Risk of carbon leakage in Dutch non-ETS sectors

Final report

Trinomics

Contract details

Risks for carbon leakage in Dutch non-ETS sectors
NL Ministry of Economic Affairs and Climate Policy

Presented by

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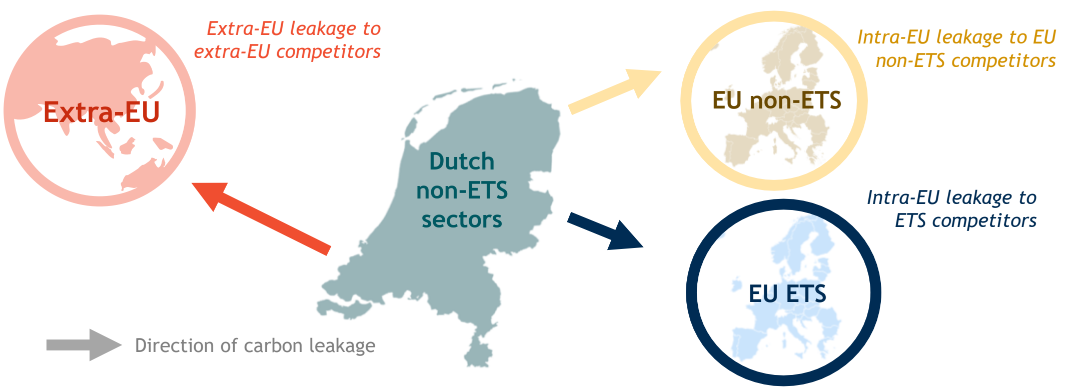
Executive summary

Objectives and concepts

The primary aim of this study is to assess carbon leakage risks in the Dutch non-ETS sectors when stricter climate policies on fossil fuel consumption for these sectors are implemented. In contrast to companies under the European Union (EU) Emissions Trading System (ETS), non-ETS companies do not face an explicit carbon price in the Netherlands.[1] For these non-ETS companies, there is limited information available on what the potential consequences are if they were to face carbon pricing. Particularly, little is known on their potential risk of carbon leakage, which varies significantly for each sector. This study seeks to identify to what extent Dutch non-ETS sectors are exposed to carbon leakage risks and explore to what extent EU policies could mitigate these risks. It aims to support the Dutch Ministry of Economic Affairs and Climate Policy (EZK) in the context of European and national decision-making on new climate policy.

Carbon leakage refers to when an emissions reduction policy inadvertently causes an increase in emissions in other jurisdictions that do not have equivalent emissions reduction policies. Climate policies, such as carbon pricing, can lead to additional costs. These costs can result in competitiveness loss, depending on: i) the significance of these costs, ii) the availability and costs of abatement options, and iii) the room to pass costs down the value chain without losing market share. Competitiveness loss increases the risk for production and investment to shift to competitors in other countries. If production and investment would shift to countries with more lenient climate policies, it could increase in emissions in those countries, and thus is considered carbon leakage. As shown in Figure 0-1, carbon leakage could occur in three ways if a carbon price would be introduced in Dutch non-ETS sectors: intra-EU to non-ETS companies, intra-EU to ETS companies and extra-EU.

Figure 0-1 Carbon leakage from Dutch non-ETS sector to competitors



Source: Trinomics (2022).

Methodology

As a first step, the carbon leakage indicators of Dutch non-ETS sectors were calculated. Carbon leakage risk is gauged by emissions intensity related to fossil fuel consumption and trade intensity. These serve as proxies to determine the relative significance of the cost impact of a carbon pricing policy on fossil fuel consumption and the ability for companies to pass on the carbon cost down the value chain, respectively. For this study, the analysis used by the European Commission (EC) to determine carbon leakage risks in EU ETS, is mirrored for Dutch sectors, using publicly available data.

[1] Except for waste incineration plants and nitrous oxide installations that fall under the Dutch CO_2 levy.

As the level of carbon leakage risk depends on the stringency of domestic and international climate policies, differences in non-ETS climate policies in the Netherlands and in key trading partners were then assessed. Carbon leakage indicators do not take the stringency of climate policies into account, and as such, do not suffice to make conclusions on carbon leakage risks. In the second step, the stringency of non-ETS climate policies in the Netherlands on fossil fuel consumption was compared against the stringency of relevant climate policies in key European trading partners: Belgium, France, Germany, Spain and the United Kingdom (UK).

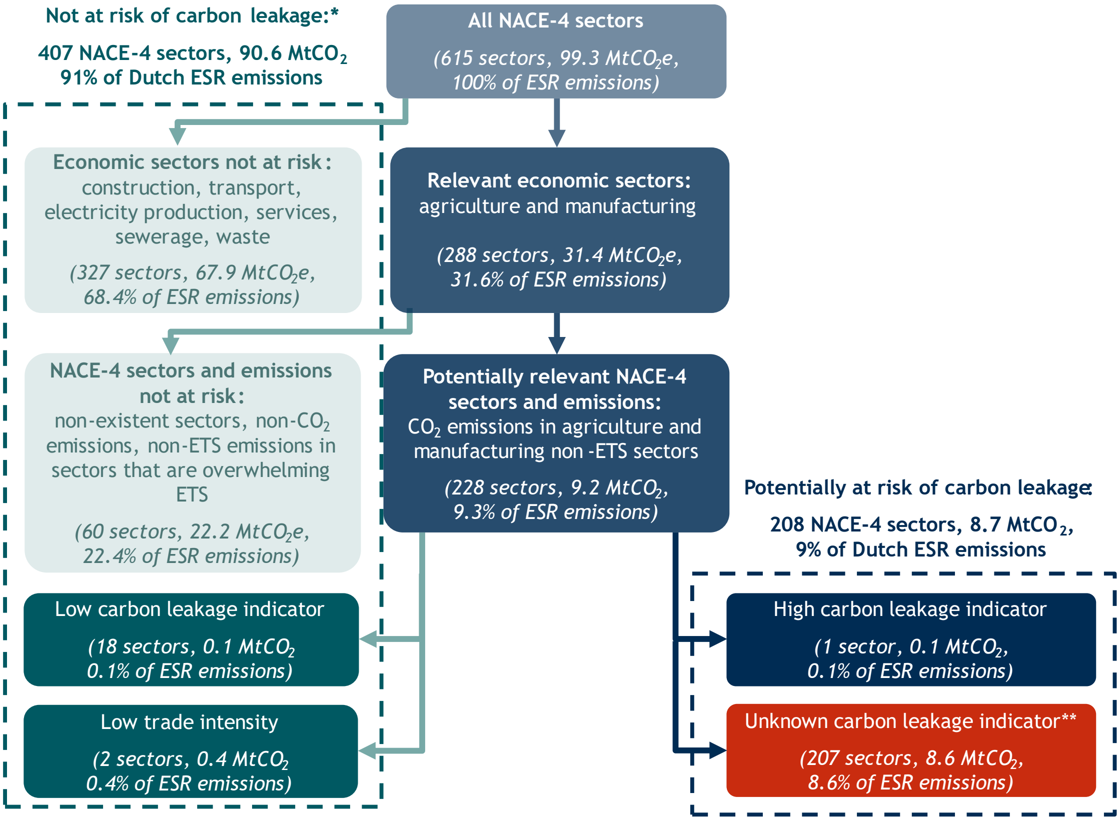
In anticipation of data limitations, carbon leakage risks in selected relevant sectors, representing a significant share of non-ETS emissions, were assessed in more detail to supplement the analysis and to identify sectoral nuances. Based on emission intensities, volume of non-ETS emissions and importance to the Dutch economy, three sectors (polymers, dairy products and greenhouse horticulture) were selected for in-depth assessments. These sectors cover a majority of the non-ETS CO_2 emissions in the agriculture and manufacturing sector. They also represent key non-ETS industries in the Netherlands: (specialty) chemicals, food processing and horticulture. The in-depth assessments covered analyses on the relevance of climate-related costs in terms of: i) total costs, ii) the level of international competition, iii) room to pass-through costs and iv) the differences in carbon leakage risks under unilateral Dutch carbon pricing on fossil fuel consumption and EU-wide equivalent.

Results

407 sectors are estimated to not be at risk of carbon leakage if Dutch non-ETS carbon pricing on fuel consumption would be strengthened, corresponding to 91% of the current Dutch ESR emissions. As shown in Figure 0-2, 327 sectors, which are associated with 68% of the Dutch emissions under the EU Effort Sharing Regulation (ESR), were deemed not at risk due to low trade intensities, no substantial fuel use or already largely covered under the EU ETS. These emissions belong to construction, service sectors, transportation, electricity production, sewerage and waste collection and treatment. From the remaining relevant economic sectors, agriculture and manufacturing, some NACE-4 sectors and emissions were directly filtered out and considered not at risk by excluding: i) non-CO_2 emissions as they do not relate to fossil fuel combustion, ii) sectors that are non-existent or do not have any trade and iii) non-ETS emissions from sectors that are overwhelmingly covered under the EU ETS. This accounted for 22% of the Dutch ESR emissions and 60 NACE-4 sectors. The remaining 228 sectors were assessed based on emissions and/or trade intensity. This excluded a further 20 sectors from being considered at risk of carbon leakage, accounting for 0.5% of the ESR emissions.

208 NACE-4 sectors could potentially be at risk of carbon leakage, which account for 8.7 $MtCO_2$ of non-ETS emissions from fuel consumption, corresponding to about 9% of the current Dutch ESR emissions. These are the average emissions for the sectors potentially at risk over 2016—2018. This is calculated top-down by deducting the non-ETS emissions not relevant or not considered at risk of carbon leakage under unilateral Dutch carbon pricing on fossil fuel consumption from the total Dutch ESR emissions. About three-quarters of the non-ETS emissions from fossil fuel use potentially at risk are related to agriculture and about a quarter to manufacturing. For non-ETS agriculture, the emissions from fuel use are concentrated in horticulture sectors. For non-ETS manufacturing, the emissions spread out over a large variety of sectors. Public statistics allowed to attribute about 77% of these emissions to specific NACE-4 sectors.

Figure 0-2 Overview of the filtering of Dutch sectors and ESR emissions to determine the non-ETS sectors and their associated emissions at risk of carbon leakage under strengthening of Dutch non-ETS carbon pricing on fossil fuel consumption



* Findings on carbon leakage risks relate to the strengthening of Dutch non- ETS climate policy on fossil fuel consumption only as risks related to climate policies on non -fuel emissions in e.g. waste incineration are out of scope of this study.
** A breakdown of this category of sectors based on available data can be found in the descriptive text of this figure.

Source: Trinomics (2022). Number of NACE-4 sectors, their average emissions over 2016—2018 and percentage of total Dutch ESR emissions in parentheses. Numbers on emissions in the boxes may not add up due to rounding.

The 9% of Dutch ESR emissions potentially at risk of carbon leakage should be considered an upper limit and it is likely lower. A further breakdown of the 207 sectors for which the carbon leakage indicator could not be determined reveal some further differentiation on carbon leakage risks:

- *High trade intensity*: 121 NACE-4 sectors—accounting for at least 70% of the non-ETS emissions on fossil fuel consumption potentially at risk—have a high trade intensity of 30% for both the trade intensities for intra-EU and extra-EU trade combined (relevant for unilateral Dutch carbon pricing) and the extra-EU trade alone (relevant for EU-wide carbon pricing). The 30% threshold was used by the EC in Phase 3 of the EU ETS to consider a sector to be at significant risk of carbon leakage as a standalone criterion. This means that for these sectors, their emission intensity would have to be 0.67 kgCO_2/EUR GVA to be able to meet the threshold of 0.2, or less if their trade intensity is higher than 30%. This level of emission intensity can be observed in sectors where fuel use for heating is a key production process step, such as for manufacturing of food ingredients. This group covers a wide range of sectors from agriculture and food processing to manufacturing of industrial components and machines as well as consumer products. Available emissions data for the NACE-4 sectors show that fossil fuel consumption in these sectors are responsible for at least 6.2 MtCO_2, with the vast majority of these emissions (87%) coming from horticulture sectors. It is feasible that some of these 121 sectors meet the threshold, but it is unlikely for all sectors.
- *Low trade intensity*: another 19 NACE-4 sectors—accounting for at least 2% of the non-ETS emissions potentially at risk—have a low extra-EU trade intensity. These sectors could therefore

be considered not at risk of carbon leakage under EU-wide carbon pricing on fossil fuel consumption, but they could still be at risk under Dutch unilateral carbon pricing. Sectors include sheep, poultry and pig farming and manufacturing of bread and certain metal, wooden, plastic and mineral end products.

- *Unknown trade intensity*: for the remaining 67 NACE-4 sectors, there was insufficient data to do any calculation of carbon leakage risk. These sectors also account for at least 2% of the non-ETS emissions potentially at risk. There is a large variety among these sectors ranging from certain agricultural products and fishing to post-production processing of metals, machining and manufacturing of clothing, cutlery and gas. Based on the description of the sectors, some of these sectors are probably not at risk of carbon leakage, but this cannot be confirmed with statistics. However, the risk of carbon leakage cannot be excluded from these sectors.

The in-depth sector analysis of the polymers, dairy products and greenhouse horticulture sectors—representing 66% of the non-ETS emissions potentially at risk—confirm the presence of carbon leakage risks, though there are sector specific nuances. The in-depth analysis confirms that the selected sectors are at risk of carbon leakage in the case where the Netherlands would introduce a stronger non-ETS climate policy on fossil fuel consumption unilaterally:

- About 1% of the non-ETS emissions from fossil fuel consumption potentially at risk relate to the Dutch **polymers manufacturing** sector. In general, products within this sector are relatively trade and emissions intensive. Furthermore, the carbon price that Dutch producers effectively face from Dutch climate policies such as energy taxes, which explicitly and implicitly set a carbon price, is higher than those in competing countries. However, not all non-ETS polymer producers will face carbon leakage risks for their products. For instance, various non-ETS producers are active in specialty products (instead of commodity plastics), which are less emissions and trade intensive, have higher possibilities for cost-pass through and hence face lower risks.
- About 4% of the non-ETS emissions potentially at risk for carbon leakage relate to the Dutch **dairy product manufacturing** sector. Certain commodity products in the sector (such as whey, milk powder and lactose) are particularly trade and emissions intensive. As the current effective carbon price for non-ETS companies is higher in the Netherlands than in competing countries, these products are at risk of carbon leakage under a unilateral Dutch carbon pricing. Specialty products–such as Gouda cheese and infant formula–face lower carbon leakage risks as they allow for more cost-pass through.
- 61% of Dutch non-ETS emissions at potential risk of carbon leakage relate to the **Dutch non-ETS greenhouse horticulture** sector, which is by far the largest non-ETS sector affected by a non-ETS climate policy on fuel use. Even though the sector was found to be at risk of carbon leakage, a distinction needs to be made between carbon leakage towards countries with heated (greenhouse) and countries with unheated production. While carbon leakage from heated Dutch greenhouses to unheated production in warmer climates negatively affects production levels in the Dutch sector, **it may lead to lower global CO_2 emissions due to lower carbon footprints per unit of product**. This is not the case for leakage towards (Northern) countries using heated greenhouses, like the Netherlands.

Furthermore, in the manufacturing of polymers and greenhouse horticulture sectors, many producers use CHPs, which are at lower risk of carbon leakage. This is because the use of CHPs in the Netherlands has an effective carbon price of €0/tCO_2 due to various exemptions, unlike in some other countries like Germany and France where they do face a higher effective carbon price. However, this is set to change in the coming years, as the Dutch Coalition Agreement announced to abolish tax exemptions on CHPs.

Any carbon leakage risks of Dutch non-ETS sectors are expected to relate to production and/or investment shift to non-ETS and non-EU competitors, since the risk of carbon leakage to ETS competitors is considered low. The results of the analysis on climate policies shows that climate policies across the EU are relatively lenient in non-ETS sectors compared to ETS sectors, even when free allowances are taken into account. Expected ETS revisions are likely to further strengthen ETS policies, thereby contributing to a greater asymmetry between ETS and non-ETS climate policies. Only if the non-ETS carbon pricing on fuel use would be more stringent than the EU ETS, could it lead to carbon leakage. Some of the non-ETS sectors, such as greenhouse horticulture, only face limited or no competition from ETS companies.

For now, the stricter non-ETS climate policies in the Netherlands compared to key trading partners confirm the presence of the risk of carbon leakage to non-ETS European competitors, but this may change soon. All key trading partners are expected to implement stricter policies to meet the 2030 climate targets. This is because all EU Member States must reduce non-ETS emissions substantially to reach their new ESR targets. Despite not having an ESR-target, additional climate policies are also required in the UK according to its national targets. Consequently, these developments in competing countries reduce the carbon leakage risks of Dutch companies in the case where the Netherlands would unilaterally strengthen climate policy on non-ETS fuel consumption. An EU-wide approach, such as an all-fuels ETS, would create a level playing field. The risk of carbon leakage to non-ETS European competitors would therefore be mitigated.

Risks for carbon leakage to non-European competitors will remain present in either a unilateral Dutch or an EU-wide approach. Both unilateral Dutch and EU-wide stricter climate policies on fuel consumption in non-ETS sectors increase the risk of production and investment shifts towards competitors outside the EU. Even though differences between climate policies in the EU and global competitors has not been assessed, it is expected that EU climate policies are stricter than the average non-EU climate policy. Under this assumption, Dutch and EU climate policies increase carbon leakage risks to global competitors.

Conclusions

At most, 8.7 MtCO_2 of emissions from fuel use in Dutch non-ETS sectors would be at risk of carbon leakage under a unilateral Dutch approach. Though, some of these emissions relate to specialty products, which would face a lower risk of carbon leakage. Specialty products have relatively low emissions and trade intensities, which are indications of a lower carbon costs and more room to passthrough costs. As such, carbon leakage risks are relatively small for companies producing specialty products. This share of Dutch ESR emissions also includes sectors for which there was no publicly available data to determine whether sectors are at risk of carbon leakage. Therefore, this 8.7 MtCO_2, corresponding to about 9% of ESR emissions, is considered as the upper limit of emissions at risk of carbon leakage.

