production	Hydrogen production	Ammonia production	Ammonia production
Pure CO_2 under ETS 2005-2007	Yes	No	Yes	No	No
Process	Gasification of refinery residues		Steam reforming of natural gas	Steam reforming of natural gas	Steam reforming of natural gas
Production (kton CO_2/year)	1000	40 (2004)	100 (1999)	2200 (2004)	1175 (2004)
Internal use (kton CO_2/year)				630 (2004)[9]	170 (2004)[10]
Transfer (kton CO_2/year)	0 (2004) 300 (2006, OCAP)	40 (2004)	0	350 (2004)	300 (2004)
Emissions to air (kton CO_2/year)	1000 (2004) 700 (2006)	0 (2004)	100	1220 (2004)	705 (2004)

[7] Shell requested an op-out of the ethene production facility, which was approved. This means that this installations does not fall under the ETS during the first trading period.
[8] Shell Moerdijk (2005) Communication with Mr L. Tops d.d. 19 January 2005
[9] CO_2 is used as raw material for the production of ureum
[10] CO_2 is used as raw material for the production of ureum and melamine

2.3 Current CO_2 transfers to and from the power sector

Steel manufacturer Corus delivers residual gases, which act as fuel for the power plants in IJmond (at the site of Corus) and Velsen (Nuon, 2003)[11]. Both power plants are owned and operated by Nuon Power Generation. The power plants at IJmond and Velsen use coke oven gas, blast furnace gas and basic oxygen furnace gas delivered by Corus. Coke oven gas is a hydrogen-rich residual gas. The CO_2 content of coke oven gas is 2-3 vol%. The exact amount of annual transfer of CO_2 from Corus to Nuon Power Generation is not publicly available, however minimum estimates of the CO_2 transfer have been made. Estimated amount of CO_2 transfer through coke oven gas is 5 kton per year (CBS, 2001)[12]. Blast furnace gas is a residual gas containing about 20 vol% of CO_2. The amount of annual CO_2 transfer from Corus to Nuon Power Generation via blast furnace gas is estimated at least 2400 kton CO_2. The installations of Corus as well as of Nuon fall under the ETS.

Another route is the transfer of CO_2 from the *electricity production sector* to *greenhouse growers*. Currently, transfer of CO_2 takes place from only one electricity production site in the Netherlands; the RoCa3 power plant of E.ON in Rotterdam/Capelle a/d IJssel. The RoCa3 is a CHP plant with a capacity of 290 MWe and 480 MWth (van Vliet, 2002)[13], which delivers heat and CO_2 to 140 greenhouse growers. In this way 43 kton of CO_2 (Eneco, 2005)[14] is transferred annually from the power plant to the greenhouse growers. The CHP plant of Eon falls under the ETS.

2.4 Current CO_2 transfers to and from industrial gas producers

Industrial gas companies distribute and supply CO_2 to a great variety of purchasers that use the CO_2 for different applications. The gas companies do not produce CO_2 themselves in the Netherlands, but collect CO_2 from the industry. They deliver CO_2 for a whole range of applications, the most important being[15]:

---

11 Nuon Power Generation (2003). Milieujaarverslag 2003.

12 CBS (2001) Calculation based on data from De Nederlandse Energiehuishouding 2001 CBS, Voorburg.

13 Van Vliet (2002). Presentation held by dhr van Vliet of EoN at the ExCo 15-16 April 2002 in Amsterdam.

14 Eneco (2005) Communication from Mr E. Valkenburg d.d. 24 February 2005

15 In the Montoring guidelines for the Emissions Trading scheme, next to the applications listed two other possible transfers of CO2 are mentioned: (1) CO_2 used as feedstock in the pulp industry (carbonates) and (2) CO_2 used as feedstock in the fertilizer industry (urea). Both applications are not relevant for the Netherlands, because (1) in the Netherlands only mechanical pulp production is applied in which case the production of carbonates in not relevant and (2) there is no seperate urea production facility in the Netherlands (there are only plants in which the ammonia and urea production are integrated).

1. Used to carbonate beverages/food. In this case the CO_2 is stored in beverages and food, which is either consumed in the Netherlands or exported.
2. Used to protect welded joints against oxidation.
3. Used as dry ice for cooling purposes.
4. Used as fire extinguishing agent.
5. Used as refrigerant. In this case the CO_2 is stored in the refrigerator, and released again after dismantled.
6. Used as laboratory gas (e.g. in the medical sector)
7. Used for grains disinfestations;
8. Used as solvent into the food or chemical industry.

There are three producers of industrial gases active on the Dutch market; Air Liquide, Air Products and Hoek Loos (part of Linde group). Air Liquide and Air Products don't acquire or sell substantial amounts of CO_2 in the Netherlands (Air Liquide, 2005)[16] (Air Products, 2005)[17], which leaves the Dutch CO_2 market dominated by Hoek Loos. The most important supplier of CO_2 to Hoek Loos is Yara Sluiskil. Data on the amount of CO_2 supplied by Yara and the sales of CO_2 from Hoek Loos are not publicly available (Hoek Loos, 2005)[18].

DSM Agro delivers pure CO_2 originating from the ammonia production process to Carbolim. The amount of CO_2, which this company receives from DSM Agro, is estimated at 300 kton CO_2 per year[19]. Carbolim liquefies this gaseous CO_2 and delivers this to several clients. Major part is delivered to the beverage industry and breweries. Other applications are packaging industry, dry ice and greenhouses[20].

Because of lack of data we are not able to provide data on the use of CO_2 for the different applications mentioned in this section. We were only able to make an estimate of the overall uptake of CO_2 by the production of soft drinks and mineral waters in the Netherlands, which is estimated at least 13 kton CO_2 per year[21].

With the data from the different sources we are now able to get a rough picture on the transfers of CO_2 from the fertilizer industry. In total these transfers sum up 650 kton per year. At least 230 kton is exported to other countries, 13 kton is used in the beverage industry, which leave approximately 400 kton being used within the Netherlands. This 400 kton is not all used for the applications listed in this paragraph but is also supplied to greenhouse growers. We however do not know how much this is.

[16] Air Liquide (2005) Communication with Mr. R. Breslau d.d. 10 January 2005
[17] Air Products (2005) Communication with Mr. F. Govaert d.d. 6 January 2005
[18] Hoek Loos (2005). Communication with Mr. F. Hage d.d. 10 January 2005
[19] Agro DSM (2005). Communication with Mr. T. Tolboom d.d. 22 February 2005
[20] Carbolim (2005). Communication with Mr. A. Bontemps d.d. 17 March 2005
[21] Calculation based on 7 g CO_2/liter soft drink (source: Coca Cola Productiefabriek Dongen, communication d.d. 25 February 2005) and annual production of 1848 million liters of carbonated soft drinks and mineral waters in the Netherlands (source: CFW (http://www.frisdrank.nl/frisdran/frfrisdr.htm date 24 febr 2004))

2.5 Current geological storage of CO_2

The first CO_2 storage project in the Netherlands started in spring 2004, with the injection of CO_2 in an off-shore depleted gas field by Gaz de France. This demonstration project is part of the so-called CRUST project: CO_2 Reuse through Underground STorage. The initial demonstration project is running for 4 years and aims at injection of 20 kton CO_2 per year. The injected CO_2 stems from existing off-shore gas fields that contain large amounts of CO_2. This CO_2 is separated from the extracted natural gas and then -instead of emitted to the air- injected in the underground. The next phase of the CRUST project aims at large-scale injection of CO_2 in the same gas field at injection rates of 310-475 kton CO_2/year. The potential available storage volume of the depleted gas field is estimated at around 8 Mton CO_2 (Novem, 2003) [22]. The CRUST project is the only project of geological storage of CO_2 in practice in the Netherlands until date.

2.6 Future CO_2 transfers to the horticultural sector

The transfers of CO_2 to the horticultural sector will increase as of 2005. Starting from 2005 onwards OCAP, a joint venture of Hoek Loos and the construction company VolkerWessels, will annually transfer 300-320 kton (OCAP, 2005)[23] of pure CO_2 from Shell Pernis to greenhouse growers. Due to less need for the greenhouse growers to operate their own boiler during periods when there is no heat demand, the project is estimated to reduce overall CO_2 emissions in the Netherlands by 170 kton CO_2 in the first year (Utilities, 2004)[24].

2.7 Future CO_2 transfers for storage in geological reservoirs

2.7.1 CO_2 storage potential

In principle, CO_2 could be stored in the following geological reservoirs (TNO et al, forthcoming)[25]:

- *On-shore gas fields*. The overall storage capacity in the Netherlands in on-shore gas fields is estimated at 12 Gton CO_2 of which the Slochteren field accounts for 10 Gton. Offshore storage capacity of CO_2 in gas fields is estimated at 1.3 Gton

[22] Novem (2003) CRUST CO_2 reuse through underground storage, brochure Novem, May 2003
[23] OCAP (2005) (Communication with Mr. de Vlieger d.d. 12 January 2005)
[24] Utilities (2004) 'Shell's kooldioxide naar tuinders', Utilities, p. 14-15, January/February 2004
[25] TNO et al (forthcoming) Cost curves for CO_2 storage, part 2: European sector, TNO-NITG, BGS, Ecofys, GEUS (to be published)

- *On-shore oil fields*. The CO_2 storage capacity of the on-shore oil field at Schoonebeek is estimated at 19 Mton, while the total offshore CO_2 storage capacity in oil fields in the Dutch part of the North Sea is estimated at 20 Mton. Estimations of the CO_2 storage capacity of coal beds in the Netherlands indicate an overall capacity of nearly 2 Gton. CO_2 can also be used to stimulate the extraction of methane from coal beds by ECBM (enhanced production of coal bed methane).
- *Aquifers*. Finally, the CO_2 storage capacity of aquifers in the Netherlands is estimated to be more than 8 Gton. One large off-shore aquifer in the Netherlands Southern North Sea Basin is estimated to have a storage potential of more than 5 Gton CO_2, whereas the on-shore storage capacity in aquifers is about 3 Gton CO_2.

Although most of the oil and gas fields are still in production today, a substantial part of them will be depleted within ten years time. As -generally spoken- the geology of gas fields and oil fields are known in more detail compared to the geology of coal beds and aquifers, depleted hydrocarbon fields are expected to be of more interest for CO_2 storage in the Netherlands. Given the higher storage potential, especially *depleted gas fields* are expected to contribute to the geological storage of CO_2 in the Netherlands. Storage of CO_2 in gas fields could be carried out in combination with Enhanced Gas Recovery (EGR).

2.7.2 Estimation of future CO_2 storage

As the costs of carbon capture are high compared to the costs of carbon storage, the *storage of pure CO_2* is considerably more attractive from an economical point of view than the capture of carbon dioxide from flue gases. We therefore assume that on the short to mid-term storage of pure CO_2 streams in depleted gas fields, coming from the fertiliser industry and the refineries, is the most attractive options for the Netherlands. In the period 2005-2007 about 800 kton of pure CO_2 that is emitted to the air will fall under the Emission Trading Scheme (Table 1: Shell Per+ and Esso). Compared with the potentials of CO_2 storage in gas fields, oil fields and aquifers, we can conclude that there is sufficient storage potential for CO_2 in the Netherlands. Assuming that for example 25% of this amount will be stored on the short term, 200 kton of CO_2 would need to be transferred annually to underground storage reservoirs. When we take the pure CO_2 streams of ammonia production facilities into account as well, a share of 25% storage would imply storage of about 680 kton CO_2.

2.7.3 Overview of CO_2 emissions in the CO_2 capture and storage (CCS) chain

Figure 2 provides an overview of possible emissions occurring during the carbon capture and storage process. In Figure 2 a distinction is made between fugitive CO_2 emissions (red encircled emissions in Figure 2, i.e. transferred CO_2 emissions that are emitted again), and CO_2-emission related to energy consumption (mainly electricity) to operate the CO_2 capture and storage process.

Fugitive emissions

In case of capture of pure CO_2 streams from refineries and the chemical industry close to 100% of the pure CO_2 stream can be captured. Besides special circumstances leading to a major leak in the pipeline, under normal conditions fugitive CO_2 emissions during transport are practically zero. This also holds for the emissions at the injection point. CO_2 emissions due to imperfect storage are highly uncertain. A recent study based on CO_2 storage in the Weyburn aquifer in Canada estimates that 0.2% of the overall amount of stored CO_2 might be released to the atmosphere during a storage period of 5000 years, assuming leakage via one imperfect wellbore sealing. This suggests that approximately 100% of the annually transferred CO_2 remains stored in the underground.

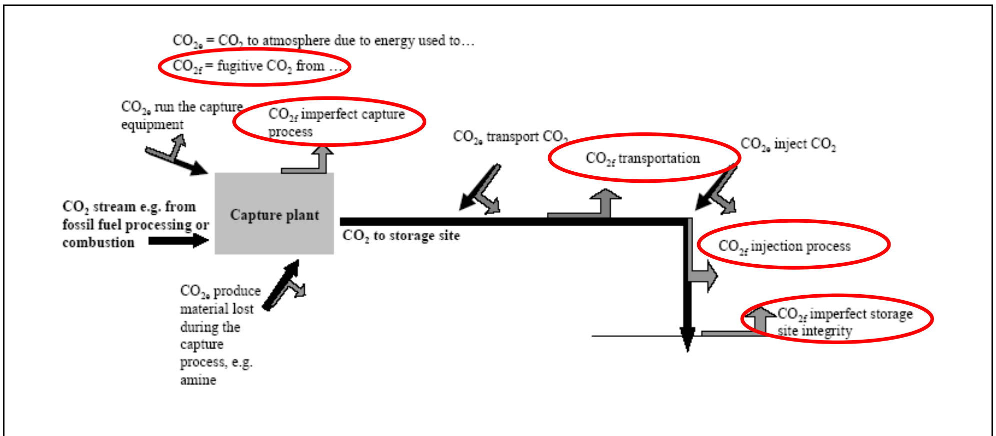

Figure 2 Possible emissions occurring during carbon capture and storage

Emissions due to additional energy use

At various points additional energy is needed compared to the situation that the CO_2 would not be stored. In most cases the additional energy needed is electricity. At the installation where the CO_2 is captured electricity is needed to capture the CO_2 and bring the captured CO_2 at the right pressure before it can be transported. In case of pure CO_2 streams the capture energy is practically zero and only electricity is needed to compress the CO_2. Typical figures are an energy use of 0.4 kJe/kg CO_2 compressed. Furthermore electricity is needed to transport the CO_2. Typical figures are 0.5 kJe/km.kg CO_2 (Hendriks et al, 2002)[26]. Assuming that the CO_2 is compressed to the accurate pressure at the capture point no additional electricity is needed at the injection points. This means that the additional CO_2 use is equal to (0.4 kJe + 0.5 kJe/km*transport distance)*CO_2 factor electricity production. E.g. assuming a transport distance of 100 km and taking the average CO_2 emission factor for the Dutch power grid this leads to a CO_2-emission of 0.007 kg CO_2 per kg of CO_2 transferred (Hendriks et al, 2002)[27]. I.e. when storing a specific amount of pure CO_2 in the underground, an amount equal to 0.7% of the CO_2 stored will be emitted to the air due to the energy use needed for compression and transportation. (It must be noted that CO_2 capture from electricity production installation leads to higher CO_2 emissions per kg of transferred CO_2 as the capture step (in which the CO_2 is captured from flue gases) is the most energy intensive step, while this step is avoided in case of storage of pure CO_2 streams).

2.8 Other possible future carbon and CO_2 transfers

2.8.1 Mineralization of CO_2

An alternative option for the storage of CO_2 is to react CO_2 with naturally occurring minerals, such as magnesium silicate, thus producing carbonates that could be stored permanently. However, the mass of mineral that is needed is substantially more than the mass of CO_2 to be mineralized (IEA, 2001)[28]. Additional limiting factors are low speed of the mineralization process and the much higher costs compared to storage in oil and gas reservoirs. It is expected that mineralization will only be viable when the produced mineral carbonates can be sold at a reasonable price. However, the market for such mineral carbonates is estimated to be limited. On the short and mid term the quantitative contribution of CO_2 mineralization to the storage of CO_2 is estimated to be negligible.

2.8.2 Application of CO_2 in methanol production

Methanol is produced through reforming of natural gas by which syngas is formed (a mixture of H_2 and CO). As the H_2/CO ratio is too high for efficient production of methanol, the surplus of hydrogen is usually combusted. Adding external CO_2 to the mixture would allow for a more efficient use of hydrogen, thus leading to a reduction of the use of natural gas for the same methanol output. A schematic representation of the production of methanol in both the conventional way and when using external CO_2 is given in Figure 3.

---

[26] Hendriks et al (2002). Climate neutral energy carrier in the REB. Ecofys, Utrecht, 2002
[27] As average emission factor for the Dutch grid 0.55 kg CO_2 per kWhe elecricity was taken.
[28] IEA (2001) Putting carbon back into the ground', IEA Greenhouse Gas R&D Programme, February 2001

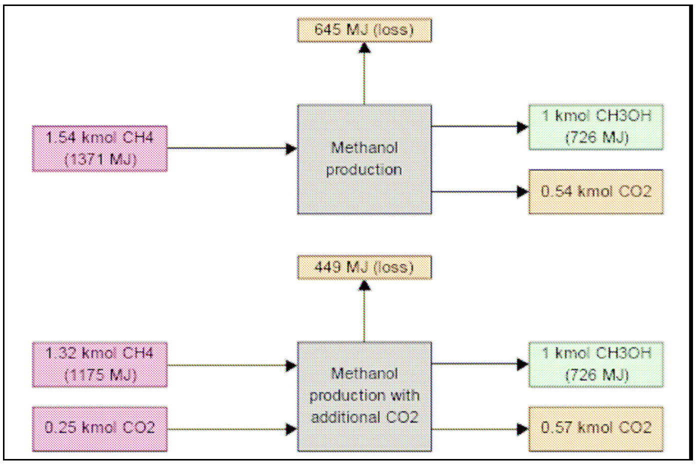

Figure 3 Simplified methanol production scheme without and with external CO_2 input (Hendriks et al, 2002)[29]

In the Netherlands there is one manufacturer of methanol, called Methanor. Assuming an annual methanol production of 800 kton[30] at Methanor, an input of 275 kton CO_2 is needed for the production of methanol with external CO_2. This would lead to an annual reduction of 1200 TJ natural gas[31]. The CO_2 output would be 625 kton CO_2, whereas the conventional way of production of the same quantity of methanol gives an annual output of 600 kton CO_2. This implies that the overall annual reduction is 250 kton CO_2 compared to the conventional way of production.

As manufacturing methanol with external CO_2 input strongly interferes with the existing production process, applying this method will have far reaching consequences for Methanor. Within the scope of this study we cannot evaluate the technical and industrial economical consequences and whether Methanor will decide for this option on the short or mid-term.

2.8.3 C-fix

C-fix is a new construction material made from high carbon residues from the petrochemical industry. Long-term fixation of carbon prevents discharges of carbon as CO_2 emissions to the air. Claims are that by using 1 ton of C-fix one reduces CO_2 emissions by 150 kg (C-fix, 2005)[32]. A highway of 10 km made with C-fix would prevent 20 kton CO_2 emissions, whereas an industrial floor of 500m x 500m locks

[29] Hendrik et al (2002) Climate neutral energy carriers in the regulatory energy tax (REB), Ecofys, February 2004
[30] Based on the production capacity of Methanor of 920 kton/year and assuming an actual production of about 85% of available capacity (actual production data are not available)
[31] Methanor (2001) (Communication with Mr. F. Geuzebroek from TNO-MEP, December 2001)
[32] C-fix (2005) www.c-fix.com (25 February 2005)

up 9900 ton of CO_2. The application of C-fix has not been taken into account, as it is a way of preventing CO_2 emissions, without any transfer of CO_2 being involved.

2.9 Quantitative overview of CO_2 transfers

An overview of current and future transfers of CO_2 in the Netherlands is shown in Figure 4. In this figure we have assumed that current transfers of CO_2 would stay on the same level in future years.

Figure 4 shows that *currently* the most important transfer (at least 2400 kton) is the transfer of CO_2 coming from the steel production sector to the electricity production sector. The second largest transfer (~650 kton) is the CO_2 transfer from the fertiliser industry and which is partly going to a great variety of applications within the Netherlands, while the remaining part is being exported. No imports of CO_2 from other countries to the Netherlands have been identified.

Important *future* transfers that will be established on the short term, are the transfers of CO_2 from the Shell refinery to horticultural sector (~300 kton). On the medium term the transfers of CO_2 for storage in the underground such as empty gas fields can be of significant importance.

Figure 4 furthermore shows that *currently* only one stream (from the electricity production sector (E.ON) to the horticultural sector) involves a transfer from an ETS participant to a non-ETS participant. The transfers from ETS to non-ETS sectors on the short term will significantly increase as soon as the OCAP project will start. However the volume of CO_2 transfers is still limited compared to the total amount of allocated allowance: the volume of transfers will be ~0.7 Mton, whereas the total amount of allowance allocated to the Dutch industry is ~95 Mton (MinEZ, 2004)[33].

[33] Min EZ et al (2004) Allocation plan CO2 allowances 2005 until 2007.