More ambitious EU-wide non-ETS climate policies would contribute substantially to mitigate carbon leakage risks in Dutch sectors. For most sectors, EU competition is fiercer than global competition. EU-wide carbon pricing for non-ETS sectors could therefore reduce the non-ETS emissions potentially at risk of carbon leakage by up to two-thirds—down to 3% of the Dutch ESR emissions. This is based on the estimated non-ETS emissions at risk of carbon leakage from competitors outside the EU.

Carbon leakage from Dutch non-ETS sectors can also lead to lower global CO_2 emissions. A popular argument for the need of measures preventing carbon leakage is that carbon leakage harms local production levels (with corresponding economic damage) without reducing global CO_2 emissions. This is not necessarily the case as shown for greenhouse horticulture, one of the largest Dutch non-ETS sectors where at least 61% of the non-ETS emissions from fossil fuel use potentially at risk is located. The CO_2 emissions from fuel use associated with agricultural products grown in unheated production systems can be much lower than in heated greenhouse production systems. This means that despite the negative economic impacts of carbon leakage from heated Dutch greenhouses towards competitors in warmer climates, it can result in a reduction in global CO_2 emissions.

Final remarks

From an economic and climate perspective, it is more effective to implement stricter non-ETS climate policies across the EU than unilaterality. EU carbon pricing for non-ETS sectors would strengthen climate policies for non-ETS companies across the EU, reinforce the level playing field, and effectively mitigate carbon leakage to non-ETS competitors in the EU. EU climate policies can be considered economically more efficient than a unilateral policy as they limit the room for national governments to lower carbon prices for economic reasons. From a climate perspective, an EU approach could also be more effective as the impact on CO_2 emissions reductions of EU policies is likely to exceed the accumulated impacts of that of national policies, because not all countries may voluntarily implement climate policies as strict as the EU.

There are various ways to achieve stricter climate policies for Dutch non-ETS sectors, while mitigating the risk of carbon leakage to EU competitors. Alignment of climate policies with the main EU trading partners could also make room to increase stringency, while mitigating potential carbon leakage affects. All key EU trading partners are expected to implement stricter non-ETS climate policies to meet national climate goals and renewed ESR targets, which lowers carbon leakage risks.

However, a low risk of carbon leakage does not mean production and investment would not shift; stringency of climate policy is only one of the many factors that determine competitiveness. Others factors, such as market developments and energy costs, generally have a stronger impact. This study is limited to carbon leakage risks: emissions reduction policy inadvertently causing an increase in emissions in other jurisdictions that do not have equivalent emissions reduction policies due to mainly shifts of production and investments to those jurisdictions. In practice however, other factors play a much stronger role. In general, market developments across the world are the key driver for production and investment shifts. Lately, the sharp increases in energy costs affect competitiveness more than climate policy. The conclusions from this study should therefore be considered as only one component, if used in the context of the overall competitiveness of non-ETS sectors.

1 Introduction

1.1 Context

Additional climate policy is being explored at European Union (EU) and national level to reduce greenhouse gas (GHG) emissions in non-ETS sectors. In the Fit for 55 policy package of July 2021, the European Commission (EC) proposed to increase the overall EU-wide Effort Sharing Regulation (ESR) target from 30% to 40% emissions reduction in 2030 compared to 1990 levels. This translates into higher national targets for the ESR sectors, i.e. sectors that do not fall under the current European Union Emissions Trading System (EU ETS) –also referred to as non-ETS sectors. Additional climate policy is thus needed in the Netherlands and other EU countries to meet these increased targets. An ETS or other forms of carbon pricing is one of the instruments that could incentivise the required emission reductions.

One of the options considered was the implementation of an EU-wide ETS on all fossil fuel use outside of the current EU ETS—also known as an *all-fuels ETS*. In the Impact Assessment (IA) for the revision of the EU ETS[2], one of the policy options examined to incentivise emission reductions in the non-ETS sectors was an all-fuels ETS[3]. Under this option, all GHG emissions from the combustion of fossil fuels, which are not already covered by the existing EU ETS, would be covered by a new ETS. This would include fossil fuel use in road transport and buildings, as well as small non-ETS industry, agriculture, forestry, off-road machinery, non-electric railway and the military sector.

The all-fuels option did not make it to the final EC policy proposals, partially due to concerns with difficulties compensating non-ETS sectors for carbon leakage risks. The IA states that free allocation measures would need to be foreseen for non-ETS industry in order to create a level playing field and to avoid carbon leakage. However, such mechanisms risk being complex. Therefore, the Fit For 55 package proposed a new ETS for only the road transport and buildings sectors. It is, however, unclear from the IA to what extent the sectors, such as the non-ETS industry, would be at risk of carbon leakage if they would be included in a new ETS.

The absence of an EU-wide approach on fossil fuel emissions not covered under the current EU ETS or newly proposed ETS for road transport and buildings implies that more would need to come from national climate policy, although concerns on carbon leakage remains. Additional climate policy will most likely be needed in all Member States (MS) to meet higher ESR targets, including in the Netherlands. However, any additional unilateral Dutch policy could increase the risk of carbon leakage in Dutch non-ETS sectors if their competitors do not face the same policy stringency. However, for some sectors, this increased risk will be limited, particularly for sectors that have relatively low fossil fuel consumption and/or face limited international competition.

[2] EC (2021). SWD(2021) 601 final, part 1 of 4.
[3] ICF et al. (2020), Possible extension of the EU Emissions Trading System (ETS) to cover emissions from the use of fossil fuels in particular in the road transport and the buildings sector.

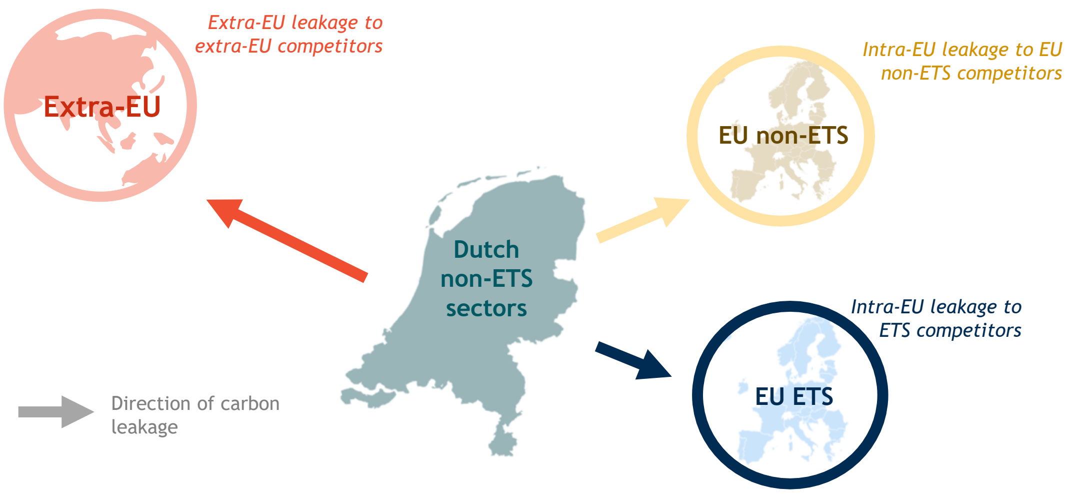
1.2 Objectives and scope

In light of the above recent developments, the primary aim of this study is to assess carbon leakage risks of Dutch non-ETS sectors. Currently, there is still limited information available on potential consequences of stricter Dutch or EU climate policies on the potential risk of carbon leakage in non-ETS sectors. Therefore, this study seeks to explore potential carbon leakage risks and identify which Dutch non-ETS sectors may be exposed to these risks. It aims to support the Dutch Ministry of Economic Affairs and Climate Policy (EZK) in the context of European and national decision-making on new climate policies for these sectors.

The scope of the study is in line with a possible extension of carbon pricing on fossil fuel consumption in non-ETS sectors in addition to road transport and buildings. This means that direct CO_2 emissions (scope 1) from fossil fuel combustion are in scope. Emissions related to electricity use and non-CO_2 emissions are out of scope. CO_2 emissions from waste incineration, which are currently not covered under the EU ETS, are also out of scope of this study as only a very small proportion of these emissions relate to fossil fuel consumption. Non-ETS sectors in scope are mainly small industry and agriculture. Total emissions of these non-ETS sectors are around 5% of total GHG emissions in the EU[2] as well as in the Netherlands.[4] The carbon leakage assessments are based on publicly available statistics related to emissions and trade intensities, supplemented with a review of literature and interviews with sector stakeholders.

Differences in carbon leakage risks under a unilateral Dutch climate policy and an EU-wide climate policy are assessed. The costs incurred from additional carbon pricing could lead to production and investment shifts for Dutch non-ETS sectors, and hence risk of carbon leakage to their competitors if they face more lenient climate policies. We assess the risk of leakage to both non-ETS and ETS companies in the EU, as well as leakage to companies outside of the EU (as shown in Figure 1-1). In this report, the EU refers to countries that are included in the EU ETS, thus including Liechtenstein, Norway and Iceland, unless explicitly stated otherwise.

Figure 1-1 Carbon leakage from Dutch non-ETS sector to competitors



Source: Trinomics (2022).

[4] Estimated using on 2016–2018 GHG emissions data from Emissieregistratie.nl and the National Inventory Report 2021 of the Netherlands.

1.3 Relevant concepts: carbon pricing and carbon leakage

Carbon leakage and loss of competitiveness are critical points in the introduction of any climate policy but can be subject to misconceptions. Competitiveness loss and carbon leakage could impede the effectiveness of climate policy and lead to a rise in GHG emissions. Climate policies—especially carbon pricing policies—therefore often include measures to prevent carbon leakage in the form of compensations or exemptions. In this context, loss of competitiveness, carbon leakage and increasing emissions are often used in conjunction. They are, however, not synonymous to one another and misconceptions on carbon leakage are particularly prevalent in the policy debate.[5]

It is therefore important to have a common understanding to the relevant concepts related to carbon leakage. In this report, these concepts are used as follows based on how they are commonly defined in literature:

- **Carbon pricing** generally refers to policies that explicitly put a price on GHG emissions in form of a price per tonne of CO_2.[6] However, policies that affect fossil fuel use or GHG emissions such as energy taxes, performance standards, fossil fuel subsidies and support mechanisms for renewable energy also implicitly put a price on carbon.[7] In this report, carbon pricing in principle refers to explicit carbon pricing but not does exclude implicit carbon pricing instruments.
- **Effective carbon rates** (or effective carbon prices) are a way to measure the costs incurred by companies from policies that explicitly and implicitly put a price on GHG emissions after taking into account compensations and exemptions, expressed as a price per tCO_2e.[8] In this report, the effective carbon rate only includes the carbon price from explicit carbon pricing policies and implicit carbon price from policies directly pricing the use of fossil fuels for combustion such as fuel excise duties and energy taxes. Other forms of implicit carbon pricing such as performance standards are not included in the effective carbon rate.
- **Competitiveness loss** refers to the deterioration of the competitive position of a sector or company compared to the status quo in this report. This could be due to the introduction of climate policy such as carbon pricing. However, most changes in competitive position are not related to climate policies, but rather they are related to other market developments.[9]
- **Carbon leakage** generally refers to an emissions reduction policy such as a carbon price inadvertently causing an increase in emissions in other jurisdictions that do not have equivalent emissions reduction policies.[10] While this could impede the emissions reduction effort of the climate policy being introduced, it could still lead to a **net decrease in global emissions**. This would be the case if the emission intensity of the production being displaced is higher than the production replacing it. Furthermore, the definition of carbon leakage also means that if production shifts to competitors that face equally or more stringent climate policy, it is **not** considered carbon leakage in this report. Such a shift would still have a negative impact on competitiveness and the domestic economy, however, it would not be caused by having more stringent climate policy.

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[5] LSE (2021). *What is carbon leakage? Clarifying misconceptions for a better mitigation effort*, available at: https://www.lse.ac.uk/granthaminstitute/news/what-is-carbon-leakage-clarifying-misconceptions-for-a-better-mitigation-effort/.
[6] Partnership for Market Readiness (2021). *Carbon Pricing Assessment and Decision-Making: A Guide to Adopting a Carbon Price,* World Bank, Washington, DC.
[7] World Bank (2021). *State and Trends of Carbon Pricing 2021*, World Bank, Washington, DC.
[8] OECD (2021). *Effective Carbon Rates 2021*, available at: https://www.oecd.org/tax/tax-policy/effective-carbon-rates-2021-0e8e24f5-en.htm; Dominioni, G. (2022). *Pricing carbon effectively: a pathway for higher climate change ambition*, Climate Policy.
[9] OECD (2019). *Carbon Pricing and Competitiveness: Are they at Odds?*, Environment Working Paper No. 152.
[10] Partnership for Market Readiness (2015). *Carbon Leakage: Theory, Evidence, and Policy*, PMR Technical Note 11. World Bank, Washington, DC; IPCC (2007). *Climate Change 2007: Working Group III: Mitigation of Climate Change, 11.7.2 Carbon leakage.*

- **Production and investment leakage** is generally used to describe a form of carbon leakage, i.e. the introduction of a more stringent climate policy in one jurisdiction leading to production or investment shifting to a jurisdiction with laxer climate policy.[11] Though, not all shifts of production or investments due to the introduction of a climate policy is considered leakage. For example, introducing a carbon price in a sector that currently has very lax climate policy could induce a shift to a jurisdiction with the more stringent climate policy if the overall costs in that jurisdiction become more favourable. This would still constitute competitiveness loss due to the climate policy. However, it is not commonly referred to as leakage as there already existed an asymmetry in climate policy stringency. In this report, we therefore only use leakage to describe competitiveness loss due to the introduction of climate policy that is more stringent than the climate policy competitors are facing.

Competitiveness loss, carbon leakage and global net increase in GHG emissions are therefore considered separately in this report. Competitiveness loss due to the introduction of climate policy does not necessarily lead to carbon leakage if there was already an asymmetry in climate policy stringency in the status quo. In turn, carbon leakage does not necessarily lead to an increase in net global emissions if production shifts to competitors that are less emissions intensive, at least on the short term. In the long-term, carbon leakage could still result in a net increase in GHG emissions in this situation. Companies in the countries with less stringent climate policies would have less incentive to invest in abatement measures compared to the situation if they stayed, hampering advancements in abatement technology in the sector.

1.4 Research method and report structure

This report is structured based on a series of methodological steps:

- **Chapter 2: Carbon leakage mechanisms under non-ETS policy options.** This chapter dissects the potential carbon leakage concepts to provide the reader with a required understanding of possible carbon leakage mechanisms and how they are affected by a unilateral Dutch or EU-wide carbon pricing.
- **Chapter 3: Overall carbon leakage assessment of Dutch non-ETS sectors.** In chapter 3, an overall carbon leakage assessment based on public statistics for Dutch non-ETS sectors is presented. This overall assessment gives an indication of which specific sectors potentially have a high carbon leakage risk and the magnitude in GHG emissions could potentially be at risk. Section 3.1 describes the used methodology, Section 3.2 estimates the sectors and associated emissions from fuel consumption potentially at risk of carbon leakage, and in Section 3.3, the selection is made of the most relevant sectors for a sector-specific in-depth assessment based on their potential carbon leakage risk.
- **Chapter 4: Non-ETS climate policies in the Netherlands and trading partners.** This chapter provides an overview of the relevant EU (4.1) and national policies (4.2) for non-ETS sectors. We focus on the Netherlands and five key European trading partners: Germany, Belgium, France, the United Kingdom and Spain. To compare the stringency of climate policy between countries and hence the potential risk of carbon leakage to those countries, an estimate is made of the effective carbon price for the most used fuels in the most relevant sectors in these countries.
- **Chapter 5: Sector-specific carbon leakage assessments.** Based on the analysis of chapter 3, three main sectors were selected with potentially high carbon leakage risks: Manufacturing of polymers (5.1), Manufacturing of dairy products (5.2) and (greenhouse) horticulture (0). For each

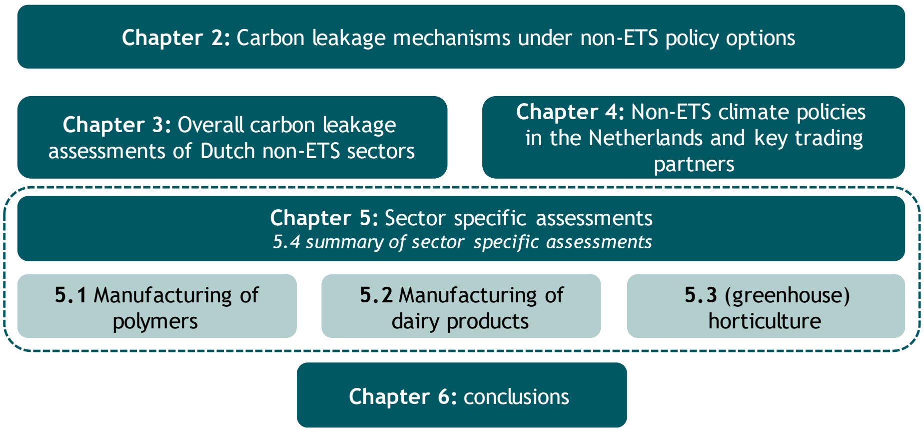
[11] Umweltbundesamt (2019). *Carbon Leakage Risks in the Post-Paris World.*

of these sectors, first, we present the effective carbon price businesses experience in the analysed countries, then, we zoom in on carbon leakage indicators (emission intensity, trade intensity). This is followed by the eventual assessment of carbon leakage risks in the sector for both a unilateral Dutch and EU-wide approach.

- **Chapter 6: Conclusions on carbon leakage risks.** Chapter 6 draws conclusions to what extent Dutch non-ETS sectors are at risk of carbon leakage. This is done for a unilateral Dutch approach on carbon pricing on non-ETS sectors (6.1), followed by how conclusions might change in case of an EU-wide approach (6.2).

In addition, multiple annexes are attached to the report in which we provide more data and in-depth analyses of relevant subjects. Annex I includes more details about the used methodology for the overall analysis of carbon leakage risks from Chapter 3. Annex II discusses the relevant non-ETS climate policies for the Netherland and the five key trading partners on which the analysis in Chapter 4 is based. Annex III discusses the selected sectors in more details, including an analysis of energy use for tomato production. Annex IV Provides a list of all interviewees that were consulted for this study.

Figure 1-2 Overview of the report structure



2 Carbon leakage mechanisms under non-ETS policy options

This study assesses carbon leakage risks of Dutch non-ETS sectors under two policy options. Carbon pricing could be introduced on the fossil fuel consumption of non-ETS sectors in various forms. Regardless of the form, the carbon leakage impact of a carbon pricing policy ultimately boils down to the stringency of a policy on a company compared to its competitors. If competitors would be covered under the same or equivalent policy—even if they face different carbon costs, this will not constitute as carbon leakage as explained in Section 1.3. In this study, we therefore assess the impact of two policy options that differ in geographical coverage:

- **Unilateral Dutch approach:** the Netherlands implements a carbon pricing unilaterally on the fossil fuel consumption in all sectors not covered by the EU ETS. This could be through an additional ETS or carbon tax, or other climate policies that implicitly impose a carbon price (see Section 1.3 on an example of an implicit carbon pricing instrument).
- **EU-wide approach:** a carbon price is implemented at EU level on the fossil fuel consumption in all sectors not covered by the EU ETS. This would be similar to an ETS extension to all-fuels emissions, as investigated in the Commission Impact Assessment.[12]

The introduction of a carbon price in non-ETS sectors can lead to a loss of competitiveness and carbon leakage in different ways. When costs increase due to carbon pricing—with all else being equal, the risk of competitiveness loss increases in the absence of any compensation measures. We consider three ways that competitiveness loss and carbon leakage could exhibit itself from the perspective of the Dutch non-ETS sectors:

1. **Extra-EU leakage between Dutch non-ETS sectors and their extra-EU competitors**: a carbon price could put non-ETS companies in the EU at a competitive disadvantage compared to extra-EU competitors that face less stringent climate policies and therefore have lower costs. This could lead to more extra-EU imports and less exports to outside the EU. In the unilateral Dutch approach, it would only be Dutch non-ETS companies facing this competitiveness loss and leakage risk, whereas in the EU-wide approach, it affects all EU non-ETS companies.
2. **Intra-EU leakage between Dutch non-ETS sectors and their non-ETS competitors in the EU:** competitiveness loss could occur within a non-ETS sector if Dutch non-ETS companies face a different increase in cost compared to its EU competitors. Under a unilateral Dutch approach, the competitiveness loss would be in one direction with a shift from Dutch non-ETS companies to its EU competitors. Whether this also translates into carbon leakage depends on the level of stringency of the unilateral Dutch approach compared to the climate policy its non-ETS competitors are currently facing. In the EU-wide approach, competitiveness loss can occur in both directions. The latter depends on whether Dutch non-ETS companies are less emission intensive than their EU competitors and therefore have a competitive advantage when all non-ETS companies are facing a carbon price. However, the EU-wide approach would not introduce any additional carbon leakage risks, as the policy would apply to both Dutch non-ETS companies and their non-ETS EU competitors.
3. **Intra-EU leakage between non-ETS and ETS companies:** this leakage risk is relevant for sectors where ETS companies and non-ETS companies operate in the same market. In the status quo, non-ETS companies do not face an explicit carbon price in the Netherlands.[13] ETS

[12] European Commission (2021). *Impact assessment report accompanying the document amending Directive 2003/87/EC*, SWD(2021) 601 final.
[13] Except for waste incineration plants and producers of acrylonitrile covered under the Dutch CO_2-levy for industry.

companies must pay for their emissions under the EU ETS, but at the same time receive free allowances—although for most companies, these do not fully cover their carbon costs. With a carbon price in the non-ETS sectors, non-ETS companies may face a competitive disadvantage in the absence of any compensation measures. This loss of competitiveness can occur under both policy options. Whether this competitiveness loss leads to carbon leakage depends on the stringency of non-ETS carbon pricing policy compared to the EU ETS and other climate policies faced by ETS-installations. If the non-ETS policy would be similar or laxer than the EU ETS, there would be no additional carbon leakage risks despite the non-ETS competitiveness loss. Alternatively, it would be correcting the asymmetry in climate policy between ETS and non-ETS companies. Even if there the non-ETS policy would be more stringent than the EU ETS, carbon leakage to ETS installations is dampened by the EU ETS cap. Consequently, an increase in ETS emissions due to production shifts from non-ETS companies would lead to a rise in the ETS price, further increasing the stringency of the EU ETS.

Overall, an EU-wide approach would lead to less competitiveness loss and lower leakage risks for Dutch non-ETS sectors as a whole compared to a unilateral approach. The key difference between the two policy options is the impact of intra-EU leakage between Dutch non-ETS companies and their non-ETS competitors within the EU. The EU-wide approach ensures a level playing field on carbon costs in non-ETS sectors instead of carbon cost only increasing for Dutch non-ETS companies in the unilateral approach. An EU-wide approach could also indirectly lower the competitiveness loss and leakage risk for Dutch non-ETS sectors. Compared to the status quo, extra-EU companies and ETS installations would see their competitiveness improve in a larger market than just the Dutch non-ETS companies operate in. As companies have limited resources and capacity, it might be more attractive for extra-EU companies and ETS installations to focus on other markets than the markets where Dutch non-ETS companies are active in. This would in turn lower the competitive pressure for Dutch non-ETS companies.

Which sectors are exposed to an increased risk of competitiveness loss and carbon leakage depends on a range of sector-specific factors. These factors include the level of competition within the market, the impact of carbon costs on profitability, the ability to mitigate these costs through emission abatement measures or passing the costs on to customers.[14] These factors are, however, difficult to determine in practice. Carbon pricing initiatives therefore generally use emissions intensity and trade intensity of a sector to assess its leakage risk. Emissions intensity serves as an indicator of the cost impact a carbon pricing policy may have. Trade intensity can be considered a proxy for the ability of a company in the sector to pass on its carbon cost without significant loss of market share—with a high trade intensity indicating a low-cost pass-through ability. These indicators were used by the European Commission (EC) to establish the list of sectors at significant risk of carbon leakage. In Chapter 3, we try to use the same method to determine which Dutch non-ETS sectors may be at significant risk of carbon leakage.

[14] Partnership for Market Readiness (2015). *Carbon Leakage: Theory, Evidence, and Policy*, PMR Technical Note 11. World Bank, Washington, DC.

In addition to sector-specific factors, the extent to which competitiveness loss and carbon leakage may occur also depends on climate policy costs in the countries where production and investments may shift to. If the cost differential resulting from climate policy in the Dutch non-ETS sectors is already higher than their competitors in the status quo, the introduction of a carbon price would exacerbate this cost differential—increasing competitiveness loss and leakage risks. On the other hand, if Dutch non-ETS sectors currently face lower climate costs than their competitors, the increase in leakage risk would depend on the stringency of the non-ETS carbon pricing policy being introduced. This is being investigated for a selection of non-ETS sectors in key trading countries in Chapter 4.

3 Overall carbon leakage assessments of Dutch non-ETS sectors

The EC assesses the carbon leakage risk of sectors in the EU ETS using a combined criteria of trade intensity and emission intensity. The list of sectors at significant risk of carbon leakage over Phase 4 (2021–2030) of the EU ETS is established at the NACE 4-digit sector level primarily based on public statistics. The EC uses *trade intensity x emission intensity* of a sector as the carbon leakage indicator. If this indicator is greater than 0.2, then the sector is considered to be at significant risk of carbon leakage. The two components of the carbon leakage indicator are defined as:

- *Emission intensity:* emissions / gross value added; and
- *Trade intensity*: (imports + exports) / (imports + production).

For the emission intensity, the EC considered both direct emissions of installations as well as indirect emissions related to electricity consumption. However, this study only covers emissions from fuel combustion. Indirect emissions related to electricity consumption are therefore not taken into account. For the trade intensity, both the trade intensities for intra-EU and extra-EU trade combined (in relation to the unilateral approach) and the extra-EU trade alone (relevant under an EU-wide approach) are considered.

Public statistics have been used to calculate the EC's carbon leakage indicator of the Dutch non-ETS sectors as an indicator for carbon leakage risks but there were significant data limitations. For many sectors, either data on trade, production, gross value added (GVA) and/or emissions are missing at NACE 4-digit level. Also, available data on the economic indicators do not distinguish between ETS or non-ETS origin. The carbon leakage indicator can therefore only be calculated for the entire NACE 4-digit sector. Section 3.1 describes the data sources and limitation. Section 3.2 presents the results for the Dutch sectors for which data is available. Section 3.3 discusses the sectors that have been selected for an in-depth analysis given the data limitations.

3.1 Data to assess carbon leakage risks of Dutch non-ETS sectors

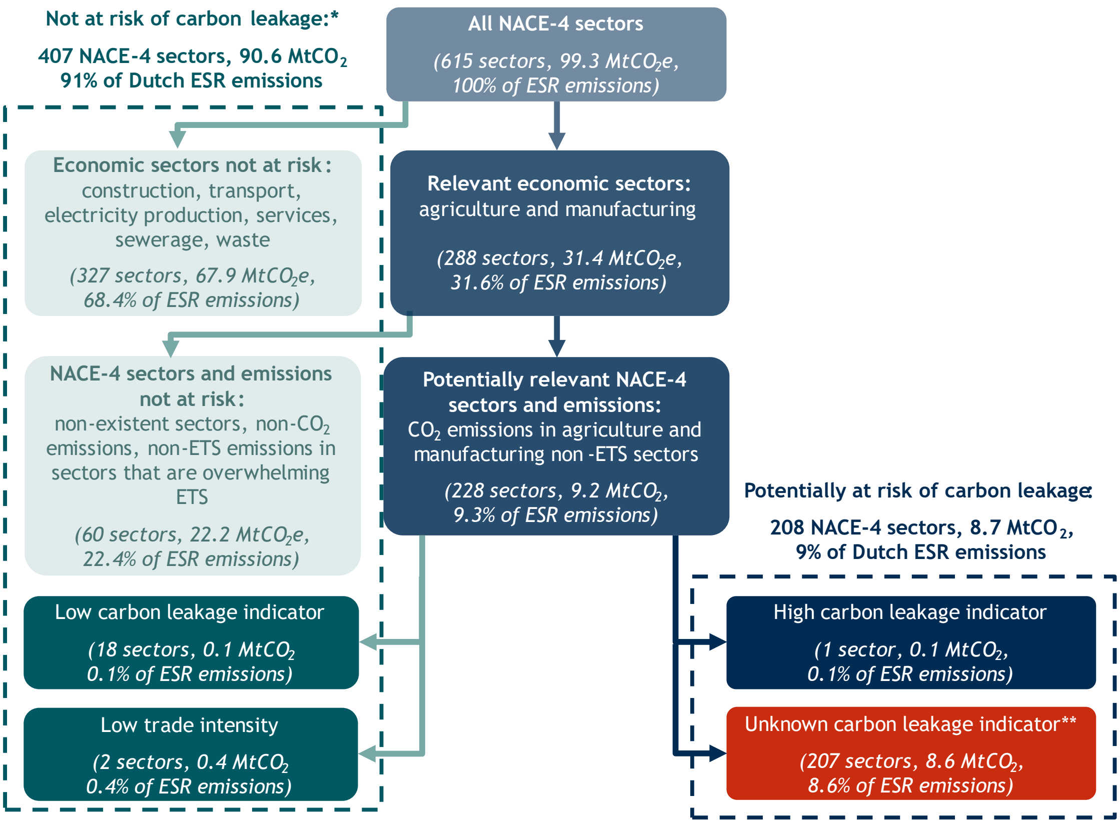
The data for assessing the risk of carbon leakage for Dutch non-ETS sectors have been sourced from various public statistics, primarily from Eurostat and Dutch statistics. Multiple sources for calculating the trade and emission intensity per sector were used to: i) cover trade of Dutch sectors with all of the relevant countries (including non-EU countries), ii) cover all of the relevant NACE 4-digit sectors as much as possible, and iii) calculate emissions based on energy use if emissions values are not available. Overall, the primary data source for economic indicators (trade, production and GVA) was Eurostat to be consistent with the data the EC used in their carbon leakage assessment in the EU ETS. Where there were gaps, data from Statistics Netherlands (CBS) were used. For emissions, CO_2 emissions data was used with data from the Dutch *Emissieregistratie* the primary source for almost all sectors, and energy balance statistics as gap filling. Because not all statistics have data available for the most recent years at the time of this study, the average of 2016–2018 was used. Table I-1 in Annex I provides a detailed overview of the data sources used.

There are several data limitations to the public statistics with significant data missing, no distinguishment between ETS and non-ETS values and incomplete emissions data. A major limitation of the data is the significant amount of data missing for several carbon leakage indicator components. The lack of data is most severe for GVA and emissions. Additionally, none of the economic indicators is distinguished between ETS and non-ETS. Therefore, the analysis is based on sectors as a whole. Lastly, there are no comprehensive public statistics on total emissions or non-ETS emissions at NACE 4-digit level for the Netherlands nor the EU. The Dutch *Emissieregistratie* is the best available data source on total and non-ETS emissions at NACE 4-digit level in the Netherlands. Though, the emission data at that level contains various gaps. Companies do not have an obligation to report their emissions if they are not in the EU ETS. Therefore, it only contains data reported on a voluntary basis. Also, for the emissions of ETS-installations that are included, their NACE 4-digit sector classification is not the same as used to determine the Phase 4 EU ETS carbon leakage list. These limitations to the emissions data could lead to an under- or overestimation of a sector's total emissions and non-ETS emissions. For the in-depth sector analysis, the total emissions values for the selected sectors are adjusted to reduce the under/ overestimation. A more in-depth description of the data limitations is provided in Annex I.

3.2 Carbon leakage indicators of Dutch non-ETS sectors

The sectors and their associated non-ETS emissions potentially at risk of carbon leakage have been estimated by subtracting GHG emissions not affected or unlikely to be at significant carbon leakage risk if carbon pricing would be introduced in the Dutch non-ETS sectors. Figure 3-1 shows an overview of the elimination steps to come to an estimate of the share of Dutch ESR emissions potentially at risk of carbon leakage.

Figure 3-1 Results of public data collection for carbon leakage indicators of Dutch non-ETS sectors, NACE-4 level



* Findings on carbon leakage risks relate to the strengthening of Dutch non- ETS climate policy on fossil fuel consumption only as risks related to climate policies on non -fuel emissions in e.g. waste incineration are out of scope of this study.
** A breakdown of this category of sectors based on available data can be found in the descriptive text of this figure.

Note: Percentage of total Dutch ESR emissions and number of NACE-4 sectors in parentheses. Not at-risk economic sectors include: construction (NACE F), wholesale/retail trade (NACE G), Transport and storage (NACE H), Service sector (NACE I-U) and sewage and waste treatment and collection (NACE 37 and 38); overwhelming ETS sector = >90% of total emissions come from ETS installations and/or ETS Directive Annex I activity except for solely combustion of fuels >20MW; High carbon leakage indicator = trade intensity x emission intensity ≥ 0.2; Low carbon leakage indicator = trade intensity x emission intensity < 0.2. Data are based on 2016-2018 averages from sources as described in Annex I.1.

First, the non-ETS emissions from the construction, service sectors, transportation, electricity production, sewerage and waste collection and treatment were deemed to be not at significant risk of carbon leakage, which account for 327 NACE-4 sectors and 68.4% of the Dutch ESR emissions.[15] For these sectors, the public statistics show that the trade intensity is either non-existent or very low (<10%),[16] except for a few service sectors and waste. This is an indicator that there is no or a very low risk of carbon leakage. The few service sectors that did have a high trade were publishing activities, which are unlikely to have such high fuel consumption that they would be at risk of carbon leakage. The high trade intensity in the waste sector is related to the collection of waste and not related to the production of a product that could be traded. Waste sectors that could produce products such as material recovery showed a very low trade intensity. The waste sector was therefore also deemed not at risk of carbon leakage under a carbon price on fossil fuel consumption.[17] In addition, air transport is already covered under the EU ETS and maritime transport considered as well, so they would not be affected by the introduction of carbon pricing in the Dutch non-ETS sectors. Also, next to a low trade intensity, the electricity production sector is considered overwhelmingly ETS as only about 5% for their emissions are non-ETS.

Second, GHG emissions and NACE-4 sectors that are not relevant in the remaining economic sectors—manufacturing and agriculture—were also excluded, as they are not affected by non-ETS carbon pricing on fuel consumption. These sectors add up to 60 NACE-4 sectors and 22.4% of Dutch ESR emissions, consisting of the following components:

- **The non-CO_2 emissions in manufacturing and agriculture, accounting for 22.3% of the Dutch ESR emissions, were excluded.** In the agriculture sector, about half of the emissions are related to methane and about 20% to N_2O emissions. These non-CO_2 emissions would not be affected a carbon price on fuel consumption. These emissions also often take place in sectors not associated with intensive fuel use, such as cattle farming and open field agriculture. The non-CO_2 emissions were therefore considered not relevant. In addition, non-CO_2 emissions in the non-ETS industry are also not related to fuel consumption and therefore excluded.
- **23 NACE-4 sectors in manufacturing and agriculture were also excluded from the analysis for which statistics could confirm that they are non-existent in the Netherlands and/or having no trade.** These are sectors for which production value and/or total trade values of zero were reported. These were primarily mining sectors and various sectors in clothing, drinks and mineral product manufacturing. NACE-4 sectors for which the production and/or trade values was not available in statistics have not been excluded, as in many cases these values are not reported due to confidentiality reasons.
- **The CO_2 emissions in 37 NACE-4 sectors in the manufacturing sector that were considered overwhelmingly ETS[18] were eliminated, which were less than 0.1% of the Dutch ESR emissions.** For these sectors, their emissions are already covered under the EU ETS except for some installations that are too small to meet the ETS inclusion threshold. The emissions of

[15] Estimated using GHG emissions data from Emissieregistratie.nl, except for the sewerage and waste sector for which GHG emissions data from the National Inventory Report 2021 of the Netherlands was used.
[16] NACE4 sectors with a trade intensity of <10% were considered low, which corresponds to the threshold the EC used in Phase 3 of the EU ETS to consider a sector not at significant risk of carbon leakage in combination with a carbon cost intensity (emission intensity x carbon price) of <5%. These sectors would have to have an emission intensity of >2 $kgCO_2$/EUR GVA to be able to meet the threshold of 0.2, which is very unlikely for non-ETS sectors as that corresponds to the emission intensity of energy-intensive sectors such as glass, chemicals, bricks and tiles.
[17] Almost all CO_2 emissions in the waste sector relate to the waste incineration. The carbon leakage risk of unilateral Dutch carbon pricing on these emissions have not been assessed in this study.
[18] In this report, we consider a sector overwhelmingly ETS if their share of ETS emissions in the total emissions is more than 90% or if the activity of the sector falls under Annex I of the EU ETS Directive other than combustion of fuels in installations with a total rated thermal input of >20MW.

these installations in these sectors known in public statistics is less than 0.1 $MtCO_2$.[19] The impact of non-ETS carbon pricing is therefore considered to be negligible in these sectors. There were no NACE-4 sectors in agriculture that were considered overwhelmingly ETS.