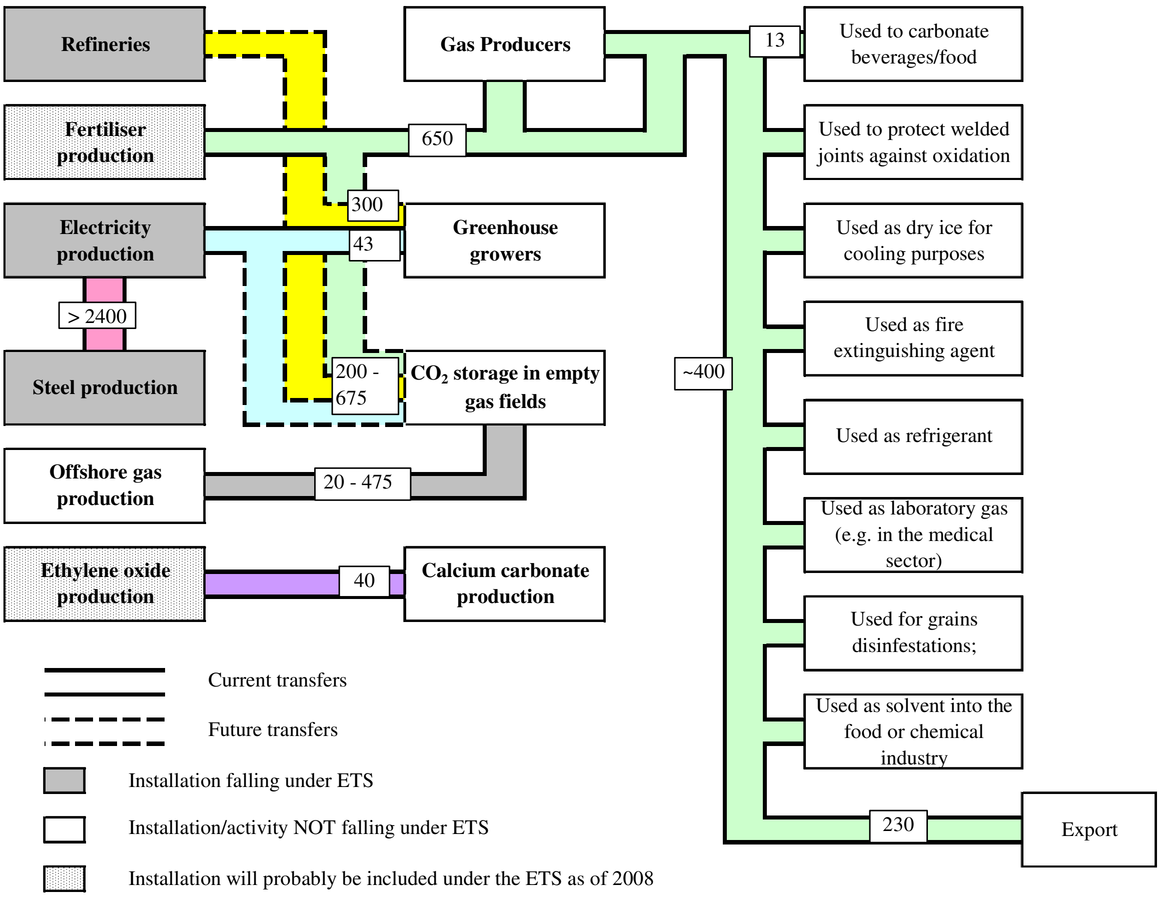

Figure 4 Quantitative overview of most important current and estimated future transfers of CO_2 in the Netherlands

3 Framework to assess sustainability of CO_2 transfers

3.1 Introduction

The previous chapter provides an overview of several CO_2 transfers in the Netherlands. Furthermore an overview is provided of the sources most relevant for the Netherlands with and indication of the volume of these transfers. This chapter provides a framework that can be used to assess *if* the transfer of CO_2 leads to permanent reductions of CO_2 on a global scale, *which* part of the transferred CO_2 is permanently reduced, and *where* the CO_2 is transferred to and stored or reduced.

In this chapter a three-step approach is applied:

1. First the crucial elements for a framework to assess *if* the transfer of CO_2 leads to permanent reductions of CO_2 on a global scale, *which* part of the transferred CO_2 is permanently reduced, and *where* the CO_2 is transferred to and stored or reduced
2. Secondly a checklist with concrete questions is developed, which enables to make a split between transfers that lead to permanent CO_2 reductions and transfers that don't.
3. Thirdly a quantitative analysis is carried out for the most important current and future CO_2 transfers described in chapter 2 to assess possible CO_2 reductions linked to these transfers.

3.2 Crucial elements for a framework to assess sustainability of CO_2 transfers

Figure 5 provides a general framework to follow flows of transferred CO_2 and analyse the relationship between CO_2-transfers and CO_2-emissions. In principle the framework boils down to following the streams of transferred CO_2 indicated with Y and analysing changes in emissions due to this transfer.

The following crucial elements are detected for a framework to determine *if* the transfer of CO_2 leads to permanent reductions of CO_2 on a global scale, *which* part of the transferred CO_2 is permanently reduced, and *where* the CO_2 reductions take place:

- *System boundaries* The system boundaries determine which transfers and emissions need to be considered in the assessment to determine which part of the transferred CO_2 lead to permanent CO_2 reductions. Situation number 5 in Figure 5 e.g. shows the situation in which part of the CO_2 is transferred to third installations. The choice of the system boundary determines how many installations need to be taken into account. The system boundaries furthermore determine which emissions have to be accounted for. In case of CO_2 storage it e.g. has to be determined if possible emissions from the storage sites need to be taken into account or not.

- *Storage of CO_2*. It has to be determined which part of the transferred CO_2 is stored. If the CO_2 is only used in the installation receiving the CO_2 (e.g. in case of use of CO_2 for cleaning or for CO_2 fertilisation) the total amount of transferred CO_2 (Y) will be emitted again on the short term at this installation. If the CO_2 is stored it has to be determined which part is stored in products or the underground and for how long, and which part is emitted again from the installation.
- *Reference situation*. It is important to determine what would have happened in the absence of the CO_2 transfer. This so-called reference situation needs to be determined in order to be able to quantify changes in CO_2 emission due to the transfer. Analysis will show that the definition of the reference situation is not always straightforward.
- *Time scale*. The choice for the time horizon determines which CO_2 storage activities are considered to lead to permanent reductions and which do not. CO_2 storage is often looked at as an option to "buy time" for the implementation of reduction options leading to the implementation of permanent reductions on the long term. When e.g. a time horizon of 100 years is taken only transfer of CO_2 for CO_2 storage in the underground can probably be considered as permanent storage. Whereas with a time horizon of 20 year also storage in certain products can be defined as permanent storage.
- *Change in fossil energy use*. Due to the transfer of CO_2 energy use with the installation consuming the CO_2 may change compared to the situation that no transfer of CO_2 takes place (reference situation). This change in energy use needs to be taken into account in order to be able to determine the overall changes in CO_2 emissions due to the transfer to CO_2.
- *Inside or outside the ETS*. Four different situations are outlined in Figure 5. In situation number 1 the CO_2 is transferred from an installation falling under the ETS to an installation within the national borders, also falling under ETS, which is (partly) storing or using the transferred CO_2. In situation number 2 on the other hand the CO_2 is transferred to an installation within the national borders not falling under the ETS.
- *Inside or outside the national borders*. Two other options are outlined in Figure 5. In situation number 3 and 4 the CO_2 is transferred to an installation outside the Netherlands either falling under the ETS (situation 3) or not (situation 4).

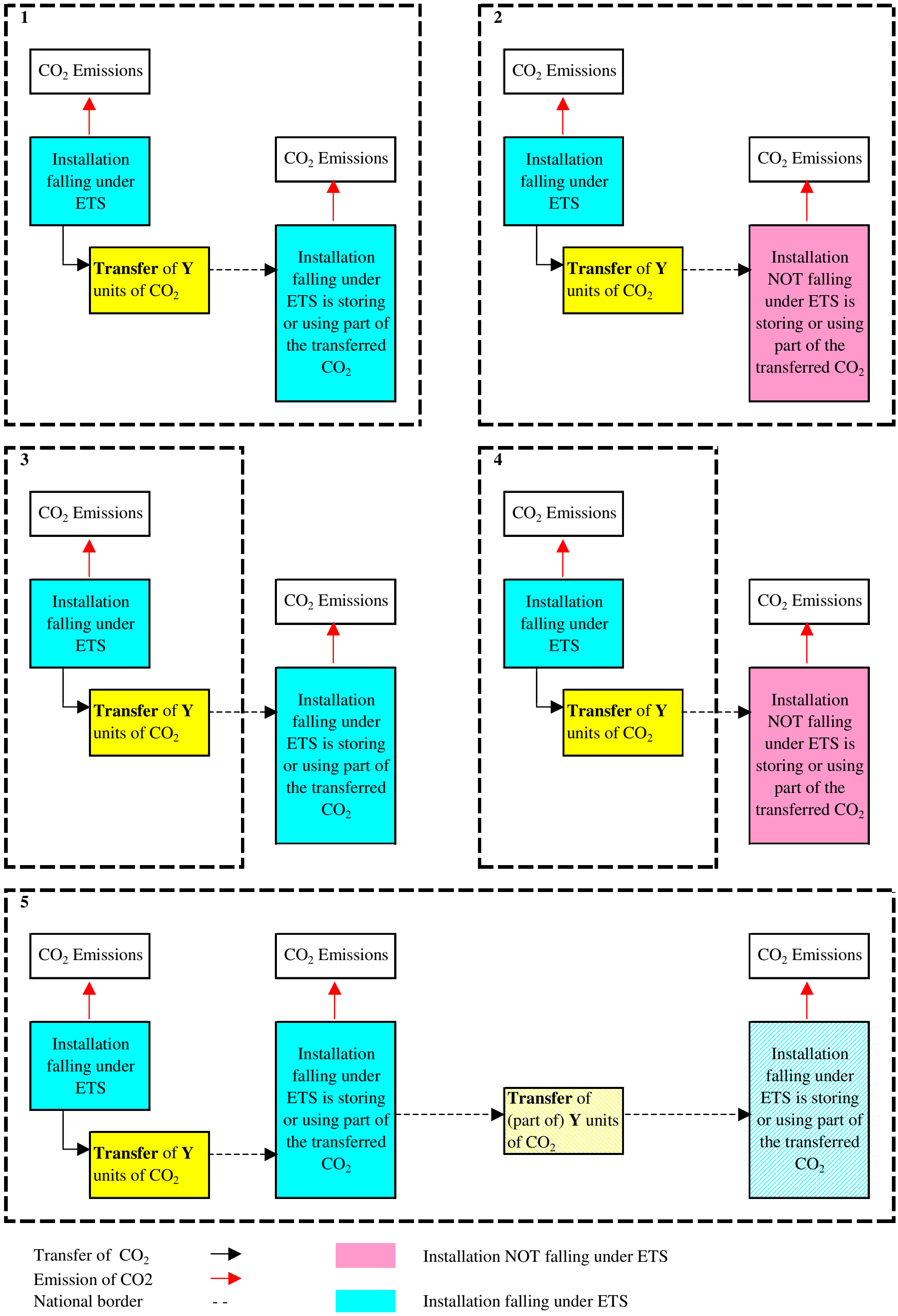

Figure 5 Outline of relationship between CO_2 transfers and CO_2-emissions for different transfers

3.3 Checklist to follow CO_2 transfers and assess permanent reductions

Based on the general framework from the previous paragraph a checklist is developed in order to be able to make a first selection between CO_2 transfers that lead to permanent CO_2 reductions and which do not. In order to be able to draw up this checklist we made the following choices:

- Storage of CO_2 is considered permanent in case the CO_2 is stored for more than 100 years.
- All emissions and each transfer need to be taken into account.