For the remaining sectors, public statistics could only determine that the carbon leakage indicator of 1 NACE-4 sector meets threshold potentially at significant risk of carbon leakage, with the non-ETS emissions from fuel use of this sector estimated to be 0.1 $MtCO_2$. For only 19 of these sectors the carbon leakage indicator could be calculated due to a lack of GVA data, with the list provided in Table I-2 of Annex I. Only one of these sectors meet the EC threshold of 0.2 used in Phase 4 of the EU ETS and may potentially be at risk of carbon leakage: manufacturing of plastics in primary forms. The non-ETS emissions from fuel use of this sector are estimated to be 0.1 $MtCO_2$ (see Section III.1), corresponding to 0.1% of the Dutch ESR emissions. 18 sectors are quite far removed from the 0.2 threshold (almost all below 0.1). In this report, they are therefore considered not to be at significant risk of carbon leakage if additional non-ETS climate policy on fuel consumption would be introduced.

A further filtering was done on the remaining sectors which had a very low trade intensity or non-existent in the Netherlands, which excluded two more NACE-4 sectors from carbon leakage risks accounting for 0.4 $MtCO_2$. This corresponds to 0.4% of Dutch ESR emissions. The most relevant sector is dairy cattle farming, which is responsible for these emissions as there was no emission data for the other sector with low trade intensity (ready-mixed concrete). Both sectors had a trade intensity of 2% for their combined intra-EU and extra-EU trade. This would mean that in order to meet the 0.2 threshold for significant carbon leakage risks, their emission intensity would have to be 10 $kgCO_2$/EUR GVA. This would correspond to the emission intensity for the oil refining sector.[20] It is therefore very unlikely that the fuel emissions of these sectors would be at risk of carbon leakage.

The carbon leakage risk for the remaining 207 NACE-4 sectors could not be determined with public statistics and are estimated to account for about 8.6 $MtCO_2$ of non-ETS emissions from fossil fuel consumption. The is based on the average of 2016—2018, calculated by subtracting the emissions for which the carbon leakage risks could be determined in the earlier steps. Using bottom-up data at NACE-4 level, about 77% of these emissions can be traced to specific sectors with the following observations regarding carbon leakage risks (See Table I-2 in Annex I for sectoral breakdown for each group):

- *High trade intensity*: 121 NACE-4 sectors have both a combined trade intensity as well as an extra-EU trade intensity that can be considered high (>30%).[21] This means that for these sectors, their emission intensity would have to be 0.67 $kgCO_2$/EUR GVA to be able to meet the threshold of 0.2, or less if their trade intensity is higher than 30%. This level of emission intensity can be observed in sectors where the use of fuel for heating is a key step in the product process such as manufacturing of food ingredients.[22] It is therefore feasible that at least some of these sectors are potentially at risk of carbon leakage. This group covers a wide range of sectors from agriculture and food processing to manufacturing of industrial components and machines as well as consumer products. Available emissions data for the

[19] This has been determined by comparing the list of installations from Emissieregistratie with the public list of Dutch ETS installations and their associated NACE codes used by the European Commission for determination of the ETS Phase 4 carbon leakage list, and only including emissions from non-ETS installations.
[20] European Commission (2018). *EU ETS phase 4 Preliminary Carbon Leakage List – Carbon Leakage Indicator underlying data.*
[21] A trade intensity of 30% corresponds to the threshold the EC used in Phase 3 of the EU ETS to consider a sector to be at significant risk of carbon leakage as a standalone criterion.
[22] European Commission (2018). *EU ETS phase 4 Preliminary Carbon Leakage List – Carbon Leakage Indicator underlying data.*

NACE-4 sectors show that these sectors represent at least 6.2 $MtCO_2$, with the vast majority of these emissions (87%) coming from horticulture sectors.

- *Low trade intensity*: 19 NACE-4 sectors which have low extra-EU trade intensity (<30%). 7 of these sectors even have a trade intensity <10%, meaning that their emission intensity needs to be greater than 2 $kgCO_2$/EUR GVA for the carbon leakage indicator to be higher than 0.2. The latter is very unlikely for non-ETS sectors as that corresponds to the emission intensity of energy-intensive sectors such as glass, chemicals, bricks and tiles.[23] These sectors could therefore be considered not at risk of carbon leakage under an EU-wide approach. For sectors where there is emissions data available, these add up to about 0.2 $MtCO_2e$. Sectors include sheep, poultry and pig farming and manufacturing of bread and certain metal, wooden, plastic and mineral end products.
- *Unknown trade intensity*: For 67 NACE-4 sectors, trade intensity cannot be estimated since no production and/or trade value data was reported. Emission data is only available for a few sectors in statistics, which add up to 0.2 $MtCO_2e$ emissions. There is a large variety among these sectors ranging from certain agricultural products and fishing to post-production processing of metals, machining and manufacturing of clothing, cutlery and gas. Based on the description of the sectors, some of these sectors are probably not at risk of carbon leakage, but this cannot be confirmed with statistics. As sometimes data is not publicly reported in statistics due to confidentiality reasons, the risk of carbon leakage cannot be excluded from these sectors.

From the analysis, we conclude that up to 208 NACE-4 sectors could potentially be at risk of carbon leakage, which account for 8.7 $MtCO_2$ of non-ETS emissions from fossil fuel consumption and corresponding 9% of the Dutch ESR emissions. About three-quarters of these emissions relate to the non-ETS agriculture and about a quarter to non-ETS manufacturing. This is the sum of the one sector for which the carbon leakage indicator was higher than 0.2 and the 207 sectors for which data was insufficient to draw conclusions on their carbon leakage status. For non-ETS agriculture, this comes down to about 6.8 $MtCO_2$ potentially at risk of carbon leakage with emissions are concentrated in horticulture sectors. For non-ETS manufacturing, about 2 $MtCO_2$ could be at risk of carbon leakage with the emissions spread out over a variety of sectors.

For the 208 NACE-4 sectors potentially at risk of carbon leakage, the amount of non-ETS emissions at risk of intra-EU leakage appears to be twice as high as extra-EU leakage. Comprehensive data that distinguishes between emissions associated with intra-EU trade and extra-EU trade does not exist. Instead, the intra-EU and extra-EU trade values for the 208 sectors have been used as an indicator for this split between their emissions. The average trade values (i.e. import and export) over 2016—2018 for each of the sectors was used and weighted against the non-ETS emissions per NACE-4 sector where data was available. This found that for the emissions potentially at risk, about two-thirds of the emissions would be at intra-EU leakage risk and a third at extra-EU leakage risk. A major assumption is that the emission intensity of goods traded in and outside the EU within a sector is the same. However, this will not be the case in practice, as the trade data for the sectors for in-depth analysis show (see Annex III). This estimate also assumes that carbon leakage occurs along the same proportions as the current intra-EU and extra-EU trade flows in a sector, with domestic production fully displaced. However, there are many factors such as foreign production capacity, business environment and costs other than climate cost that determine where production and emissions will shift to. Nonetheless, this provides an overall indication of the intra-EU compared to extra-EU leakage risks.

[23] Ibid.

3.3 Selection of sectors for in-depth analysis

The limitations in the carbon leakage assessment of Dutch non-ETS sectors using public statistics warrants a more in-depth analysis of the sectors. Section 3.2 shows that a large number of non-ETS sectors could potentially be risk at carbon leakage. Though, this could not be confirmed with public statistics due to a lack of data at NACE-4 level (or even at NACE-3 level), preventing from the carbon leakage indicator for these sectors to be calculated. However, even if the carbon leakage indicator would meet the EC criteria of 0.2, it only tells one part of the story, as discussed in Chapter 2. Among others, the indicators do not take into account the climate policies competitors outside of the Netherlands face.

Six Dutch NACE 4-digit sectors have been selected for an in-depth analysis, representing 66% of the non-ETS emissions potentially at risk of carbon leakage. Among the 208 NACE-4 sectors potentially at risk of carbon leakage, the sectors for which data were available were ranked based on their importance to the Dutch economy and trade and the emission intensity of their production value.[24] This resulted in the following sectors for the in-depth analysis with their *share in non-ETS emissions potentially at risk of carbon leakage* (See Annex I.4 for more details on methodology):

- Manufacturing of plastics in primary forms (NACE 20.16), *1%*;
- Manufacturing of dairies and cheese making (NACE 10.51), *3%*;
- Manufacturing of homogenised foods preparations and dietetic food (NACE 10.86), *0.3%*;
- Growing of vegetables and melons, roots and tubers (NACE 01.13), *35%*;
- Growing of non-perennial crops (NACE 01.19), *16%*; and
- Plant propagation (NACE 01.30), *11%*.

To consider the impact of climate policies on competitors in the carbon leakage risk, the top five European countries that the six Dutch sectors trade with most have been selected for the in-depth analysis. As determined in Section 3.2, the risk of intra-EU carbon leakage is estimated to be higher than the extra-EU risk for non-ETS sectors. This seems to be reflected in the trade statistics for these six sectors. The average ratio for trade in these sectors is 68% intra-EU and 32% extra-EU. The in-depth analysis therefore focuses on the EU countries that the six Dutch sectors have the highest trade value with as a whole. These are Germany, France, Belgium and Spain,[25] covering 70% of the intra-EU trade in these six sectors. In addition, the United Kingdom (UK) is also analysed as it has similar climate policies as in the EU and cover a substantial part (20%) of the extra-EU trade. Such a cross-country analysis is particularly relevant to contrast the carbon leakage risk of a unilateral Dutch approach with an EU-wide approach.

In the sector specific assessments, the six NACE-4 sectors are grouped into three sectoral categories: polymers, dairy products and (greenhouse) horticulture. Policy measures are generally structured around economic sectors at a higher aggregated level than NACE 4-digitcodes. This means that climate policies and related exemptions or compensation measures for *Manufacturing of dairies and cheese making* and *Manufacturing of homogenised foods preparations and dietetic food* will largely be the same. The production processes for these NACE-4 sectors are also similar as described in Chapter 4. The same goes for the horticultural NACE codes. In the rest of the report, the analysis is therefore

[24] Emission intensity of the production value is used as an alternative indicator of emission intensity used for calculating the carbon leakage indicator due to the lack of data available on GVA for many sectors. The emission intensity based on production value is lower than based on GVA, because the production value also contains other factors such as the cost of purchased goods and services in addition to the GVA.
[25] Spain is particularly relevant for the horticulture sector.

grouped in polymer plastics (20.16), dairy products (10.51 and 10.86) and (greenhouse) horticulture (01.13, 01.19 and 01.30, although used scope deviates slightly from NACE codes[26]).

[26] Our non-ETS carbon leakage risk assessment showed three agricultural four-digit NACE code sectors that show a high CL risk: 01.13 – Growing of vegetables and melons, roots and tubers; 01.19. Growing of other non-perennial; 01.3 Plant propagation. These three categories are the main categories where production in the Netherlands takes place in greenhouses. In greenhouses 80% of the total energy in the Dutch agricultural sector is used (Trinomics, 2021). Therefore, we assume that the Dutch carbon leakage risk is mainly the result of crops that are produced in greenhouses and use these crops produced in greenhouses in the Netherlands as the scope of this sector. The scope is based on the *crop* and not on the production method. For example, tomatoes—which are produced in greenhouses in the Netherlands but also in open field in Spain—are in scope. The three NACE sectors also includes non-greenhouse crops in the Netherlands, such as potatoes. As potatoes are not produced in greenhouses in the Netherlands, potatoes are out of scope of the sector analysis.

4 Non-ETS climate policies in the Netherlands and key trading partners

This section compares the key components of non-ETS climate policies in the EU, the Netherlands and the top five European trading countries, mainly focusing on the selected sectors. These are Germany, Belgium, the UK, France and Spain, as discussed in Section 3.3. The comparison is based on the analysis of climate policies in the respective countries, provided in Annex II.

4.1 EU policy framework for non-ETS sectors

The most important EU climate legislation for non-ETS sectors is the Effort Sharing Regulation (ESR). In contrast to ETS sectors, each EU country has a specific ESR climate target for the joint GHG emissions from agriculture, buildings, road transport, waste and the non-ETS industry. At EU level, ESR emissions account for 57% of total GHG emissions.[27] In the Netherlands, ESR emissions account for 55% of total GHG emissions.[28] Under the proposed Fit For 55 policy package, the EC aims to increase the overall EU-wide ESR reduction target from 30% to 40% emissions reduction in 2030 compared to 1990.[29] National targets have to be updated to reach the proposed EU-wide 40% target. Consequently, each Member State needs to formulate their own policies for meeting their targets, although these are largely affected by other EU legislation, such as the Energy Efficiency Directive, the Renewable Energy Directive and the Energy Taxation Directive.

Based on the proposed Fit For 55 targets for ESR sectors in 2030, all key EU trading partners require substantive additional climate policies in non-ETS sectors to reach the new targets. The proposed ESR targets under Fit For 55—ranging from 38% for Spain to 50% for Germany as shown in Figure 4-1—leave significant emission gaps compared to the expected emission reductions from implemented and announced policies. In 2019, the EC assessed the expected emission reductions by 2030 under announced policies in the National Energy- and Climate Plans (NECPs).[30] In the Netherlands, current and announced policies at that time were expected to result in 31% emission reduction, leaving a gap of 17% percentage points compared to the new proposed target. In Belgium, this gap equals 36% percentage points (see Figure 4-1). Other countries fall within this range and also need substantive new climate policy in non-ETS sectors in order to meet their ESR targets. Since then, there have been new policy developments in the analysed countries to narrow these gaps (see Section 4.2). However, some of these developments have yet to be worked out into concrete measures.

Also in the UK, stricter climate policies for non-ETS companies can be reasonably expected to meet their overall emission reduction target of 63% reduction in 2030 (compared to 2005). As a result of Brexit, the UK is not required to comply with an ESR target. However, their overall reduction target is considered ambitious at 63% reduction in 2030 compared to 2005. Currently implemented policies are estimated to reach a reduction of 44%.[31] As such, stricter climate policies can also be expected in the UK.

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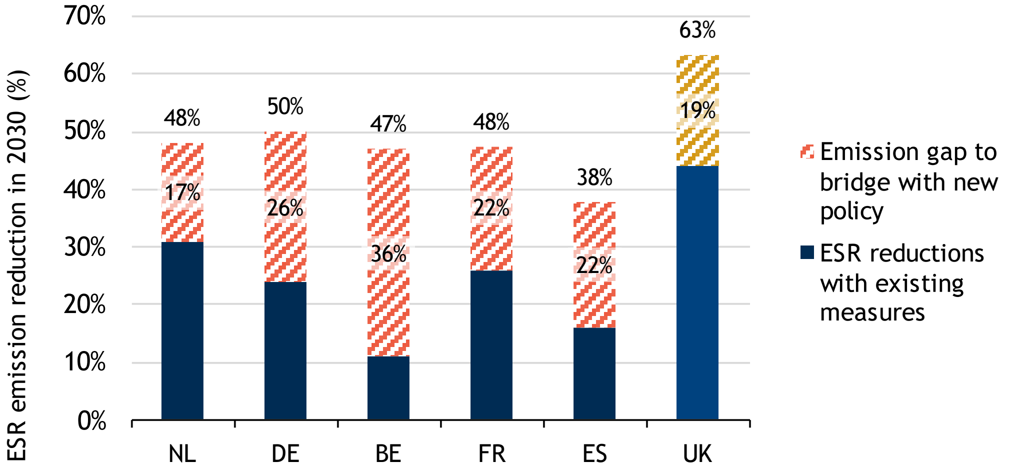
[27] Transport & Environment (2021). Effort Sharing Regulation.
[28] PBL (2021). *Klimaat- en energieverkenning.*
[29] Besides the EU-wide ESR target, all other mentioned targets in chapter 4 are compared to *2005* and not 1990
[30] European Commission (2020). National Energy and Climate Plans.
[31] UK analysis is based on the impact assessment of the Sixth Carbon Budget. It is not possible to convert this overall target to a target that better corresponds with the non-ETS sectors.

Figure 4-1 Proposed Fit For 55 ESR targets for emission reduction and the existing emission gap with current policy in 2030 (compared to 2005) for analysed countries for existing and announced policies in 2019.



Source: European Commission (2020). National Energy and Climate Plans assessments; UK: Sixth Carbon Budget Impact assessment.
Note: As the UK is not part of the EU and does not have ESR target, their overall target for 2030 (compared to 2005) is shown.