3.3.1 General checklist

The checklist starts from the viewpoint of the installation/firm that is falling under ETS and is transferring (part of) the CO_2 to another installation. All transfers and emissions refer to annual volumes.

Question 1. Where is the transferred CO_2 going?

Installation falling under ETS within national borders	A%
Installation NOT falling under ETS within national borders	B%
Installation falling under ETS abroad	C%
Installation NOT falling under ETS abroad	D%
Total	100%

→ Go to **Question 2**

Question 2. Which part of the transferred CO_2 is physically stored for more than 100 years in products or in the underground in the Netherlands or abroad?…% (E)

- **a.** If the share is 0% → Go to **Question 3**
- **b.** If share is >0% → Go to **Question 4**

Question 3. Does the transfer of CO_2 lead to changes in the use of fossil fuels with the installation(s) that is using the CO_2 compared to the situation in no CO_2 is transferred? Yes/No

- **a.** If No → *Go to end of checklist*
- **b.** If Yes → What is the relative change in CO_2 emissions at the installations(s) that is using the CO_2 per unit of CO_2 transferred?[34] (Put a minus (–) in case of savings and a plus (+) in case of an increase in energy) ………% (F) → *Go to end of checklist*

[34] How much CO_2 is reduced with a greenhouse grower for each tonne of CO2 transferred? Or how much energy is needed, and what is the accomponying CO_2 emission, for each unit of CO_2 stored in the underground.

Question 4. Does the transfer of CO_2 lead to changes in the use of fossil fuels with the installation(s) that is using the CO_2 compared to the situation in no CO_2 is transferred? Yes/No

- **a.** If No → Go to **Question 5**
- **b.** If Yes → What is the relative change in CO_2 emissions at the installations (s) that stores the CO_2 per unit of CO_2 transferred? (Put a minus (–) in case of savings and a plus (+) in case of an increase in energy) ………% (F) → Go to **Question 5**

Question 5. Which part of the CO_2 stored in products and/or the underground is annually emitted again? ……% (G) → *Go to end of checklist*

Results of checklist

		%
A:	Share of transferred CO_2 to installation falling under ETS within national borders	
B:	Share of transferred CO_2 installation NOT falling under ETS within national borders	
C:	Share of transferred CO_2 installation falling under ETS abroad	
D:	Share of transferred CO_2 installation NOT falling under ETS abroad	
Check total A+B+C+D		100%
E:	Share of transferred CO_2 stored for over 100 years	
F:	Relative change in CO_2 emissions at the installations(s) that is/are using the CO_2 per unit of CO_2 transferred	
G:	Part of stored CO_2 that is annually emitted again	

3.3.2 Application of checklist to CO_2 transfers in the Netherlands

The checklist is applied to the current and future CO_2 transfers listed in chapter 2. In this table we checked CO_2 transfers between ETS companies and between ETS and non-ETS companies, but we also checked transfers from installations not yet falling under the ETS. The results of the checklist are included in the table below.

CO_2 transfer from …to…..		**Answer to question from checklist:**
A	Electricity producers, refineries **> to** > horticulture (RoCa and OCAP)	A= 0%, B= 100%, C=0%, D=0% E= 0%, F=-x%, G=n/a • 100% of the physically transferred CO_2 is emitted with the greenhouse growers (F=0%) • However the transfer leads to an overall reduction in CO and a decrease in CO_2 emissions with x% compared to the reference situation. As in the ab-

CO_2 transfer from …to…..	**Answer to question from checklist:**
	sence of CO_2 transfers the greenhouse grower will use its boiler to produce CO_2. • For the OCAP project approximately 0.5 unit of CO_2 are reduced per unit of transferred CO_2. • The CO_2 is transferred from an installation currently falling under ETS to an installation not falling under ETS. • <u>*Conclusion*</u> > In principle transfers are leading to permanent CO_2 reductions in the Netherlands compared to the situation in which no CO_2 would have been transferred, because of a reduction in the amount of energy consumed at the greenhouse grower.
B Steel production (Corus) **> to >** electricity production (Nuon).	A= 100%, B= 0%, C=0%, D=0% E= 0%, F= 0%, G=n/a • 100% of the physically transferred CO_2 is emitted with the electricity producer (F=0%) • The transfers do not lead to changes in energy use. • The transfer involves two ETS installations. • <u>*Conclusion*</u> > The transfers do not lead to permanent CO_2 reductions on the national level.
C Refineries, fertiliser production, electricity production **> to >** storage in the empty gas fields	A= a%, B= b%, C=c%, D=d% E= e%, F= +x%, G=g% • Almost 100% of the physically transferred CO_2 is stored in the underground and permanently reduced (E=~100%) • The transfer leads to an increase in CO_2 emissions with the energy production sector due to energy needed to operate the CCS chain. • <u>*Conclusion*</u> > The transfer of CO_2 leads to a decrease of CO_2 emissions on a national level. Part of the stored CO_2 is emitted again, and storage of the transferred CO_2 requires additional energy input resulting in additional CO emissions.
D Ethylene oxide production (Shell) **> to >** Calcium carbonate production (Omya) > paper industry	A= 0%, B= 100-x-y%, C=x%, D=y% E= 0%, F= x%%, G=n/a. • 100% of the physically transferred CO_2 is emitted again when the carbonate is consumed e.g. used in the paper industry (CO_2 is first stored in the calcium carbonate but emitted again after use in e.g. the paper industry).

CO_2 transfer from …to…..	Answer to question from checklist:
	• The transfers of CO_2 may however lead to changes in the use of energy compared to the situation without CO_2 transfers. In case the calcium carbonate producer itself would have produced the CO_2 by means of fossil fuels the transfers lead to CO_2 reductions (due to lack of data we are however not able to determine the size of the CO_2 reductions). However in case the CO_2 would have otherwise have been purchased from another supplier of CO_2 no energy is saved. • <u>*Conclusion*</u> > Depending on the assumptions with respect to the reference situation the transfers lead to reduction between 0 and x%.
E Fertiliser production (> gas producer (Hoek Loos) >) **to >** various costumers to protect welded joints, dry ice, laboratory gas, disinfestations and solvent, carbonate beverages/food, fire extinguisher, refrigerant.	A= 0%, B= 100-x%, C=0%, D=x% E= 0%, F= 0%, G= y% • Physically 100% of the transferred CO_2 is emitted again, when the CO_2 is used or the produced products are consumed. • We assumed that no changes take place in the amount of energy consumed, as in most cases the customers otherwise would not have produced the CO2 itself but either used another product or another supplier. • Transfer of CO_2 does not lead to CO_2 reductions on the global scale. At least 35% of the CO_2 is emitted outside the Netherlands, the remaining part within the national boundaries. • In this case the choice to take a time period of 100 year instead of a period of e.g. 20 years affects the outcome, because in case of the use of CO_2 as refrigerant this may be stored for ~20 years. • <u>*Conclusion*</u> > The transfer of CO_2 does not lead to permanent reduction on a global scale (on a time scale of 100 years) but part of the emissions is exported.

3.4 Overall picture

Table 2 summarises the results of this chapter. The table shows that with the exception of storage of CO_2 in the underground all physically transferred CO_2 is emitted again with either the direct buyer of the CO_2 or otherwise further down the chain at the moment when produced products are consumed.

CO_2 transfers often do lead to a decrease in fossil energy use and CO_2 associated emissions. Whether transfers lead to a decrease in fossil energy use depends on the assumption with respect to the reference situation, which is defined as the situation that would have occurred in the absence of CO_2 transfers.

Table 2 Summary on CO2 reduction achieved through transfers

CO_2 transfer from …to…..	**Is physically transferred CO_2 emitted?**	**Does transfer lead to changes in energy use compared to reference situation?**	**Is part of transfers CO2 exported?**
A. Electricity producers, refineries **> to >** horticulture (RoCa and OCAP)	Yes	Yes (decrease)	No
B. Steel production (Corus) **> to >** electricity production (Nuon).	Yes	No	No
C. Refineries, fertiliser production, electricity production > to > storage in the empty gas fields	No	Yes[1] (increase)	N.A.
D. Ethylene oxide production (Shell) **> to >** Calcium carbonate production (Omya) > paper industry	Yes	Yes (decrease)	Yes
E. Fertiliser production (> gas producer (Hoek Loos) >) **to >** various costumers to protect welded joints, dry ice, laboratory gas, disinfestations and solvent, carbonate beverages/food, fire extinguisher, refrigerant.	Yes	No[1]	Yes

[1] Depending on the assumption with respect to the reference situation.

4 CO_2 transfers under national greenhouse gas emission inventories

4.1 Introduction

Under the United Nations Framework Convention on Climate Change (UNFCCC) countries have to make an annual inventory of their national greenhouse gas emissions. By order of the UNFCCC the Intergovernmental Panel on Climate Change (IPCC) guidelines are established for national greenhouse inventories in 1996. The UNFCCC affirmed in 1997 that these guidelines shall be used as "methodologies for estimating anthropogenic emissions by sources and removals by sinks of greenhouse gases" in calculation of legally binding targets during the first commitment period (IPCC, 2005)[35]. In 2006 revised guidelines will be published.

In the assessment of guidelines for national emission inventories it is important to have the basic criteria for establishing these guidelines and in evaluating the quality of national greenhouse gas inventories in mind. The UNFCCC Guidelines for reporting (UNFCCC, 1999)[36] defined the following *basic criteria* for emission inventories: the need to be transparent, consistent, comparable, complete and accurate. These basic criteria are used throughout this chapter when assessing current guidelines and in assessing different ways to include CO_2 transfers.

This chapter starts with an overview of the way CO_2 transfers are currently included in the IPCC guidelines and in the Dutch national emission inventories. The inventory shows that no specific rules are currently in place to record and account for CO_2 transfers. This chapter therefore continues with discussing different ways for recording CO_2 transfers in the national emission inventories.

4.2 CO_2 transfers in the Dutch national emission inventories

Until the national emission inventories of 2004 the greenhouse gas emissions for the industry and electricity production sector in the Netherlands were taken from the ERi (Emission Registration individual). The ERi holds information on the emissions for a whole range of pollutants (including greenhouse gases) that are calculated on company level and provided by the companies themselves. The ERi is not

---

[35] IPCC (2005). http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm Download 10 January 2005.

[36] UNFCCC (1999) UNFCCC, 1999: UNFCCC Guidelines for reporting and review. UNFCCC Secretariat, Bonn. Doc. No FCCC/CP/1999/7. January 2000.

very transparent, because documentation requirements are very limited. In addition the ERi is often not complete resulting in inconsistent time series. Because of the limited documentation requirements it is for example not clear if and how CO_2 transfers from the electricity production sector to the horticultural sector are included in the ERi. Because of lack of transparency and incompleteness of information the Ministry of VROM decided that as of 2005 the ERi would no longer be used to establish the national greenhouse gas emission inventories (Olivier, 2005)[37].

As of 2005 a more transparent approach will be applied that complies with the IPCC guidelines. The most important changes are (Olivier, 2005):
1. CO_2 emissions from fuel combustion will be calculated using the national energy statistics and emission factors per fuel source and will no longer be taken from the ERi.
2. Emissions from feedstock will be calculated to the extent possible from the national energy statistics and will no longer be taken from the ERi.
3. Only direct CO_2 emissions from products (like e.g. lubricants) consumed in the Netherlands will be taken into account, and no longer will the CO_2-emissions from the products produced in the Netherlands be reported.

CO_2 transfers from one sector to another or transfers across national borders are neither explicitly included in the IPCC guidelines nor in the Dutch national emission inventories. If deemed relevant on the national level these transfers are currently reported as a separate item, but no guidelines are in place for these transfers.

4.3 White spots in the current international and national emissions inventories

In order to have a complete picture of the greenhouse gas emissions on the *international, national* and *sector* level CO_2 transfers should be properly included in the national inventories and transparent guidelines should be established.

One transfer is already correctly included under the current guidelines. This is the transfer of CO_2 from the steel production sector to the electricity production sector. The transfer of CO_2 from steel production (Corus) to the electricity production sector is in the form of residual gases. This transfer of residual gases is recorded in the national energy statistics as an output of energy for the steel production sector and an input for the electricity production sector. Under the guidelines for greenhouse gas emission monitoring the CO_2 emissions from the steel production sector are calculated by taking the consumed amount of fuel from the national energy statistics and multiply this with the CO_2 emission factor per fuel, and subtract the exported amount of fuel from the national energy statistics multiplied with the corre-

[37] Olivier (2005). Interview with Jos Olivier of the RIVM dd 17 January 2005

sponding CO_2-emission factor per fuel (in fact this reflects the CO_2 which is stored in the products which are exported).

The CO_2 emissions from the electricity production sector are determined by taking the actual consumed amount of fuels (including residual gases) from the national energy statistics and multiply these with the CO_2 emission factor per fuel.

Having covered above-mentioned transfers this means that guidelines need to be established to cover the following most important white spots in the (international) emissions guidelines:

1. Transfer of CO_2 from the electricity production sector and refineries to the horticultural sector.
2. Transfer of CO_2 from ammonia producers to industrial gas producers and other small-scale users such as the beverage industry.
3. Transfer of CO_2 from ethylene oxide production (Shell) to calcium carbonate production (Omya).
4. Export of CO_2 such as the export of CO_2 by ammonia producers.
5. Transfer of CO_2 for storage in the underground. CO_2 emissions related to fossil energy needed to operate the capture and storage process is included under the current inventories because this mainly includes electricity use and therefore is reported under the electricity sector. However additional national and international reporting requirements are needed to account for the achieved reductions through CO_2 storage and report possible fugitive CO_2 emissions.

In the next sections we explore ways to include these different transfers in the national emissions guidelines.

4.4 Including CO_2 transfers to the horticultural sector in the national emission inventories

The current guidelines for national emissions inventories would lead to the correct CO_2 emission on the national level, but to incorrect reporting of CO_2 emission on the sector level in case CO_2 transfers from the electricity production sector and refineries to the horticultural sector are not included in the inventories. We will illustrate this by analysing CO_2 emissions for the OCAP project.

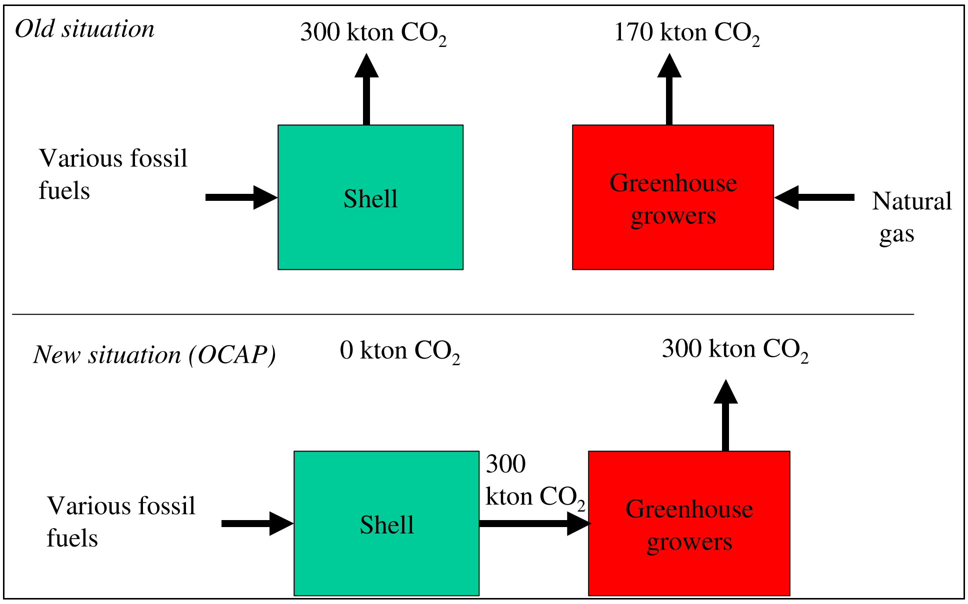

Figure 6 Emissions in the old situation for Shell and the greenhouse growers (upper picture) and when the OCAP project is in operation (lower picture).

The upper picture in Figure 6 shows the CO_2 emissions for Shell and the greenhouse growers before the OCAP project is put into place. The lower picture outlines CO_2 emissions in the new situation, when CO_2 is transferred from Shell to the greenhouse growers.

Under the guidelines for greenhouse gas emission monitoring the CO_2 emissions from the refineries are calculated by taking the consumed amount of fuels from the national energy statistics and multiply this with the CO_2 emission factor per fuel and subtract from the exported amount of fuels from the national energy statistics multiplied with the CO_2 emission factor per fuel (in fact this reflects the CO_2 which is stored in the products which are exported). The emissions of the greenhouse growers are calculated by multiplying the amount of consumed natural gas with the emission factors for natural gas.

- In the old situation this leads to allocating 300 kton of CO_2 emissions to Shell and allocating 170 kton of CO_2 emissions to the greenhouse growers. Total CO_2 emissions are 470 kton.
- In the new situation this leads to allocating 300 kton of CO_2 emissions to Shell and 0 kton of CO_2 to the greenhouse growers (because they don't use any natural gas anymore during the summer months). Whereas in practice Shell is emitting 0 kton and the greenhouse growers 300 kton. Total reported CO_2 emissions are 300 kton.

This example shows that current national emission inventory guidelines lead to the correct reporting of CO_2 emissions on the national level but to incorrect reporting of CO_2 emission on the sector level.

In order to establish the correct CO_2 emissions on the sector level transfers of CO_2 should be separately reported in the national emission inventories. In practice this means that

- Shell will have to monitor and report the amount of transferred CO_2 to the greenhouse sector. This amount of CO_2 needs to be subtracted from the level of CO_2 emissions calculated by applying the current guidelines i.e. amount of fossil fuel input times CO_2 emission factor. In the national inventory report the transferred amount needs to be subtracted from the level of emission calculated for category 1A1 (Combustion emissions of the energy industries).
- At the same time CO_2 emissions of the horticultural sector will have to be increased by the same amount of CO_2 reported by Shell (with possibly a correction for the amount of CO_2, which is being stored in the crops). This means that in the national inventory report emissions of the category 3D (Other solvent use and product use) needs to increase.

The situation for the ROCA power station is in principle the same as for the OCAP project (see Figure 7). In this case in the national inventory report 43 kton of CO_2 needs to be transferred from the category 1A1 (Combustion emissions of the energy industries) to the category 3D (Other solvent use and product use).

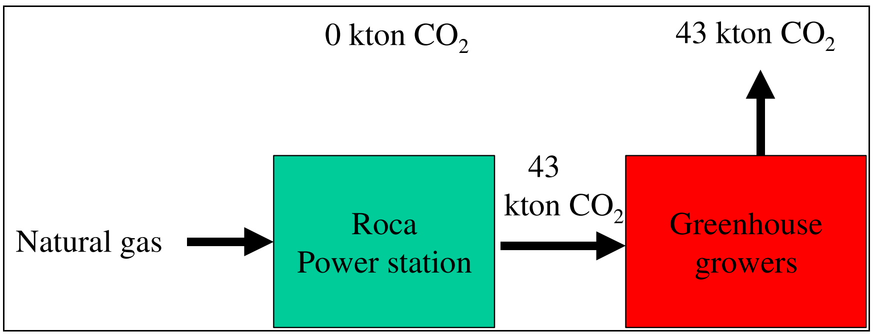

Figure 7 Outline of emissions for the ROCA project

4.5 Including CO_2 capture and storage in the national emission inventories

Currently the IPCC guidelines do not hold provision to properly account for reduction that can be achieved through carbon capture and storage. Under the new guidelines CO_2 capture and storage will receive attention.

Current debate on how to account for CO_2 capture and storage (CCS) under the UNFCCC focuses on the discussion if CCS should be treated as a sink or as an emission reduction (Haefeli et al, 2004)[38] (Bode S, M Jung. 2004)[39]. Currently IPCC guidelines do not offer guidance to decide for either the one or the other. In this section we explore both routes to account for emissions from and reductions through CCS under the national greenhouse gas inventories.

Figure 8 provides an overview of the fugitive emissions occurring during the carbon capture and storage process. Only the fugitive emissions are included in the picture and not the CO_2 emissions related to the additional energy use in the CCS chain.