The Energy Taxation Directive (ETD) is the main EU legislation that affects the implicit carbon price directly imposed on non-ETS sectors. The ETD regulates national energy taxation regimes by setting minimum tax rates and defining rules for tax exemptions and deductions, both voluntary and mandatory. This means that EU Member States can impose higher tax rates on energy consumption including fossil fuels, but not lower than stipulated in the ETD. Through these mechanisms, the ETD effectively imposes an implicit carbon price on fossil fuel use. The energy tax as mandated through the ETD is also the main pricing instrument on fossil fuel consumption in non-ETS sectors in most EU Member States, as discussed in Section 4.2.

4.2 National non-ETS climate policies in the Netherlands and trading partners

Ultimately, the cost of climate policies companies face is based on a combination of both direct pricing policies, regulatory policies and support programmes. This report focusses on direct pricing via a) energy pricing and b) explicit carbon pricing as expressed in effective carbon prices. Estimating effective carbon prices is complex. Many policy types affect the price for emitting CO_2. As mentioned before, this report estimates the effective carbon prices resulting from direct carbon pricing and energy pricing. As such, the estimated effective carbon prices in this report do not reflect all measures. Instead, it is used as a quantitative indicator for the level of stringency of non-ETS policy in a country.

Overall, the effective carbon prices in key trading partners are comparable to the Netherlands, with some key differences, similarities as well as exceptions. A detailed analysis on effective carbon prices is provided in Annex II. Table 4-1 presents an overview of the effective carbon rates for the Netherlands and key trading partners for the most relevant sectors and fuels for our analysis. The key observations on the stringency of non-ETS climate policies in the key European trading partners are:

- **Non-ETS effective carbon rates are generally lower than what is required to limit global warming below 2°C.** While the exact required effective carbon price is difficult to assess, estimates of the necessary carbon price to avoid emissions in line with the Paris agreement range between €100/tCO_2 and higher by 2030.[32] In most sectors and for most fuels analysed in this report, the effective carbon price is substantially lower. Carbon rates for fossil fuels that are mostly used for transport are an exception: excise duties on fuels such as fuel oils (gasoline and diesel) are from a climate perspective relatively high in all countries. However, the fuel oil rates are much lower in many industrial and/or agricultural sectors.

- **Effective carbon prices differ between fuels, fuel uses and sectors.** This is the result of many reduced rates and exemptions in national energy taxes. Several exemptions are in place in various countries, such as exemptions for fuel used for electricity generation or the dual use of coal or gas. In addition, fuel use in the agricultural sector receives reduced rates or exemptions in several countries, such as in Belgium, France and the Netherlands. Energy-intensive industry also receives reduced tax rates in Belgium, UK and Germany.
- **Germany is the only key trading partner with a sizable explicit carbon price (nEHS) for non-ETS sectors.**[33] As a consequence, carbon prices in Germany are relatively high for non-ETS sectors. In 2022, the rate is €30/tCO_2 and will increase up to €55/tCO_2 by 2025.[34] However, many (industrial) sectors with a high carbon leakage risk receive a partial compensation for their carbon costs under the nEHS, ranging between 65% and 95% until at least 2025. This leads to a lower effective carbon price. The level of compensation depends on the direct emission intensity of a sector.[35] So far, only sectors deemed at significant risk of carbon leakage under the phase 4 of the EU ETS can receive compensation. For example, the rate for the polymer sector and certain dairy products are effectively reduced by 65%. Additional German sectors and subsectors can apply to receive partial compensation if they show that the carbon leakage indicator (emission intensity x trade intensity) meets the threshold of 0.2.[36]
- **For natural gas, most carbon rates are comparably low (below €10/tCO_2). Smaller industrial gas users in the Netherlands are a key exception.** In most non-ETS sectors natural gas is the main used fuel. All key trading partners have low, flat (or slightly degressive) energy tax rates for natural gas below €10/tCO_2. Only in Germany, the effective carbon price is higher because of the nEHS. For smaller gas users, the Netherlands is an exception, as it has a degressive energy tax on gas with relatively high rates at low consumption volumes. As a result, smaller industrial companies—which are often non-ETS—have high carbon prices of €45/tCO_2 or higher (see also Sections 5.1 and 5.2). Larger industrial companies in the Netherlands, which often are mainly ETS, have more comparable carbon rates with trading partners.
- **Natural gas used in Combined Heat and Power plants (CHPs) have very low effective carbon rates in the Netherlands and all key trading partners.** CHPs are commonly used in many non-ETS sectors, including the production of polymers and heated greenhouse horticulture production. The rationale for the low rate is that CHPs have a high energetic efficiency, in case all heat can be used. However, CHPs still rely on fossil fuels which is not favourable from a climate perspective. In the Netherlands, Germany, Belgium, the UK and Spain, (efficient) CHPs are fully exempt of energy taxes—although the nEHS still applies in Germany.

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[32] Based on a literature review of sources of e.g. IEA, European Commission and OECD from Trinomics (2020). Energy costs, taxes and the impact of government interventions on investments.

[33] France also has an explicit carbon price (*la composante carbone)* but in practice its price is neglible for the non-ETS sectors within this reports scope because of many tax rebates.

[34] Umbundesamt (2021). National Emissions Trading BEHG.

[35] The level of compensation to German non-ETS companies has been determined using values for emission intensity per NACE-4 sector calculated by the European Commission for establishing the carbon leakage list for Phase 4 of the EU ETS.

[36] Companies need to meet various conditions when showing that their sector meets the carbon leakage threshold including on representativeness, quality and consistency. In addition, sectors that have a carbon leakage indicator between 0.1 and 0.2 or an emission intensity of >1.0 kgCO_2/€ GVA can also apply for compensation based the qualitative criteria similar to the ones for the carbon leakage status in the EU ETS. For more information, see Umbundesamt (2021). Leitfaden zu den Antragsverfahren zur nachträglichen Anerkennung beihilfeberechtigter Sektoren und zum Besonderen Einstufungsverfahren nach der BEHG-Carbon-Leakage-Verordnung.

- **Effective carbon rates for coal range between €0.7/tCO_2 and €42/tCO_2, but its use is low in non-ETS sectors.** In the Netherlands, the UK and Spain coal have a carbon price lower than €10/tCO2. However, it is likely that coal use in non-ETS sectors is limited given that in most countries, coal is primarily used for power generation or for larger industrial processes that are included in the ETS (e.g. steel); Germany is a large coal user and could be an exception, but this is not further analysed as it is not deemed likely for sectors in the in-depth assessments in Chapter 5.

Table 4-1 Effective carbon rates of direct carbon and energy pricing policies in the Netherlands and key trading partners (€/tCO_2e). For fuel oil, the rate in the agricultural sector is between parentheses.

Fuel	Application	NL	DE	BE	UK	FR	ES
Natural gas	Industry	29-251	14-53[37]	4-8	5-30[38]	8	2.7
	Agriculture	25-40	53	3-3.3	5	3	2.7
	CHP	0	10-33	0	0	3-8	0
Fuel oil	Industry (agriculture)	185	131	140 (0)	48	21-227 (58)	114 (24)
Coal	General	0.7	31	n/a	3-18	10-42	2.7

Source: Multiple sources, see annex II country profiles. Note: For fuel oil we use effective carbon rates for off-road use (so not for use as transport fuel), given that transport is out-of-scope in this report.

All countries have subsidy schemes in place to support decarbonisation of non-ETS sectors, which affect effective carbon prices. For all key trading partners, operational subsidies for renewable energy production are in place (e.g. the Dutch SDE++ or German EEG). However, operational subsidies for electrification (e.g. heat pumps) or the use of renewable molecules (e.g. green hydrogen or biomethane) are still relatively limited in most key trading partners. The Dutch SDE++ is one of the few instruments which targets CO_2 emission reduction instead of renewable energy generation. In Germany, the Federal funding for energy and resource efficiency in the economy may be used for investments to increase energy efficiency and lower fuel use. In the UK, the IETF is the most relevant scheme that supports the deployment of more transformative energy efficiency measures and new decarbonisation technologies. In Belgium and Spain, decarbonisation subsidies appear to be the most limited. A cross-country comparison of the quantitative impacts of subsidies on effective carbon rates is out-of-scope for this study, given that it is complex and there is no consistent methodology to take them into account.[39] In addition, other factors, such as the short-term availability of grid capacity to electrify industrial processes, also influence the applicability for non-ETS sectors to make use of these subsidies to reduce their emissions.

More stringent climate policy can be expected in the key European trading partners, which will likely mitigate the carbon leakage risk of a unilateral carbon pricing approach in the Netherlands. As shown before, the examined trading partners need additional climate policy to reach their national climate targets for 2030 and 2050. Since then, the Netherlands has announced in its coalition agreement an overall emission reduction target of 55% in 2030—with the intention to reach a 60% reduction.[40] Some trading partners show a similar trend towards more ambitious targets and policy plans: Germany has set a reduction target of 65% in 2030[41] and the UK aims for 63% reduction in 2030

[37] Including German CO_2-tax of €30/tCO_2 for horticulture and €10.5/tCO_2 for relevant industrial sectors
[38] In practice most gas used in industrial sectors (including polymers and dairy) is taxed on the lower end of the range (close to €5/tCO_2), as most receive a large discount as a consequence of involvement in a Climate Change Agreement(CCA).
[39] World Bank (2019). State and Trends of Carbon Pricing 2019.
[40] Coalition agreement (2021). Coalitieakkoord.
[41] Bundesregierung (2021). Climate Change Act 2021.

(compared to 2005)[31]. However, national reduction targets in France[42], Belgium[43] and Spain[44] are less ambitious than what is most likely required in order to meet their ESR targets. This means that they will also have to implement additional or more stringent measures in non-ETS sectors to meet these targets. As climate policy measures become stricter in key European trading partners, the risk that carbon leakage could occur from Dutch non-ETS sectors to those countries decreases.

[42] Ministère de la Transition Écologique et Solidaire (2020). *Stratégie nationale bas-carbone*.
[43] Flanders: 40% non-ETS target in 2030 (bijkomende maatregelen klimaat); Wallonia: still a 30% non-ETS target for 2030 (Decret 'climat').
[44] Proposed national target of 37.7% in non-ETS sectors in 2030: NECP Spain.

5 Sector-specific carbon leakage assessments

This section assesses the carbon leakage risks for three selected sectors: manufacturing of polymers, food processing and greenhouse horticulture. These sectors have been selected based on the overall carbon leakage assessment as shown in Section 3.3. Each sector assessment is structured in the same way.

In each section, we first provide the (1) sector characteristics and the sector specific (2) effective carbon price & climate policies and (3) emissions & trade intensities. The sector characteristics highlight the aspects most relevant to a sector for assessing their carbon leakage risk (for detailed characteristics, see Annex III). This is followed by a discussion on the differences in sector specific effective carbon prices and relevant climate policies in key European trading partner countries. The differential in effective carbon prices is used as an indicator for the stringency of climate policy. This is used to determine whether potential risks of production shifts could also lead to carbon leakage or that it is just a correction of policy asymmetry (see Section 1.3 for how carbon leakage is defined in this report). This builds on the effective carbon prices and climate policies discussed in Section 4.2, but specifically for each sector. Detailed information on policies is presented in Annex II. Third, the two components of the carbon leakage indicators are analysed: emission intensity (combined with the possibility to reduce emissions through abatement measures) and trade intensity (combined with the ability to passthrough costs).

The sector specific assessments are tailored to non-ETS producers to the extent possible. However, statistics cover both ETS and non-ETS producers. Only non-ETS producers are relevant for this research. As such, the assessments are targeted on non-ETS producers, for instance by focusing on the products made by non-ETS producers within the sector. Yet, many sector statistics do not distinguish between ETS and non-ETS producers.

Different carbon leakage risks under unilateral Dutch carbon pricing approach for the selected non-ETS sectors are assessed. The assessment builds on the concepts and mechanisms discussed in Section 1.3 and Chapter 2. Carbon leakage risks under the unilateral Dutch approach are assessed according to the following structure:

- **Impact on competitiveness**: The impact of unilateral carbon pricing on **competitiveness** is assessed at sector level (compared to the current situation relative to their international competitors). The strictness of the carbon pricing instrument in combination with the share of carbon pricing costs in total costs (emission intensity) determines the extent of competitiveness loss. Therefore, emission intensities are a key component in this analysis.
- **Intra-EU leakage to non-ETS producers**: Whether substantial carbon pricing costs resulting from the unilateral Dutch approach (for companies with high emission intensities) increase the risk of **production and investment shifts** to non-ETS EU competitors depends on the level of international competition. The level of international competition determines to what extent producers can passthrough costs without losing market shares. Therefore, the competitiveness analysis is complemented with an analysis on international trade and abilities to passthrough costs. Finally, it is determined whether this translates into carbon leakage by comparing stringency of climate policies. Investment and production shifts are only considered to translate in **carbon leakage** if climate policies are more lenient in competing countries. Effective carbon rates are used as an indicator for climate policy stringency. If these are higher in competing countries, the carbon leakage risk is considered to be lower in a unilateral

Dutch approach. It could be implemented in a way to only correct an asymmetry in climate policy stringency (see Section 1.3). In that case, production/investment shifts are not considered leading to carbon leakage. However, if the effective carbon rates in the Netherlands are higher, the introduction of any unilateral Dutch approach would exacerbate the asymmetry in policy stringency and increase the risk of carbon leakage.

- **Intra-EU leakage to ETS producers**: This section applies the same logic on competitiveness loss, production and investment shifts and carbon leakage to assess the risk of carbon leakage form Dutch non-ETS sectors to ETS competitors. Based on this logic, potential investment and production shifts are only considered carbon leakage if ETS companies face more lenient climate policies than non-ETS companies. To assess this, effective ETS costs are estimated, using the average ETS price in 2021 (€54/tCO_2e).[45] ETS producers receive free allowances, which arguably lowers their effective carbon price.[46] If ETS companies already face a higher effective carbon price than non-ETS companies, the carbon leakage risk of a unilateral Dutch approach is considered to be lower compared to reverse situation.
- **Extra-EU leakage**: Non-ETS carbon pricing can increase the risks for carbon leakage to countries outside the EU. This section applies the same logic as described above for the extra EU context. It considers the extra EU trade intensity and explores indications of differences in emission intensities between Dutch and extra EU producers.
- **Impact on global GHG emissions**: Emissions per unit of product can differ between countries, for instance due to differences in process efficiency or fuel use. As such, production or investment shifts can impact global GHG emissions on the short run, which is explored in this section. On the long run, additional carbon pricing can contribute to decarbonisation as it becomes more expensive not to investment in abatement options. Also, higher prices of (end) products may lower consumption or cause a swift towards products with lower emission footprints, depending on the elasticity of demand. These latter mechanisms are discussed in this section if it is relevant for the sector.

Lastly, the differences between carbon leakage risks under the unilateral and EU approach are explored. Under the EU approach, non-ETS companies across the EU would face an identical carbon price. As such, intra EU carbon leakage to non-ETS companies is by definition mitigated. Production and investments shift, however, can still occur. More information on definitions is provided in Chapter 2.

5.1 Manufacturing of polymers

The manufacturing of polymers is a highly diverse sector within the plastics value chain. The plastics value chain involves raw material production, basic chemicals production, the manufacturing of polymers in primary forms, and finally the manufacturing of plastic products, such as plastic packaging products. The sector discussed in this report is manufacturing of plastics in primary forms (NACE[47] 20.16). Even though this sector is dominated by ETS manufacturers (which predominately produce commodity plastics, such polymers of propylene, ethylene, styrene and vinylchloride), about 10% of the direct emissions in the Netherlands are emitted by non-ETS producers. Among the non-ETS

[45] Since the start of 2022, the EU ETS price has been fluctuating between €58 and €98. In this study, we have assumed a conservative ETS price to show that even with low ETS prices, there is a significant asymmetry in climate policy stringency between the EU ETS and non-ETS sectors.
[46] Free allowances lower the overall ETS costs of a company as they only have to purchase emissions allowances for the emissions not covered by free allowances. This effectively lowers the average carbon price the company has to pay for their emissions. However, the number of free allowances received are not directly linked to emissions, meaning that the carbon price for emitting one tCO_2e additional (marginal carbon price) is the full ETS price. It can therefore also be argued that the effective carbon price should be the marginal carbon price.
[47] Eurostat (2008). NACE Rev. 2 - Statistical classification of economic activities in the European Community.

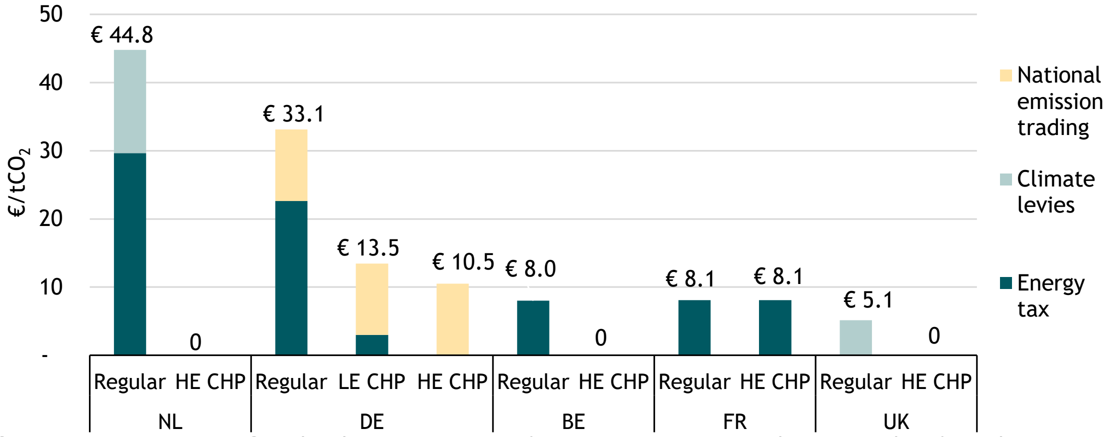
manufacturers, some producers compete with ETS-companies in the production of commodity plastics. Others produce specialty plastics instead, such as (coating) resins and catalysts. Germany and Belgium are the key trading partners within the sector. More information on the Dutch non-ETS polymer sector can be found in Annex III.1.