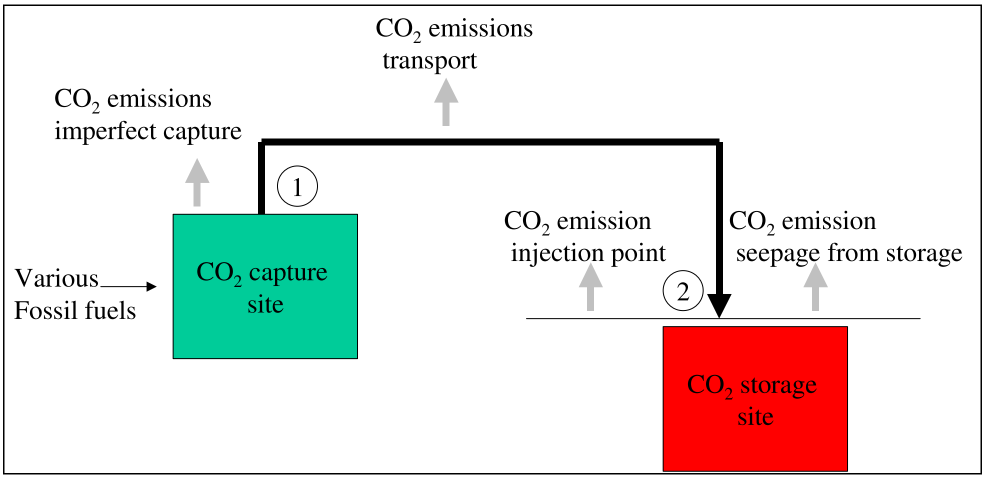

Figure 8 Outline of possible fugitive emissions during the carbon capture and storage process.

4.5.1 Sink

Under the Kyoto Protocol a sink is defined as "any process, activity or mechanism, which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere. To be considered a sink, a system must be absorbing more CO_2 than it is releasing so that the storage of carbon must be expanding" (UNFCCC, 2001)[40]. According to this definition carbon capture and storage is not a sink, as the CO_2 is not retrieved from the atmosphere but from point sources.

Sink enhancement options, which have been seriously considered so far by climate policy, are mainly restricted to the activities enhancing sequestration of carbon dioxide in the terrestrial biosphere. This issue is referred to as Land-Use, Land-Use Change and Forestry (LULUCF). The similarity between LULUCF and carbon dioxide capture and storage is:

[38] Haefeli S, M Bosi, C Philibert (2004). Carbon Dioxide Capture and Storage issues – accounting and baselines under the United National Framework Convention on Climate Change (UNFCCC). IEA, Paris, May 2004.
[39] Bode S, M Jung (2004). On the Integration of Carbon Capture and Storage into the International Climate Regime. Hamburg Institute of International Economics (HWWA) Discussion Paper 303
[40] UNFCCC (2001). Marrakesh Accord

- That they both take the CO_2 molecule and 'do something with it' i.e. after the emission has occurred.
- Its partly non-permanent character, i.e. part of the carbon dioxide re-enter the atmosphere after it has been injected into a reservoir.

If CO_2 capture and storage is considered as a sink, and the same approach would be applied for carbon capture and storage as for LULUCF under the UNFCCC. The following issues need to be taken into account:

- The captured CO_2 would need to be reported as actually 'emitted' (even though physically no CO_2 is emitted). This means that for the national inventory report either combustion or process emissions are calculated in the usual way and accounted for under category 1A (Combustions emissions) or 2B (Industrial process emissions).
- Once the CO_2 is stored in the underground CO_2 emissions are considered actual reductions. This requires measurement of the amount of CO_2, which is injected in the underground (this requires measuring the amount of CO_2 passing point 2 in Figure 8). Currently the national inventory report does not hold a category under which these reductions can be reported. So this would require creating an additional category in the national greenhouse gas emission inventories.
- Annual changes in emissions would need to be reported, i.e. that the 'net'-emissions reduction needs to reported which is the balance of net reductions and CO_2 seepage from the storage sites. This requires monitoring of the CO_2 that is annually released from the storage sites over long periods of time.
- CO_2 emissions related to additional energy input (mainly electricity for compression) is in this approach accounted for under the current national emission inventories, because this shows up in the national energy statistics.

4.5.2 Emission reduction option

In case CCS is considered an emission reduction option under the UNFCCC CO_2 reductions are accounted for by *adapting the emission factor* for the fuel combustion, i.e. the emission factor is decreased by the amount of CO_2, which is being reduced. This approach requires that changes in CO_2 emissions that occur through the whole process chain would need to be accounted for as well as the achieved reductions in order to be complete.

As was shown in Figure 8 in the previous chapter a distinction can be made between fugitive emissions and emissions related to the energy needed to operate the process.

- The emission factor does not need to be corrected for CO_2 emissions related to additional energy input needed to operate the CCS chain. This additional energy consumption (mainly electricity for compression) is already accounted for under the current national emission inventories because they show up in the national energy statistics. Taking this into account the correction of the emission factor would lead to double counting of emissions and an underestimation of reductions achieved by CCS on the national level.

- The emission factor must be corrected for all fugitive emissions; this means that in principle emissions of all potential sources of fugitive emissions are taken into account (see Figure 8). With the exception of fugitive emissions released from the storage site these emissions can be calculated by subtracting the amount of CO_2 that is captured and exported at the site from the amount of CO_2 that is injected at the storage site[41]. This requires measurement of these two streams. Furthermore the annual emissions, which are released from the storage site, would need to be monitored. Another option would be that the fugitive emissions are not monitored, but that a default emission factor is applied. As already noted in the previous chapter under normal circumstances the fugitive emissions are estimated to be very small and the fugitive emissions are most probably < 0.01% of the annually transferred CO_2.
- After all fugitive emissions have been established, the CO_2 emissions can be calculated by taking the amount of consumed fuels or level of activity and multiply these with the corrected emission factor. This means that in the national inventory report the reductions achieved through CCS are reported under either category 1A (Combustions emissions) and/or 2B (Industrial process emissions).

4.5.3 Comparison of both approaches

Both (Haefeli et al, 2004)[42] and (Bode S, M Jung. 2004)[43] argue that the environmental integrity of CCS is best guarded when CCS is treated as a sink under the Kyoto Protocol. They argue that the sink approach is most transparent because this only requires monitoring and reporting of the actually injected CO_2, and does not require developing various fugitive emission factors all along the CCS processing chain. This approach however requires revision of the current IPCC emission inventory guidelines.

The advantage of treatment of CCS as an emission reduction option is that this can be implemented under the current emission inventory guidelines by changing the used emission factor. In order to be completely transparent this requires continuous measuring of the captured as well as injected amount of CO_2. This approach probably not poses a large amount of additional costs to the CCS project, because these streams will probably be measured as part of standard procedure in managing the CCS chain.

---

[41] This measurement approach is the one advocated by DTI to be applied for monitoring and reporting of CCS under the ETS (DTI, 2005)

[42] Haefeli S, M Bosi, C Philibert (2004). Carbon Dioxide Capture and Storage issues – accounting and baselines under the United National Framework Convention on Climate Change (UNFCCC). IEA, Paris, May 2004.

[43] Bode S, M Jung (2004). On the Integration of Carbon Capture and Storage into the International Climate Regime. Hamburg Institute of International Economics (HWWA) Discussion Paper 303

4.6 Including CO_2 transfers for various applications in the national emission inventories

Current CO_2 transfers from ammonia production for various applications such as carbonisation of beverages are not included in the national emission inventories. The current guidelines for national emissions inventories would lead to the correct CO_2 emission on the national level as long as the CO_2 is transferred and emitted within the national boundaries. It however leads to incomplete emission on the sector level and to incorrect emission on the national level in case CO_2 is transferred across the national borders. We will illustrate this by outlining transfers from the ammonia industry to the beverage industry.

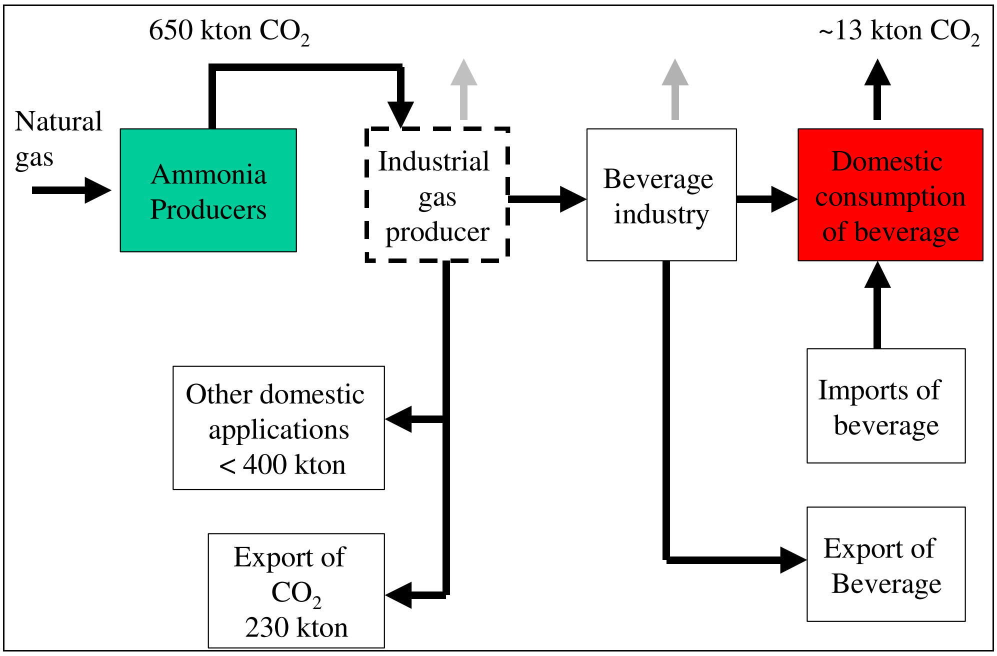

Figure 9 Emissions in case CO_2 is transferred from the ammonia industry to the beverage industry.

Figure 9 provides an overview of transferred and emitted CO_2 in case CO_2 is transferred from the ammonia industry to the beverage industry. When applying current national emission inventory guidelines the CO_2 emissions are determined by multiplying the input of fossil fuels with the CO_2 emission factor for natural gas. This means that the natural gas input of the ammonia producer is multiplied by the emission factor of natural gas and resulting in 650 kton of CO_2 that would be attributed to the ammonia sector. Figure 9 however shows that the actual emissions do not occur within the ammonia industry, but with e.g. the consumer of the beverage either within the Netherlands or abroad.

In order to establish the correct CO_2 emissions on the sector level the transfers of CO_2 should be reported separately in the national emission inventories. In practice this means that:

- The ammonia producers annually monitor and report on the amount of CO_2, which is transferred outside their installation boundaries. This amount of CO_2 needs to be subtracted from the calculated level of CO_2 emissions applying the current guidelines, i.e. amount of fossil fuel input times CO_2 emission factor. In the National Inventory Report the transferred amount needs to be subtracted from the calculated level of CO_2 emissions under the category 2B1 (Industrial process emissions from the ammonia industry) or the category 1A2 (fuel related combustions emission from the manufacturing and construction industry).
- At the same time emissions for the category 3D[44] (Other solvents and other product use) in the national emission inventories need to be increased. This category comprises all non-combustion emissions from other sectors than the manufacturing and energy industry. So far CO_2 emissions from beverage consumption are not included in this category. According to the national emission guidelines the direct CO_2 emissions from all products (including imported products) consumed in the Netherlands have to be taken into account. So in order to be able to establish the correct emissions the total beverage consumption needs to be known. The same procedure in principal needs to be applied for all other applications such the use of dry ice, fire extinguisher (see Figure 1). The problem however is the lack of good monitoring data to calculate these emissions.
- And next to that the amount that is being exported needs to be reported (this is further discussed in section 4.8).

4.7 Including CO_2 transfers from ethylene to calcium carbonate production in the national emission inventories

The current guidelines for national emissions inventories would lead to the correct CO_2 emission on the national level, but to incorrect reporting of CO_2 emission for the different industrial sectors.

- Under the guidelines for greenhouse gas emission monitoring CO_2 emissions from the ethylene producers are calculated by taking the consumed amount of fuels from the national energy statistics and multiply these with the CO_2 emission factor per fuel and subtract from this amount the exported amount of fuels from the national energy statistics and multiply these with the CO_2-emission factor per fuel (in fact this reflects the CO_2 which is stored in the products which are exported).
- The CO_2 emissions from the calcium carbonate producers are calculated by multiplying the amount of produced product with the appropriate emission factor, which is reported under 2A2 “Lime Production”. The transferred CO_2 however is not emitted but stored in the produced product.

[44] Norways reported CO2 transferred from the ammonia industry to the beverage industry as emissions with the beverage industry, i.e. that emissions of category 2D2 (Food and drink) were increased. They did not included the emissions from imported beverages.

- The calcium carbonate is further on used in the paper industry to bleach paper and during this process CO_2 is emitted again. Under the current guidelines these emissions of the production process need to be reported as process emissions within the paper industry under the category 2A3 “Limestone and Dolomite Use”.

In order to establish the correct CO_2 emission on the sector level the transfer of 40 kton of CO_2 needs to be reported. This means that – 40 kton is reported by the ethylene producer. The 40 kton emitted by the paper industry is already included under the current guidelines.

4.8 Including cross border CO_2 transfers in the national emission inventories

Currently part of the transferred CO_2 is already crossing the national borders. It is also very well possible that in future years CO_2 is captured in one country and transferred to another country to be stored. Currently no explicit provisions are in place to account for these cross border CO_2 transfers. The only thing stated in the common reporting format is that for industrial process (CRF Sector 2) emissions of CO2 the option is given to add in an extra column in which cases can be entered in which the final emissions are reduced with the quantities of emission recovery, oxidation, destruction, transformation. Adjusted emissions are reported and the quantitative information on recovery, oxidation, destruction, and transformation should be given in the additional columns provided. In order to properly account for the import and export of CO_2 new categories need to be included in the national emission inventory guidelines and it needs to be ensured that the exporting as well as the importing country report these emissions. In addition probably a provision needs to come in place in case CO_2 is transferred to non-Annex I countries.

4.9 Conclusions and recommendations

CO_2 transfers were probably not accounted for in the Netherlands in the national emission inventory in place up to 2004. Under the inventory guidelines in place as of 2005 also no provisions are included to properly account for all transfers of CO_2.

In order to establish correct CO_2 emissions on national and sector level CO_2 transfers explicitly need to be reported in the national inventory report. The following transfers would currently need to be reported:

Transfers	Output Category in NIR	Input Category in NIR
CO_2 from refineries to horticulture	1A1 (Combustion emissions of the energy industries) ~ -300 kton[1]	3D (Other solvents and other product use) ~ +300 kton
CO_2 from electricity production to horticulture	1A1 (Combustion emissions of the energy industries) ~ -43 kton	3D (Other solvents and other product use) ~ +43 kton
CO_2 from ethylene to calcium carbonate producers	1A1 (Combustion emissions of the energy industries) ~ - 40 kton	Process emission from e.g. the paper industry are already included under the current guidelines
CO_2 from ammonia to several applications	2B1 (Industrial process emissions from the ammonia industry) ~ 420 kton	3D (Other solvents and other product use) ~420
CO_2 from ammonia producers to other countries (export)	2B1 (Industrial process emissions from the ammonia industry) ~ 230 kton	New category within the NIR ~ 230 kton

[1] Transfers do not yet take place

With the exception of exports of pure CO_2, which require introducing a new category in the national inventory report, all other transfers do not require any changes to the current guidelines.

Under the current IPCC emission inventory guidelines carbon capture and storage (CCS) can be treated as an emission reduction option by adapting the emission factor for fuel combustion or industrial process emissions. In this case the reductions achieved through CCS are accounted for by decreasing the combustion or industrial emissions. In order to be transparent this would require proper measurement of exported and the injected amount of CO_2 and the seepage of CO_2 from the storage site in order to account for fugitive emissions occurring in the carbon capture and storage chain.

Another option is to treat CCS as a sink under the IPCC guidelines. This only requires monitoring of the injected amount of CO_2 and the seepage of CO2 from the storage site. This approach however requires amendments to the IPCC guidelines by including a new category to account for storage.

5 CO_2 transfers under the ETS

5.1 Introduction

The guidelines for monitoring and reporting of greenhouse gas emissions under the European Emissions Trading Scheme (ETS) state with respect to CO_2 transfers that "CO_2 which is not emitted from the installation but transferred out of the installation as a pure substance, as a component of fuels or directly used as a feedstock in the chemical or paper industry, shall be subtracted from the calculated level of emissions" (EC, 2004)[45].

This means that under the guidelines valid for the first trading period CO_2 transferred out of the installation:

- Is immediately deductible from the level CO_2 emissions calculated/measured for the installation from which the CO2 is transferred, and from the installation point of view can be considered as a reduction.
- Does not require accounting on the use of the transferred CO_2 after it has physically crossed the installation boundaries.

These guidelines can hamper the environmental integrity of the ETS in case CO_2 is transferred to a company or installation that does not fall under the ETS, and the physically transferred CO_2 is emitted again (as is the case for most transfers in the Netherlands with the exception of transfers for storage in the underground). During the first trading period of the ETS only CO_2 transfers from the electricity sector and the refineries to the horticulture could potentially affect the integrity of the ETS, as this includes transfers from ETS to non-ETS sectors. This chapter analyses in which way these transfers:

- Can hamper the environmental integrity of the ETS?
- Can be included under the current ETS without affecting the environmental integrity of the systems?
- Which amendments and additions are needed to the current ETS in order to ensure environmental integrity of the systems for current and future CO_2 transfers?

All other transfers analysed in the previous chapters either include transfers between ETS companies, between non-ETS companies or technologies currently not yet in place on a large scale (carbon capture and storage). For these transfers we shortly analyse in which way they could be best included assuming they will be brought under the ETS in the future.

[45] EC (2004). Guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC. Brussels, 29/01/2004 C(2004) 130 final

5.2 Options for including CO_2 transfers to the horticultural sector under the ETS

In case of transfer of CO_2 from refineries and the electricity production sector the CO_2 is transferred from installations falling under the ETS to companies not falling under the ETS. Figure 10 outlines the situation for the OCAP project in which CO_2 is transferred from the Shell refinery, which is falling under the ETS (indicated with the dotted lines in Figure 10) to greenhouse growers not falling under the ETS.

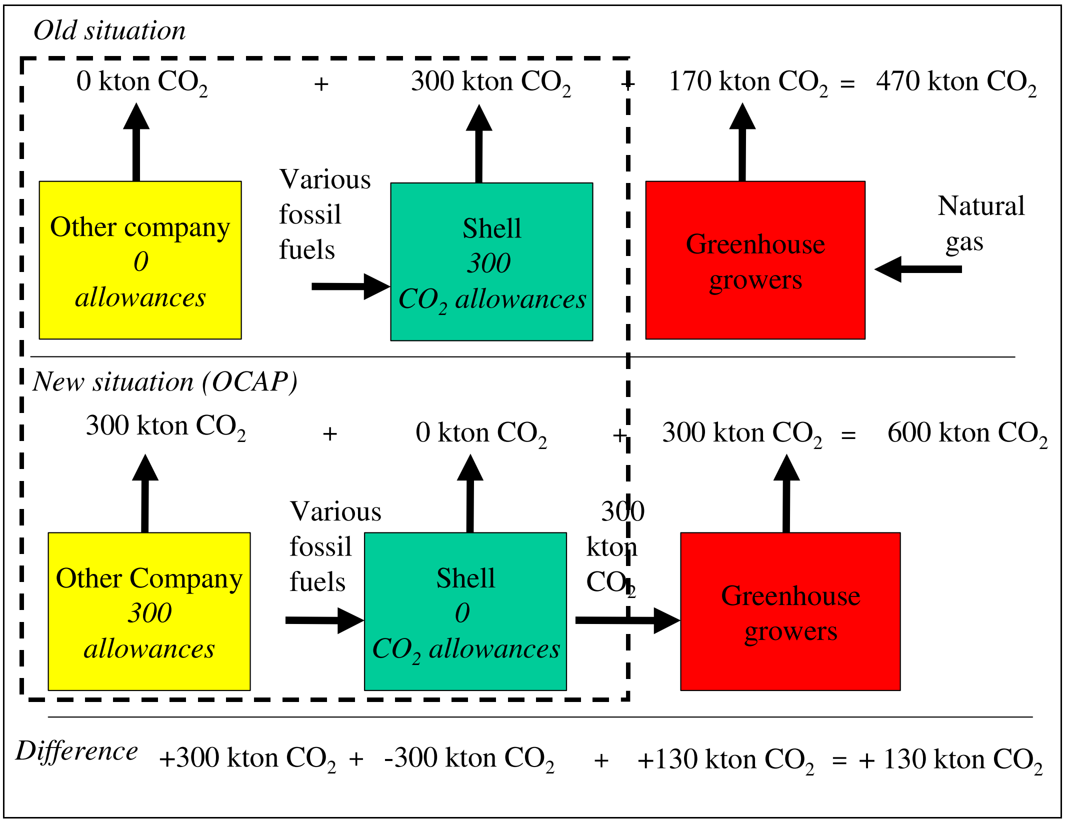

Figure 10 Outline of emissions in the old situation (before CO_2 is transferred) and in the new situation (OCAP project). The dashed lines indicate the boundaries of the ETS system.