Effective carbon price and relevant climate policies for Dutch non-ETS plastics manufacturers

In 2022, the effective carbon rates that non-ETS polymer manufacturers face in the Netherlands are estimated to be higher than in DE, BE, and the UK, except when CHP installations are used. Figure 5-1 shows the breakdown of effective carbon prices per country. It is estimated that Dutch non-ETS polymer manufacturers on average face an effective carbon price of €45/tCO_2, which is based on the energy and ODE tax for natural gas use.[48] As Dutch energy taxation has a regressive structure based on consumption (more information: Annex II.1), the effective carbon price depends on the volume of gas use. Based on emission data from non-ETS companies from *Emissieregistratie*, the effective carbon rates range from €30 to €252/tCO_2 for Dutch non-ETS polymer manufacturers. Key competitors are manufacturers in Germany, Belgium and the UK (Spain and France are less relevant in the context of polymers). The effective carbon prices for manufacturers in Germany (national emission trading system and energy tax on natural gas) and in the UK (climate change levy) are estimated to be significantly lower at the moment (€33/tCO_2 and €5/tCO_2 respectively). However, the German effective carbon price is set to rise in the coming years to a level higher than the current Dutch effective carbon price due to the planned carbon price increase under the German national ETS.

These estimates are made assuming that all countries use similar production methods and fuels (natural gas). It is stressed that substantial tax reductions are in place for natural gas used in CHPs. In the Netherlands, Belgium and the UK, efficient CHPs are fully exempted from the energy tax, leading to an effective carbon price of zero. In Germany, efficient CHPs are exempted from the energy tax, but not from their national ETS. In France, CHPs are not exempted. In the Netherlands, CHPs are commonly used for polymer manufacturing including non-ETS producers.

Figure 5-1 Effective carbon price of pricing instruments on natural gas, when not using CHP in 2022



Source: Trinomics (2022). Based on literature review of country energy taxes and emissions data from the Emissiesregistratie.
Note: LE CHP is low efficiency cogeneration; HE CHP is high efficiency cogeneration.

[48] Estimate is based on the average direct emissions from *Emissieregistratie* in 2019 for non-ETS polymer manufacturing installations, transposed to the corresponding natural gas use (3.2 million m^3). As such, we assumed that all direct emissions are resulting from natural gas.

All countries have supporting measures in place that non-ETS polymer sector can make use of for decarbonisation. Dutch non-ETS polymer manufacturers can apply for support schemes, including the EIA, MIA/VAMIL and SDE++. The SDE++ covers among others e-boilers and heat pumps, which are relevant technologies for polymer manufacturing. In Germany, the Federal funding for energy and resource efficiency in the economy may be used for investments to increase energy efficiency and lower fuel use for polymer manufacturers. In the UK, the IETF is the most relevant scheme that supports the deployment of more transformative energy efficiency measures and new decarbonisation technologies. In Belgium, regional support programmes subsidise renewable energy production.

Relevance of carbon pricing costs: emission intensity and abatement options

The high emission intensity at sector level (ETS and non-ETS), suggest that additional carbon pricing may lead to large costs increases. However, it is likely that emission intensities are substantially lower in many non-ETS companies and thus experience a lower cost impact from climate policies. Emission intensity at EU level for the overarching plastics sector is relatively high: 1.81 kg CO_2/€ GVA compared to 1.08, the simple average emission intensity of the manufacture of chemicals and chemical products in the EU in the phase IV carbon leakage list. If this emission intensity of 1.81 kg CO_2/€ GVA were to be applicable for the non-ETS sector, additional carbon pricing would trigger substantial costs increases in non-ETS businesses. However, emissions differ between products and businesses. Emission intensities are expected to be lower for non-ETS companies since many non-ETS manufacturers produce specialty products, which tend to have a higher value added and therefore lower emission intensity. Moreover, commodity plastics are more often produced on a large scale (compared to specialty products), which lowers the costs per unit of product as they face more competition. As a result, manufacturers of commodity plastics are often larger ETS companies, with relatively high emission intensities. As such, processes which are related to high emissions are more likely to exceed the threshold, thereby entering ETS. While GVA data to estimate the emission intensity of non-ETS companies is not publicly available, the lower emission intensity of non-ETS companies can be illustrated based on the emission intensity per euro turnover. The average emission intensity per euro turnover for the three largest non-ETS manufacturers is around 0.3 kg CO_2/€, whereas the average of the Dutch industry as a whole (including ETS) is around 0.5 kg CO_2/€.

While additional carbon pricing would be an incentive for the sector to decarbonise, most abatement options, such as electrification, require substantial financing. It seems unlikely that investment in decarbonisation measures can help companies mitigate cost increases, at least on the short term. Most of the decarbonisation options for the polymer sector require large scale investments, except certain energy efficiency measures. There is no indication that this would be different for non-ETS companies, as they use similar processes. It is unlikely that non-ETS companies can mitigate cost increases resulting from carbon pricing on the short term by investing in abatement options. There are support mechanisms available, which lower the costs for these investments such as the SDE++. This implies that a cost increase due to a new climate policy would likely need to be passed on to their customers or absorbed by the companies.

Exposure to international competition: trade intensity and cost passthrough

The manufacturing of polymers sector as a whole as well as many specific polymer products relevant for the Dutch non-ETS sector are very trade intensive, though variation between products is present. With an overall (ETS and non-ETS) NL-EU trade intensity of 92%, the Dutch polymer manufacturing sector exceeds the EC carbon leakage ETS Phase 3 trade intensity threshold (30%) for international competition substantially. Table 5-1 shows the trade statistics for a selection of products which are produced by Dutch non-ETS (and ETS) plastics manufacturers (as shown in Annex III.1).

Considerable differences between products are observed, with intra-EU trade being higher than extra-EU trade. In particular, trade intensities for alkyd resins and polypropylene are lower than the sector's average. This could indicate less international competition for these products within the sector compared to other products.

Table 5-1 Trade statistics (sold production, imports, exports, trade intensity-TI) of selection of products relevant for the Dutch non-ETS polymer sector in million € (2019)

Product	Sold production	Intra-EU			Extra-EU		
		Imports	Exports	T.I.	Imports	Exports	T.I.
Polymers primary forms (20.16)	**11,291**	**3,974**	**10,123**	**92%**	**2,352**	**3,765**	**45%**
Polyethylene gravity of < 0.94	848	332	756	92%	171	358	52%
Polyethylene gravity of > 0.94	302	174	342	109%	117	174	70%
Expansible polystyrene	346	57	207	66%	19	94	31%
Epoxide resins	156	91	188	113%	67	161	102%
Alkyd resins	98	22	42	53%	6	35	39%
Polypropylene	1,075	235	207	34%	130	122	21%
Propylene copolymers	328	180	673	168%	57	464	135%

Source: Trinomics (2022). Sold production based on: CBS (2021). Verkopen; industriële producten naar productgroep (ProdCom). NACE-4 trade statistics based on: Eurostat (n.d.). EU trade since 2002 by CPA 2.1 and product level trade statistics based on Eurostat (n.d.). EU trade since 1988 by SITC

Within the EU, Dutch polymer manufacturers face substantial international competition, especially those producing commodity plastics. Many Dutch non-ETS manufacturers produce specialty polymers, which face less competition in general. Based on the statistics on trade intensity and interviews, it is concluded that the European polymer manufacturing market is highly competitive. For various products, the Netherlands both imports and exports large quantities, which is an indication that there is little product differentiation within the sector. For these commodity plastics, the high trade intensity values suggest little room for cost-passthrough. Commodity plastics (such as polymers of propylene, ethylene, styrene and vinyl chloride) account for 70-75% of the European production value. The market for commodity plastics is dominated by large ETS-producers. However, some Dutch non-ETS manufacturers are active in the commodity plastics market. However, most non-ETS manufacturers produce specialty products, such as specialised (coating) resins to be used in, for instance, the automotive industry. Based on economic theory, specialty products allow for more room for cost-passthrough, as these differentiated products compete less on price, compared to commodity plastics.

Carbon leakage risks under a unilateral Dutch approach

The risks for production and investment shifts due to competitiveness loss differ substantially between producers of commodity plastics and specialty products. Despite the overall high emission intensity, emission intensities vary substantially within the overarching sector. Non-ETS companies are likely to have lower emission intensities than ETS companies within the sector. The main reason for this is that the non-ETS sector is dominated by smaller manufacturers of specialty products, thereby limiting their competitiveness loss and the risk of carbon leakage. As such, the extent to which carbon pricing would harm competitiveness of the non-ETS sector is not negligible, but likely less significant than for ETS companies, in particular, those producing specialty products with a high value added.

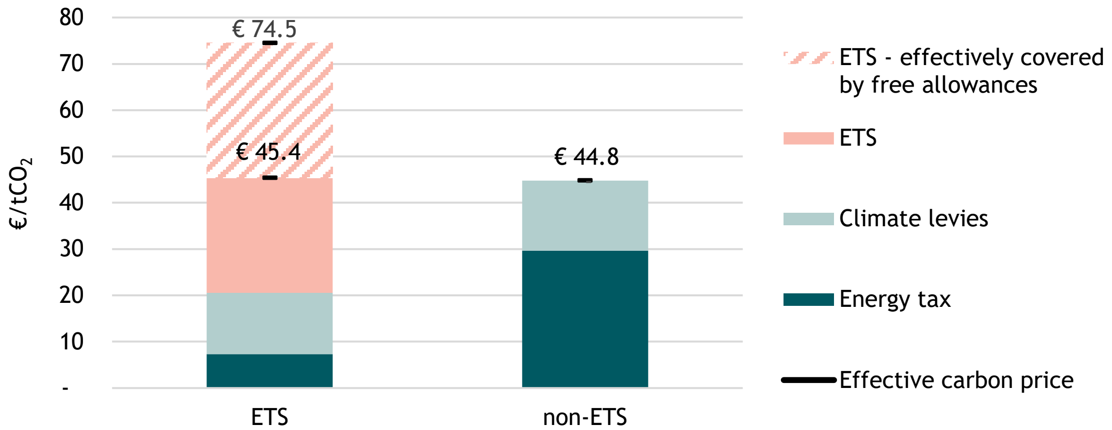
Unilateral carbon pricing is likely to increase the risks of *carbon leakage to non-ETS manufacturers* of polymers in the EU, mostly for the (few) companies active in commodity plastics. Risks are significantly lower in non-ETS companies producing specialty products. It is concluded that the risk of competitiveness loss is related to an increase in the risk of carbon leakage to non-ETS EU competitors, mostly for producers of commodity plastics. This is based on the following observations:

the Dutch non-ETS plastics sector has a relatively high trade intensity, trade intensities are significantly lower for specialty products and effective carbon rates are currently higher in the Netherlands than in competing countries. These observations are explained in more detail below:

- **Manufacturers producing commodity plastics face fierce international competition**, which is concluded based on the high trade intensity value. As a result, these manufactures have little room to passthrough costs to end users without lowering their market shares under a unilateral approach if their competitors do not face similar cost increases.
- **Manufacturers producing specialty products face much less competition.** Many Dutch non-ETS plastics manufacturers produce specialty polymers, such as (coating) resins for e.g. the automotive sector. These manufacturers face substantially less competition compared to the producers of commodity plastics and have more room to pass through costs. In addition, emission intensities are also likely to be lower for these companies (as discussed in the previous paragraph). It is noted that trade intensities for specialty products are still above the EC criterion used in their carbon leakage assessments. However, these high values are driven by high export values (rather than high export *and* import values). This is explained by the fact that many specialty products are destined for the export market. There is more room for passthrough for products destined for the export market than in markets with little production differentiation with high imports *and* exports, as companies focussing on exports of specialty products have more pricing power.
- **Unilateral non-ETS carbon pricing would increase the risk of production and investment shift to non-ETS EU competitors, mostly for the producers of commodity plastics.** This is explained by the combination of high emissions and trade intensities. Risks are much lower for manufactures of specialty products, as they have both lower emissions and trade intensities.
- **As Dutch non-ETS polymer producers already face a higher effective carbon price than their key EU competitors, the risks of production and investments shift would translate in intra-EU carbon leakage risks**. The effective carbon price is currently higher in the Netherlands than in competing countries for manufacturers of polymers that do not use CHPs. For that reason, the above-described risk of production and investment shifts to non-ETS competitors in the EU is considered to increase the risk of carbon leakage. Meanwhile, German pricing policies will be strengthened in the coming years, after which the effective carbon rate would be higher than the *current* rate in the Netherlands. This lowers the risk of carbon leakage to German non-ETS competitors. There is no indication of higher effective carbon rates in the UK. For those manufacturers that use CHPs, risks for production and investment shifts are not related to carbon leakage, as the effective carbon rates for CHPs are lower in the Netherlands than in the competing countries. The planned abolishment of the Dutch CHP exemption by 2025 would change this picture.

Non-ETS unilateral carbon pricing may lead to production and/or investment shifts to non-ETS competitors but would not necessarily increase the risk of *carbon leakage to ETS-competitors*. The introduction of non-ETS carbon pricing would lead to competitiveness loss and may also lead to production or investment shifts to ETS companies because in the status quo, non-ETS sectors do not face an explicit carbon price. However, the effective carbon rates for ETS manufacturers of polymers are at the moment higher than those of their non-ETS competitors. The effective carbon price for ETS manufacturers consists of the EB and ODE taxation. As ETS manufacturers consume larger volumes of fuel, their average tax rate is lower (lower boundary: €21/tCO_2e) than the average tax rate for non-ETS producers (€45/tCO_2e). However, ETS manufacturers also face ETS costs. For Dutch ETS-producers of polymers, the estimated share of emissions covered by free allowances over 2021–2025 is around 54%. Figure 5-2 shows the comparison of the effective carbon rates of non-ETS and ETS plastics manufacturers in the Netherlands. Even under very conservative estimates of carbon prices for ETS companies–the lowest possible EB and the ODE (€21/tCO_2e), a conservative ETS price (€54/tCO_2e) and full correction of the effective carbon price for free allocation (54%)–the effective carbon rate for ETS producers exceeds the average effective carbon rate for non-ETS producers. It is also noted that, various non-ETS companies may not be competing with ETS companies, as they produce specialty products rather than commodity plastics.

Figure 5-2 Comparison of the effective carbon price for Dutch ETS and plastics manufacturers in 2022



Source: Trinomics (2022). Based on literature review of country energy taxes, average emissions of Dutch ETS plastics manufacturer covered by free allowances using public data from the NEa. The estimate for the ETS price is a lower boundary estimate.

***Extra EU carbon leakage risks* are similar to intra EU leakage risks, with the main difference being slightly lower trade intensities, still exceeding the 30% threshold in most cases.** For all relevant products, the Netherlands trades more with EU countries compared to trade with countries outside the EU. However, trade intensities with countries outside the EU are not much lower and still exceed the 30% threshold in most cases, as shown in Table 5-1. This indicates that there is less slightly less competition from outside the EU than from within, but leakage risks and patterns are similar to those described for intra EU leakage.

There are no indications that increased carbon leakage risks under a unilateral Dutch approach would lead to substantial changes in *net global GHG emissions* due to production shifts to EU competitors. Carbon leakage to key EU competitors is not expected to have a meaningful impact on global GHG emissions, as there is no indication of major production differences (and resulting emissions per unit of product) between Dutch and EU producers. On the long run, investments in abatement options and lower production levels may contribute to decrease global GHG emissions.

Carbon leakage risks under an EU approach

An EU wide carbon pricing policy for non-ETS manufacturers would mitigate the most relevant carbon leakage mechanism: intra EU leakage towards non-ETS competitors in EU countries. If ambitious non-ETS climate policies would be implemented at an EU level, there would be, by definition, much less risk for carbon leakage from Dutch plastics manufactures to their EU competitors compared to a unilateral Dutch approach. All EU non-ETS polymer manufacturer would face the same increase in climate policy stringency, so there would not be an increase in intra-EU carbon leakage risk from Dutch non-ETS polymer manufacturers to their non-ETS EU competitors. Based on trade statistics, most of the competition for Dutch manufacturers of polymers comes from EU competitors, mostly Germany and Belgium. An EU wide approach would therefore safeguard a level playing field and prevent increased risks for carbon leakage to these countries. Yet, under the EU approach, extra EU leakage risks remain present. Moreover, leakage risks to ETS-producers also remains relevant, although the non-ETS policy should be rather stringent in order to outweigh the effective carbon price for ETS producers. This implies that carbon leakage risks remain present for Dutch non-ETS manufacturers of polymers, in particular those active in commodity plastics.

5.2 Manufacturing of dairy products

This sector analysis focuses on the operations of dairies and cheese making[49] as well as the manufacturing of infant formula[50], which cover the industrial processes of the dairy value chain. Emissions from the dairy sector[51] mainly come from the heating processes, i.e. natural gas consumption. About 29% of the dairy sector's GHG emissions come from non-ETS factories (62% for the homogenised foods sector). Among the non-ETS dairy manufacturers, some producers, particularly those with relative high emissions—but not high enough to fall under the EU ETS, compete with ETS companies, which produce similar products, such as (baby) milk powder, whey and cheese. Other non-ETS producers manufacture cheese, milk, butter and yogurt.[52] The Dutch dairy industry has a strong international competitive position, and within the EU market, its largest competitors are German and French dairy manufacturers. More information on the Dutch dairy sector can be found in Annex III.2.

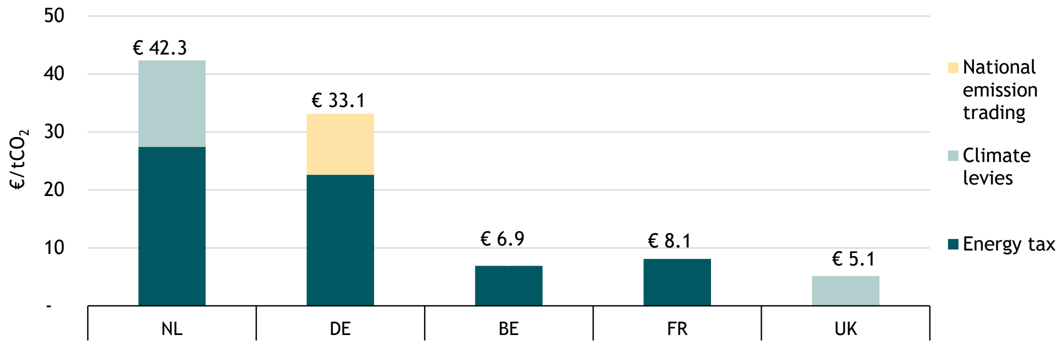
Effective carbon price and relevant climate policies for Dutch non-ETS dairy manufacturers

The effective carbon price that non-ETS dairy manufacturers face in the Netherlands is estimated to be higher than in Germany, France, Belgium and the UK. This is shown in Figure 5-3. Based on the direct emissions from Dutch non-ETS dairy manufacturers, it is estimated that, in 2022, Dutch manufacturers face an effective carbon price of €42/tCO_2 on average, which is based on the energy and ODE tax for natural gas use.[53] Key competitors are manufacturers in Germany and France but also in Belgium and the UK.[54] The effective carbon prices for manufacturers in Germany, France, Belgium and the UK are currently estimated to be significantly lower (between €5-26/tCO_2). These estimates are made assuming that all countries use similar production methods and fuels (natural gas). Notably, French manufacturers of infant formula, milk powder, casein, lactose & lactose syrup and whey have a partial exemption for the natural gas tax, as the sector is considered energy-intensive and therefore at risk of carbon leakage. This means non-ETS manufacturers are also exempted. Although the German effective carbon price is expected to rise in the coming years to a level higher than the current Dutch effective carbon price, 65% of the national ETS costs for German dairy producers are compensated due to carbon leakage risks.

The exception of Dutch effective carbon prices being higher than in European trading partners is when CHPs are used. Natural gas used in CHP is (partially) exempted from the pricing instruments in the Netherlands, Germany, Belgium and the UK (see Annex II.7 for more information about CHP exemptions). In the Netherlands, CHPs are used by some dairy manufacturers. The Dutch manufacturers, which use CHPs, face a €0/tCO_2 effective carbon price for their fossil fuel consumption.

[49] NACE 10.51, i.e. dairy products excluding ice cream
[50] NACE 10.86. For this report, the scope of the homogenized foods sector is limited to infant formula (or baby milk powder), as the other products in this sector have low emissions based on the analysis of products and confirmed through an interview with a manufacturer in the homogenized foods sector.
[51] For this report, the dairy sector constitutes the production of dairy products, including infant formula
[52] Some ETS producers also produce cheese and butter, but this is in addition to producing whey and/or milk powder.
[53] Estimate is based on the average direct emissions from *Emissieregistratie* in 2019 for non-ETS dairy and infant formula manufacturing installations, transposed to the corresponding natural gas use (3.7 million m^3). As such, it is assumed that all direct emissions are resulting from natural gas. As Dutch energy taxation contains different tax brackets, the effective carbon price depends on the volume of gas use, ranging from €32-252/tCO_2.
[54] Spain is less relevant for these sectors.

Figure 5-3 Effective carbon price of pricing instruments for the non-ETS dairy production sector (non-CHP), 2022



Source: Trinomics (2022). Based on literature review of country energy taxes and emissions data from the Emissiesregistratie. Prices based on natural gas use.

All studied countries have supporting measures in place that the non-ETS dairy sector can make use of to decarbonise their production. Dutch non-ETS dairy manufacturers can apply for support schemes such as SDE++, which covers various technologies that can be relevant for dairy processing, such as e-boilers, industrial heat pumps, residual heat and geothermal.[55] In competing countries, such as Germany, France, Belgium and the UK, support schemes are in place to decarbonise the dairy industry (see Section 4.2 for a more information support programmes for decarbonising industrial processes).

Relevance of carbon pricing costs: emission intensity and abatement options

The high emission intensity of certain dairy products (i.e. whey, milk powder and lactose), suggests that an additional carbon pricing could lead to greater costs increases, related to either the carbon pricing directly or cost-minimising investments. While data from public statistics are insufficient to determine the emission intensity of the dairy product sectors (see Section 3.2), using sector-specific studies the emission intensity of the sector as a whole is estimated to be about 0.44 kg CO_2 per euro value added.[56] However, emission intensities vary across the different dairy products. The most emissions intensive dairy products are whey (protein) powder, (baby) milk powder and lactose, which have significant higher emission intensities than other dairy products and are therefore potentially at risk of carbon leakage.[57] Whereas, condensed milk, butter and cheese have relatively lower emission intensity. While several ETS businesses produce the most emissions intensive products, so do non-ETS dairy companies. For the non-ETS businesses in the dairy manufacturing sector, a stricter climate policy in the Netherlands could trigger additional cost increases either by direct costs related to the policy or investments made to avoid these direct costs.

A stricter climate policy could nudge the non-ETS dairy manufacturing sector to decarbonise, however these manufacturers may need more targeted aid from Dutch support schemes to mitigate the high costs of the required investments. Several abatement options for the dairy manufacturing sector require substantial investment, particularly due to the required changes to the current energy distribution network, particularly the electricity network. Since Dutch dairy processing facilities are

[55] PBL, TNO (2020). Decarbonisation options for the Dutch dairy processing industry.
[56] According to a study by the Wageningen University, the emissions from dairy processing was 1 million tCO_2 in 2019 and according to the Agrimatie database, the gross value added for dairy processing was €2.25 billion in the same year. This would mean that the emission intensity is at least 0.44 kg/EUR.
Doornewaard et al. (2020). Sectorrapportage Duurzame Zuivelketen prestaties 2019 in perspectief; ZuivelNL (2020). Dutch dairy in figures 2020; Wageningen University & Research (2021). Relatief lage toegevoegde waarde per arbeidskracht op de primaire bedrijven in grondgebonden veehouderij.
[57] Since gross value added is not publicly available per dairy product, emission intensity is estimated based on emissions per ton of product. Emission intensity estimates are based on heat input estimates form the PBL study and the natural gas emissions factor (56.6 $kgCO_2/GJ$)

generally located close to dairy farms and are not located in dense industrial clusters, abatement options, such as e-boilers, would require significant investment to connect these factories to the energy distribution network.[58] Therefore, at least in the short-term, it seems that dairy manufacturers will not be able to mitigate the abatement costs. However, Dutch funding schemes, such as SDE++, can play a role in reducing the investment costs for these manufacturers. Although, the current schemes are not widely available to small non-ETS diary industry, as larger, more cost-effective projects are prioritised first. In addition to investment in renewables, a stricter climate policy may stimulate investment in more energy efficient processes, which can be less capital intensive.

Exposure to international competition: trade intensity and cost passthrough

The intra-EU trade intensity of the dairy manufacturing sector (particularly for milk, whey, milk powder and fresh cheese) greatly surpasses the ETS Phase 3 carbon leakage criterion. Table 5-2 The overall intra-EU trade intensity for the Dutch dairy processing sector is 80%, exceeding the EC carbon leakage ETS Phase 3 trade intensity threshold of 30%. Whereas the intra-EU trade intensity for the infant formula industry is 15% (although the extra-EU trade intensity is very high: 141%). In Table 5-2, trade intensities are estimated for various dairy products.[59] Trade intensities vary across these products, with milk, whey, milk powder and fresh cheese facing a high trade intensity, whereas the trade intensity for grated, powdered and blue-veined cheese is lower than the EC threshold for carbon leakage. Lower intra-EU trade intensity could indicate that products face less competition within the EU, compared to products with a high intra-EU trade intensity.

Table 5-2 Trade statistics (sold production, imports, exports, trade intensity-TI) of selection of products relevant for the Dutch non-ETS dairy and infant formula sector in € million (2019)

Products	Sold production	Intra-EU			Extra-EU		
		Imports	Exports	TI	Imports	Exports	TI
Dairy processing (10.51)	**7,750***	**3,638**	**5,522**	**80%**	**209**	**2,337**	**32%**
Milk (fat 1-6%)	187	283	240	111%	13	17	15%
Milk powder (fat >1.5%)	485	141	125	42%	40	224	94%
Fresh cheese	622	256	102	41%	43	41	13%
Grated, powdered, blue-veined cheese	2685	164	580	26%	26	152	7%
Whey	186	316	106	84%	60	108	68%
Manufacture of homogenised foods (10.86)	**1,575**	**180**	**150**	**19%**	**10**	**2,121**	**134%**
Infant formula	1,501	138	110	15%	8	2,114	141%

Source: Trinomics (2022). Sold production based on: CBS (2021). Verkopen; industriële producten naar productgroep (ProdCom). NACE-4 trade statistics based on: Eurostat (n.d.). EU trade since 2002 by CPA 2.1 and product level trade statistics based on Eurostat (n.d.). EU trade since 1988 by SITC
**This value is production value of the sector in 2019 based on: ZuivelNL (2020). Dutch dairy in figures 2020.*

Due to product specialisation in the Dutch dairy sector, dairy products such as Gouda cheese and infant formula face less competition and may have greater ability to pass costs on down to end consumers. More than 60% of Dutch cheese produced is Gouda cheese,[60] a specialised Dutch cheese.[61] Specialty products, like Gouda cheese, allow for more room for cost-pass through, as its differentiation allows for less price competition. Further, the Dutch dairy sector is considered in the global market to be knowledge-intensive and produce high quality products,[62] particularly infant formula. This reputation for high quality also allows for cost-pass through.

[58] PBL, TNO (2020). Decarbonisation options for the dutch dairy processing industry.
[59] For some dairy products, which may be at risk of carbon leakage, such as casein, lactose/lactose syrup, skimmed milk powder, it is not possible to estimate trade intensity due to missing data.
[60] ZuivelNL (2020). Dutch dairy in figures 2020.
[61] Although Gouda is a specialty cheese, Gouda does not necessarily have to be produce in the Netherlands. Though, in 2010, the European Union made "Gouda Holland" a protected geographical indication. NZO (n.d.). Gouda Holland.
[62] Rabobank (2021). Export zuivelproducten: meer kansen dichtbij huis?.

However, dairy products such as milk, milk powder and whey potentially face stronger competition due to less product differentiation. Other dairy products, such as milk, milk powder and whey, are less specialised, which might lead to greater competition in the EU market and thus reduce manufacturers' ability to pass costs down to end consumers. However, Dutch dairy manufacturers may have a home market advantage, which would allow for cost-pass through to Dutch consumers.

Carbon leakage risks under a unilateral Dutch approach

Under a unilateral Dutch approach, Dutch non-ETS dairy manufacturers would face a competitiveness loss compared to EU and global competitors. Additional non-ETS carbon pricing in the Netherlands would lead to a loss in competitive advantage for non-ETS dairy producers, which could lead to a shift in investment and production from the Netherlands to competing countries, such as Germany and France. Some dairy products, such as milk powder and whey, are much more emissions intensive. These products could face a higher competitiveness loss compared to other dairy products, as they receive a higher cost from carbon pricing. However, because these dairy product productions are integrated with the production of other products, the actual impact of higher carbon cost is more ambiguous (See Box 5-1). Specialty dairy products, such as Gouda cheese and baby milk powder, would be less affected by higher carbon cost under a unilateral Dutch approach due to strong product differentiation and therefore less risk of carbon leakage.

Box 5-1 Production integration in the dairy manufacturing sector and implications on carbon leakage

The dairy manufacturing value chain is highly integrated. Many dairy factories produce multiple dairy products because one dairy product is a by-product of another. For instance, whey is the by-product of cheese production and milk powder is the by-product of butter. While cheese and butter have a relatively low emission intensity, whey and milk powder have a high emission intensity as well as a high trade intensity. Therefore, the production of whey and milk powder are in itself at risk of carbon leakage to other competitors in the case of higher carbon pricing. However, because these products are intertwined with products which are relatively at low risk of carbon leakage (i.e. butter and cheese), the actual risk of carbon leakage is more ambiguous. Because the primary product are low risk products, the production integration may lead to a lower risk of production shift for whey and milk powder. On the other hand, if an additional carbon pricing increases the effective carbon price too much, it may also increase the risk of production of cheese and butter to shift to competitors. Therefore, although whey and milk powder remain the most at-risk dairy product for carbon leakage, this risk may be smaller due to the integral nature of the dairy manufacturing sector. Concurrently, production integration amplifies the risk of carbon leakage for cheese and butter if the carbon price is too high.

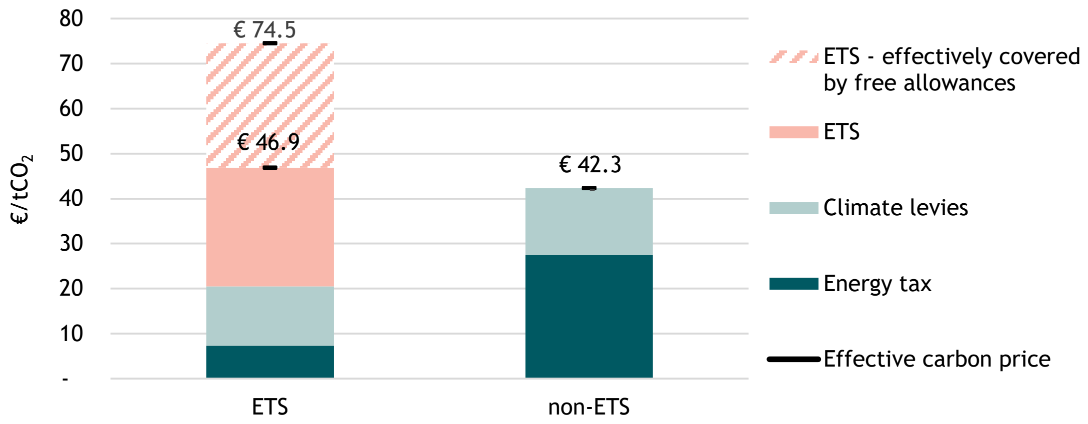
Because whey and milk powder producers face strong intra-EU competition and have little product differentiation, these dairy products have the most risk of carbon leakage to non-ETS EU competitors if there were to be an additional unilateral Dutch carbon pricing. Dairy manufacturers that produce whey, milk powder and fresh cheese have high intra-EU trade intensities (Table 5-2), which indicate that they face strong international competition.[63] Fierce competition leaves manufacturers little room to increase prices and therefore they cannot easily pass on the cost of an additional carbon price to end users, which increases the risk of carbon leakage. Dairy manufacturers that produce specialty products face less competition compared to other dairy products and thus can

[63] Milk and cheese also have a high trade intensity, but they are relatively low emissions intensive products.

more easily pass on costs to the end user. The ability for these manufacturers to differentiate their products from international competitors reduces the risk of carbon leakage.

It is not expected that a unilateral Dutch approach would lead to significant *carbon leakage from non-ETS dairy manufacturers to ETS-competitors*. While the unilateral Dutch approach causes competitiveness loss of non-ETS dairy manufacturers on similar products that are also produced by their ETS competitors, the effective carbon prices are currently higher for Dutch ETS dairy companies than for Dutch non-ETS dairy producers. ETS dairy manufacturers in the Netherlands face a lower average energy tax rate due to their large consumption of fuel (lower boundary: €21/tCO_2e) than the average non-ETS manufacturer (€42/tCO_2e). However, ETS producers also incur ETS costs[64]. After taking free allowances into account,[65] the estimated effective carbon price for ETS producers in the dairy manufacturing sector is €47/tCO_2e, higher than the non-ETS effective carbon rate. Given that the ETS price continues to increase and the share of free allowances is expected to decrease in the coming years, this is a conservative estimate of the ETS effective carbon price. Therefore, as long as an additional non-ETS carbon price in the Netherlands does not push the non-ETS effective carbon price beyond the ETS effective carbon price, a unilateral Dutch approach would not cause carbon leakage to ETS-competitors.

Figure 5-4 Comparison of the effective carbon price for Dutch ETS and non-ETS dairy manufacturers in 2019



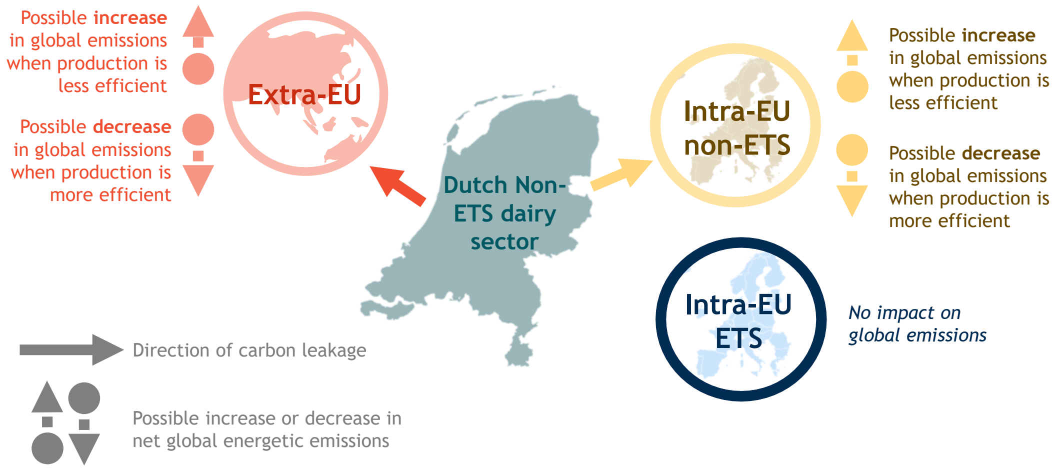
Source: Trinomics (2022). Based on literature review of country energy taxes, average emissions of Dutch ETS plastics manufacturer covered by free allowances using public data from the NEa. The estimate for the ETS price is a lower boundary estimate.

***Carbon leakage outside of the EU* depends on the extra-EU trade intensity and product differentiation, where milk powder and whey seem to be at the greatest risk.** Milk powder and whey both face a very high extra-EU trade intensity (Table 5-2), which indicates that they face strong international competition. In combination with being high emissions intensive products, these products can be considered as having greater risk of carbon leakage. Compared to intra-EU trade intensities, it seems that these products face more extra-EU competition, rather than within EU. Therefore, carbon leakage to extra-EU competitors may be higher than to intra-EU competitors. Although infant formula faces an extremely high trade intensity in the extra-EU market, this is driven by a very high export value (extra-EU import value is very small). Further, infant formula is a specialty product (i.e. able to pass costs on to end consumers), and therefore, carbon leakage risk is already considered quite low for this product.