Figure 10 shows that in the old situation the amount of allowances for Shell is equal to the amount of CO_2 emitted by Shell (300 kton). In the old situation the greenhouse growers emit 170 kton.

In the new situation Shell emits 300 kton of CO_2 less through her chimney but this is almost completely[46] emitted by the greenhouse growers. Due to the transfer greenhouse growers use less natural gas (leading to a reduction of 170 kton), but

[46] Actually part of the CO_2 is stored in the crops.

because they supply more CO_2 to their crops, compared to the situation in which they used their own boiler, the emission of the greenhouse growers exceeds the old emission level with 130 kton.

Through this transfer Shell is able to *sell* 300 kton of her allowances to another ETS company inside or outside the Netherlands or *use the allowance to expand her own production*. In case Shell uses the allowance to increase her own production or sell the allowances to a company within the Netherlands CO_2 emissions on the national level increase by 130 kton compared to the situation in which no transfers take place. In case the allowances are sold to a company outside the Netherlands emissions on the national level decrease by 170 kton, but global CO_2 emissions still increase by 130 kton. It can be concluded that this transfers potentially can affect the environmental integrity of the ETS because instead of leading to CO_2 reduction emissions on the European scale could increase.

There are different options to ensure the environmental integrity of the ETS system:

1. *At least ensuring proper monitoring and accounting of all transferred CO2.* This would require extension of the current monitoring guidelines under the ETS with provision on:
   - i measuring the amount of transferred CO_2, i.e. exported (currently mentioned in the Monitoring guidelines) as well as imported (currently not explicitly mentioned in the monitoring guidelines),
   - ii giving full account on where the CO_2 is going to and where it is emitted again,
   - iii accounting of all transfers of CO_2 (i.e. both imports and exports)) in the national inventory report. This is especially important for those transfers of CO_2,which are not covered under the current ETS guidelines for monitoring and reporting of greenhouse gas emissions, such as transfers to the horticultural sector.

   In case of the OCAP project this would mean that Shell measures the amount of CO_2, which is transferred to the horticultural sector and states this in her monitoring report. Besides the monitoring report also the national inventory report would need to include that 300 kton of CO_2 is shifted from the industry sector to the horticultural sector.

2. *Treat CO_2 which is transferred to non-ETS sectors, and which is not permanently stored as emissions.* This means that for CO_2 which is transfers to non-ETS sectors and emitted again at either the direct buyer of the CO_2 or otherwise further down the chain at the moment when produced products are consumed, is treated as an emission. This means that allowances received for CO_2 emissions, which are transferred out of the installation to non-ETS sectors and which are not permanently reduced, must be handed over to the Emission Au-

thority.
This requires amendments to the guidelines for the monitoring and reporting of greenhouse gas emissions by adding to the paragraph on transfers “CO_2 which is not emitted from the installation but transferred out of the installation as a pure substance, as a component of fuels or directly used as a feedstock in the chemical or paper industry, shall be subtracted from the calculated level of emissions *only in case the physically transferred CO_2 is permanently stored*".
The drawback of this approach is that the ‘chimney approach’, which is the starting point of the monitoring guidelines, is partly abandoned[47]. Furthermore this approach is not in line with the approach suggested for the national inventory report, in which an approach was suggested that correctly accounted for the ‘chimney’ emissions on the sector level.

3. *Charging the horticultural sector with a (relative) CO_2 cap*. The horticultural sector is currently charged with energy efficiency standards for individual greenhouse growers. This means that in principle CO_2 is currently not an issue for the individual greenhouse grower. The reduction of natural gas can be however be fully taken into account to achieve the set energy efficiency standards despite the fact that the overall CO_2 emissions increase by 130 kton.
The sector as a whole however did receive a so-called “target value” (streefwaarde) for CO_2 for the period 2008-2012 (Glami convenant). The sector is therefore currently working on replacement of the energy efficiency standard by CO_2 standards for individual greenhouse growers. These standards should then also take the import of pure CO_2 by greenhouse growers into account.
With CO_2 standards in place the environmental integrity of the ETS is better ensured because the horticultural sector benefits from good monitoring of the CO_2 streams and will negotiate with Shell that it receives financial remuneration for the project.

4. *Including the horticultural sector under the ETS*. By including the horticultural sector under the ETS the environmental integrity of the ETS is ensured because the industry/electricity sectors as well as the horticultural sector then want to make sure that all outgoing and incoming streams of CO_2 are properly monitored and accounted for because they represent ‘capital’ for both parties (and not just for the industry as is currently the case).
Including the horticultural sector under the ETS would require
   i Extension of Annex I of the Emission Trading Directive with the horticultural sector. By marking the horticultural sector as a specific activity under the Directive all CO_2 emissions of the sector are covered under the ETS, i.e. also imported pure CO_2 for fertilisation.

[47] The monitoring and reporting guidelines already include a provision which is not according to the 'chimney approach': "CO_2 being transferred as part of a mixed fuel, shall be included in the emission factor of that fuel. Thereby, it shall be added to the emissions of the installation where the fuel is combusted and deducted from the installation of origin".

ii Extension of the monitoring guidelines in order to be able to properly account for the import of CO_2. . Following the philosophy of the current monitoring and reporting guidelines this would require inserting a separate activity-specific annex for the horticultural sector.

iii Extension of the list of streams of CO_2 that are considered as transfers of CO_2 stated in the guidelines would need to be extended with transfer of CO_2 to the horticultural sector.

Inclusion of the horticultural sector under the ETS may however present insurmountable obstacles because a lot of small installations (~6000) would need to be included under the ETS, where there is currently discussion whether small emitters should be excluded from the ETS.

It should be noted that greenhouse growers operating a combustion installation with a capacity of more than 25 MW are currently already included under the ETS (about 100 greenhouse growers of in total 5000 greenhouse growers in the Netherlands). However, during the first phase of the ETS all greenhouse growers in the Netherlands are excluded, as they all fall under the opt-out of installations in the Netherlands emitting less than 25 kton of CO_2 per year.

5.3 Options for including Carbon Capture and Storage under ETS

Including carbon capture and storage under the ETS mainly requires extending the current guidelines for monitoring and reporting of emissions under the ETS in order to ensure the environmental integrity of the ETS, as part of the transferred CO_2 is released again (fugitive emissions in Figure 8). In some way or the other the fugitive emissions occurring outside the installation boundaries should be reconciled against the estimated quantity of CO_2 transferred at the installations point.

ERM and DNV have extensively examined the monitoring and reporting issues relating to including CCS under the ETS for the Department of Trade and Industry (DTI, 2005)[48] to ensure environmental integrity of the ETS. They propose an approach in which:

- The amount of emission allowances that can be brought on the market is equal to the amount of injected CO_2. This means that the transferred amount of CO_2 is corrected for the fugitive emissions that occur across the carbon capture and storage chain, with the exception of long term seepage of CO_2 from the storage reservoir. This would require proper monitoring of the amount of CO_2, which is transferred and injected. The fugitive emissions can be determined by subtracting the amount of CO_2, which is captured at the site, from the amount of CO_2, which is injected at the storage site.

[48] DTI (2005). Developing Monitoring, Reporting and Verification Guidelines for CO2 Captures and Storage Under the EU ETS. Report No COAL R277 DTI/Pub URN 05/538. January 2005.

- Long-term seepage from the storage site is not accounted for by the individual installation, but handled through the evolution of appropriate storage site licensing and permit regimes. Long-term seepage of CO_2 is however included in the national inventory report.

This approach requires amendments to the current Directive and monitoring guidelines by:
- Changing the definition of installations under the ETS in order to be able to include pipelines and storage sites,
- Include monitoring guidelines for carbon capture and storage.

5.4 Options for including CO_2 transfers from the ammonia industry to various applications in the ETS

Process emissions from the ammonia industry are not included under the first phase of the ETS, but will probably be included in the second phase. As current CO_2 transfers originating from process emissions from the ammonia industry do not lead to permanent CO_2 storage or reduction, these transfers could hamper the environmental integrity of the ETS when they are covered under the ETS.

The environmental integrity of the ETS system can be ensured in different ways:
1. *At least ensuring proper monitoring and accounting of the transferred CO_2.*
2. *Treat CO_2 which is transferred to non-ETS sectors, and which is not permanently stored as combustion emissions.*
3. *By including the costumers of the CO_2 under the ETS as well.*

Pro and cons of these approaches have already been extensively discussed in section 5.2.

4. *Don't allocate allowances for CO_2, which is transferred and not permanently stored.* As these installations do not yet fall under the ETS in the first trading period no caps have been established yet. This provides the opportunity to take the non-permanence of transfers into account up-front by not granting allowances for CO_2, which is transferred but emitted again in sector outside the ETS.

5.5 Conclusions and recommendations

The current guidelines to monitor emissions under the ETS state that "CO_2 which is not emitted from the installation but transferred out of the installation as a pure substance, as a component of fuels or directly used as a feedstock in the chemical or paper industry, shall be subtracted from the calculated level of emissions". This means that CO_2 transfers are immediately deductible from the level CO_2 emissions calculated/measured for the installation from which the CO_2 is transfers, and from the installation point of view can be considered as a reduction.

The transfer of CO_2 from ETS to non-ETS sector is a potential leakage of CO_2 from the ETS system, which can harm the environmental integrity of the ETS. On the short term the most important potential leakage is the transfers of CO_2 from a refinery to the horticultural sector, which could lead to an increase in CO_2 emission. If in the second trading period the ammonia industry is included under the ETS these CO_2 transfers are a large potential source of CO_2 leakage as well.

The integrity of the ETS can be ensured by:

- At least ensuring proper monitoring and accounting of the transferred CO_2. By measuring the amount of transferred CO_2, giving full account on where the CO_2 is going to and where the CO_2 is emitted again, and accounting of the transfers in the national inventory report.
- Treat CO_2 which is transferred to non-ETS sectors, and which is not permanently stored as an emission. This means that the allowances linked to these transferred need to be handed in with the emission authority and cannot be brought on the market. This would require small amendments to the monitoring guidelines by including that "*only in case the physically transferred CO_2 is permanently stored*" CO_2 transfers are immediately deductible from the level of CO_2 emissions. Drawback of this approach is that the 'chimney approach', which is the starting point of the monitoring guidelines, is partly abandoned.
- By including the costumers of the CO_2 under the ETS as well. In this way transferred CO_2 will stay within the ETS system. This may however present insurmountable obstacles because a lot of small installations/consumers would need to be included under the ETS, where there is currently discussion whether small emitters should be excluded from the ETS.

List of abbreviations

CCS	Carbon Capture and Storage
COP	Conference of the Parties
ERi	Emission Registration individual
ETS	Emissions Trading Scheme
IPCC	Intergovernmental Panel on Climate Change
NIR	National Inventory Report
NAP	National Allocation Plan
UNFCCC	United Nations Framework Convention on Climate Change