[64] The average ETC price in 2021 was €54/tCO_2e.
[65] The estimated share of emissions of Dutch dairy ETS-installations covered by free allowances is estimated to be 51% for 2021-2025.

The impact of a unilateral carbon pricing on global GHG emissions in the short term is ambiguous. As illustrated in Figure 5-5, if the additional carbon pricing is high enough to shift production and investments to international competitors, which can offer the same dairy products at a lower price *and* are more emissions intensive, then this would have a negative impact on global GHG emissions. However, if international competitors can offer the same dairy products which are the same or less emissions intensive[66], then an additional carbon price could have a marginal or positive impact on global GHG emissions. As the effective carbon price for the ETS dairy sector is higher than the effective carbon price for the non-ETS sector, no carbon leakage to ETS competitors is expected, therefore no impact on global GHG emissions.

Figure 5-5 Impact of unilateral carbon pricing on global GHG emissions



Source: Trinomics (2022).

Carbon leakage risks under an EU approach

An EU-wide approach to carbon pricing would mitigate the intra-EU carbon leakage for non-ETS dairy manufacturers under a unilateral Dutch approach, however, Dutch manufacturers would still be at risk of extra-EU carbon leakage. If the same additional carbon price is imposed on all EU non-ETS dairy manufacturers would increase the effective carbon price for all EU manufacturers equally. Therefore, the competitiveness of Dutch non-ETS dairy manufacturers on the European market is minimally impacted and thus the risk of carbon leakage within the EU is minimised. For dairy production which is exported outside of the EU, the carbon leakage risk still remains for non-ETS Dutch manufacturers, especially for dairy products which are emissions intensive (i.e. higher costs) and not specialised (i.e. little cost pass-through). Additionally, risk for carbon leakage to ETS producers remains unchanged if the non-ETS EU carbon pricing pushes the effective carbon price for non-ETS producers above the ETS producers' effective carbon price.

5.3 (Greenhouse) horticulture

About a fifth of the Dutch agricultural production value was produced in greenhouses, while 83% of Dutch agricultural energetic emissions were emitted by the sector. [67] This is equal to about 5.8 $MtCO_2$,[68] of which about 5.4 $MtCO_2$ are non-ETS. A wide variety of vegetables (tomato, bell peppers,

[66] The same dairy products could be less emissions intensive if international competitors have already decarbonised the production processes.
[67] CBS (2021). *Landbouw; financiele gegevens landbouwbedrijven*; agricultural sector refers to agricultural production sector. Thus, the production of e.g. agricultural machinery production is not included.
[68] Average over 2016-2018. See Trinomics (2021). *Beknopte vergelijkende analyse van het energiegebruik en de CO2-uitstoot van de Nederlandse en Vlaamse land- en tuinbouwsector.*

etc.) and ornamentals (flowers, potted plants) are produced in Dutch greenhouses. The energetic emissions are mostly resulting from heating greenhouses with natural gas (95% of energy inputs) via gas boilers or CHPs, which heat about two-thirds of the total Dutch greenhouse area.[69] While a part of the electricity produced by CHPs is used locally in greenhouses (for e.g. lighting), the majority is delivered to the grid. CO_2 produced by CHPs is used in greenhouses to further stimulate crop growth. Greenhouse production in both the Netherlands and other EU countries is overwhelmingly (>90% of emissions) non-ETS. Natural gas is also the major fuel in all analysed northern countries–and in particular Belgium and the UK, while fuel oil is also still used in Germany and France and butane/propane to some extent in France (see Table 5-3).

Dutch companies with heated greenhouses compete with both heated and unheated production systems. While northern European competitors (e.g. Germany, Belgium, parts of France and the UK) also primarily produce in heated greenhouses, competitors in warmer climates (e.g. Spain and competitors in Africa or the Middle East) can produce the same crops–such as tomatoes–in unheated greenhouses or in open field. As such, the energy use per unit of product is significantly lower in these southern countries. A literature review of tomato production—the most common crop in EU greenhouses—shows that total global warming potential of heated production is between 1 to 4 kg CO_2 eq/ per kg tomato compared to 0.05 to 0.5 kg CO_2 eq/kg for unheated production (see Annex III.4).[70] Differences between production systems are not limited to energy use. For example, water and pesticide use are generally lower in greenhouses. Abatement options in greenhouse production include switching to renewable energy, such as geothermal and biogas, as well as energy efficiency improvements and the use of residual heat. Dutch greenhouse production is predominantly destined for the export market. Germany, the UK and Belgium are the largest European trade partners. A significant share is exported to non-EU-countries (~30%). More information on the (greenhouse) horticulture sector can be found in Annex III.3.

Table 5-3 Overview of energy use characteristics in greenhouses in the analysed countries.

Component	NL	DE	BE	UK	FR	ES
Primary production method	Heated				West: heated, South: (un)heated	Unheated
Greenhouse area in 2013 (ha) [71]	9,500	3,710	1,250	1,900	9,400	>30,000 (unheated)[72]
Main energy source for heating	Natural gas	Natural gas, fuel oil[71]	Natural gas[73]	Natural gas[71]	Natural gas (45%), Butane/propane (15%), fuel oil (32%) in 2013 [74]	Not relevant
CHP use	85% of total gas use (2020)[85]	Common	>70%	Common	20% of heated area CHP, 70% gas boilers (2011) [75]	Not common

Source: see footnote 71until 76 below.
Note: Share of natural gas use likely higher in 2021 than in 2013

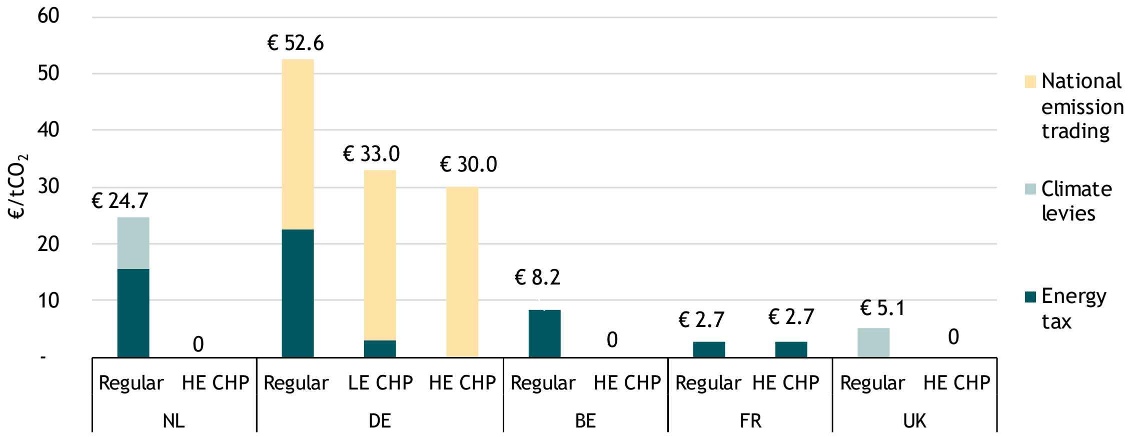
Effective carbon price and relevant climate policies for Dutch greenhouse horticulture producers

All analysed countries with heated greenhouse production have favourable tax regimes for natural gas when taking into account use of and exemptions for CHPs, leading to low effective carbon

[69] According to data from sector association *Glastuinbouw Nederland*.
[70] Pineda et al (2021). Review of inventory data in life cycle assessment applied in production of fresh tomato in greenhouse ;Note that this estimation of GWP takes into account all GHGs and the whole production supply chain. However, for heated production heating is responsible for more than 80% of total GWP.
[71] WUR (2016). Energiebelasting in de glastuinbouw in Noordwest-Europa. Reference refers to old sources for area (~2013), but this still gives a good rough indication of the current greenhouse area.
[72] Capparos-Martinez (2020). Public policies for sustainability and water security: The case of Almeria (Spain)
[73] Energiesparen (2021). Energiebalans.
[74] RVO (2021). Sector study on covered horticulture in France.
[75] Boulard et al (2011). Environmental impact of greenhouse tomato production in France.

prices. Only Germany's effective carbon price is relatively high because of its national ETS.[76] Natural gas is the most used fuel in all countries for heated greenhouses, though other fuels are used to some extent (as discussed in Annex III.3). The analysis is therefore focussed on the most relevant fuel: natural gas. The effective carbon price for natural gas use in Belgium, the UK and France are comparably low (below €5/tCO_2), among others because of reduced tax rates and/or exemptions for the agricultural sector. The effective carbon price in the Netherlands (€25-40/tCO_2) and Germany (€53/tCO_2) are higher. However, the estimated effective carbon prices do not provide the full picture with regards to stringency of climate policies. In all countries except France, there are significant tax exemptions and subsidies for the use of CHPs. The effective carbon rates for businesses using CHPs, as a result, is significantly lower in all countries (except France). Annex II.7 provides a complete overview of gas and CHP energy taxes. For natural gas used in CHPs, carbon prices are below €2.7/tCO_2 in all countries except Germany. In Germany, tax reductions for CHPs also result in a lower financial burden. However, the effective carbon price is relatively high because of the German national ETS, with a rate of €30/tCO_2 in 2022, since the greenhouse horticulture sector does not receive compensation (yet)[77] unlike the polymers and dairy sectors. It is noted that CHPs are also stimulated in Germany via the KWK Gesetz, a subsidy for CHPs which is not incorporated in the effective carbon price.[78] Thus, in terms of climate and energy taxes this leads to a relatively level playing field for production in greenhouses in the EU in which effective carbon prices are low, with only Germany as an exception because of its national ETS. Climate and energy taxes are much less relevant for competitors using unheated production systems in the south as their fuel use is negligible (as discussed in Annex III.4).

Figure 5-6 Effective carbon price of gas use for the (greenhouse) horticulture sector in 2022.



Sources: See Annex II.7. HE = high efficiency. LE = low efficiency.

Relevance of carbon pricing costs: emission intensity and abatement options

Emission intensities are high in heated greenhouses and the resulting energy costs account for a large share of total production costs, with some variations between crops. Emission intensities are much lower for unheated production. Based on an analysis of the Netherlands and Flanders, emission intensities vary between 1.0 and 1.7 kg CO_2/€ production value (see Annex III.4). Emission intensity per € GVA–which is used for calculating carbon leakage risk in the EU ETS–is higher.[79] In general, vegetables have higher emission intensities than flowers and plants. There are also differences among

[76] Blueterra (2022). *Notitie energiebelastingen, heffingen en netkosten voor tuinders in binnen en buitenland; still to be published*
[77] Horticulture is currently not on the list of sectors that can receive a partial reimbursement for their carbon costs. However, if the sector would be able to demonstrate that they meet the carbon leakage criteria in the future, this would lower their effective carbon price as noted in Section 4.2.
[78] The report of Blueterra shows that the subsidy for CHPs in Germany 'offsets' a large part of the ETS rate.
[79] As GVA is a part of the production value the emission intensity per GVA is always has a higher value than per production value.

vegetables: energy use per m^2 for crops like tomatoes, bell pepper, cucumber is higher than for crops such as lettuce, radish and strawberries.[80] Emission intensities also vary with location and fuel use. On average, energy demand is lower in warmer climates. The use of fuels with higher CO_2 footprints such as fuel oil, which is still used to some extent in Germany and France, results in a higher overall emission intensity.

Energy costs cover a significant share of total production costs in heated greenhouses. In recent years (2016-2021), energy costs constituted 20% to 30% of total production costs in regular Dutch greenhouse businesses producing vegetables.[81] A similar share of energy costs is expected in other countries with heated greenhouses. In 2021, average energy costs for vegetable production in greenhouses were €14.10/m^2 in the Netherlands and total production costs €55.40.[81] It is estimated that the introduction of a carbon tax of €30/t CO_2 would result in an additional cost of €2/m^2.[82] Thus, carbon pricing could lead to substantial cost increases for heated greenhouse production, in contrast to unheated production.

As abatement options require substantial investments and have long implementation periods, carbon pricing is expected to increase costs in the short run. Decarbonisation options for heated greenhouses include geothermal, energy efficiency measures, renewable electricity and the use of heat pumps. Various support programmes are present, such as the Dutch SDE++ or innovation programs (such as the Dutch-Flemish GLITCH).

Exposure to international competition: trade intensity and cost passthrough

Room for cost pass-through is generally limited, but somewhat higher for certain flowers and plants. All three subsectors are characterised by high trade intensities, which are driven by high imports and exports (as shown in Table 5-4). Within the EU, trade intensities vary between 86% and 115%, which is far beyond the EC's 30% criteria. This suggest that that there is little product differentiation within the sector and little room to passthrough costs. Qualitative research confirms this overall picture. It is noted that there is more room to pass-through costs for specialty products, such as certain flowers and plants. As the market for specialty products is relatively small, average pass-through options are very limited. In early 2022, several heated greenhouses in the Netherlands have temporarily halted or adjusted production due to current high energy prices, which is another indication of the limited room to passthrough costs.[83] More information is provided in Annex III.3. The combination of high emission intensities and limited room for cost passthrough translates in a high risk for competitiveness loss for the (greenhouse) horticulture sector.

Table 5-4 Trade statistics (sold production, imports, exports, trade intensity) of the three main NACE codes reflecting the horticulture sector in million € (2019).

Product	Sold production	Intra EU			Extra EU		
		Imports	Exports	T.I.	Imports	Exports	T.I.
0113 Growing of vegetables and melons, roots and tubers	4839	1,829	5,867	115%	1,128	2,783	66%
0119 Growing of other non-perennial crops	3087	356	3,080	100%	906	1,249	54%
0130 Plant propagation	4500	721	3,758	86%	282	1,467	37%

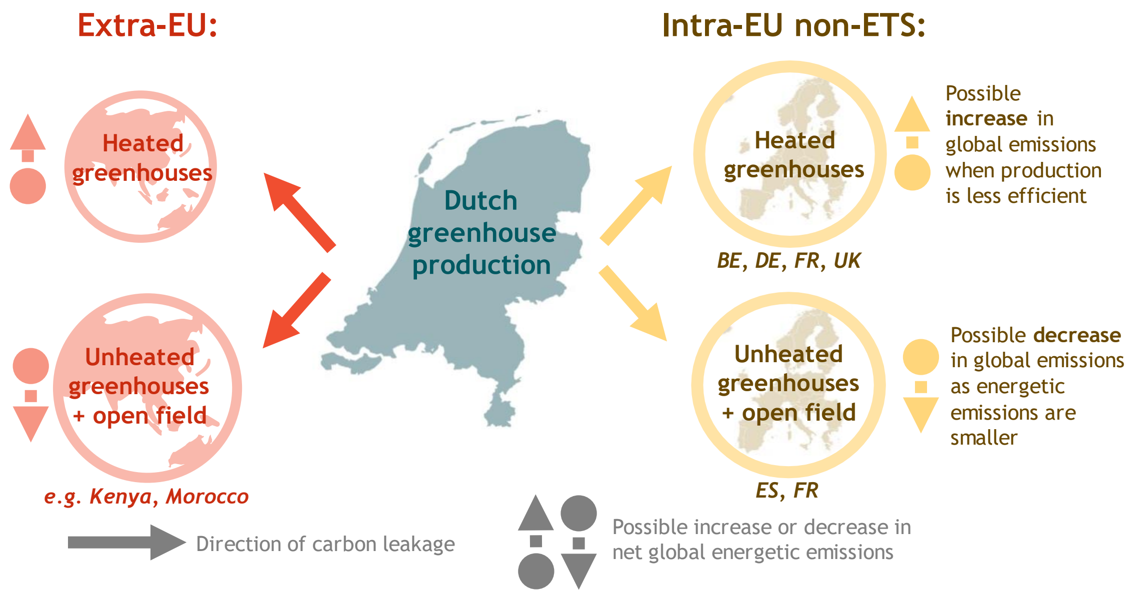
Source: Trinomics (2022). Production based on: Eurostat (2022). Economic accounts for agriculture - values at current prices. NACE-4 trade statistics based on: Eurostat (n.d.). EU trade since 2002 by CPA 2.1
Note: these NACE codes categories are broader than solely greenhouse production.

[80] Stanghellini et al (2016). Sensible use of primary energy in Organic Greenhouse Production.
[81] Agrimatie (2022). Kosten glasgroenteelt 2021. This estimate is not corrected for CHP electricity sold to the grid
[82] Estimate is based on natural gas use and an average heat demand of 332 kWh/m^2 for gas.
[83] Financieel dagblad (2022). Hoge gasprijzen dwingen vier van de tien glastuinders definitief of tijdelijk te stoppen

Carbon leakage risks under a unilateral Dutch approach

Unilateral Dutch carbon pricing will likely increase the risk of carbon leakage to both heated greenhouse producers as well as unheated production. The difference between heated and unheated production systems adds an additional component to the carbon leakage assessments, as shown in Figure 5-7.

Figure 5-7 Overview of possible directions of carbon leakage for the Dutch greenhouse horticulture sector.



The figure indicates both the direction of carbon leakage and if carbon leakage would possibly lead to increased or decreased net global energetic emissions. Also, for all categories relevant competitor countries are given.

The following observations are made on carbon leakage risks under unilateral Dutch carbon pricing:

- **Carbon leakage to other intra-EU heated greenhouse producers.** Current effective carbon prices are low in all analysed countries because of the low tax rates on natural gas and exemptions for CHPs, with Germany being a moderate exception. This means the current risk of carbon leakage to competitors in the EU is low. However, unilateral Dutch carbon pricing could increase the risks of carbon leakage for most crops. This is because of the high share of energy related costs in total costs and the limited room for cost pass-through in this competitive sector.
- **Carbon leakage to intra-EU unheated production systems.** The higher emission intensity of heated production implies that carbon pricing will widen the gap in energy related production costs between unheated producers and heated producers. Unilateral Dutch carbon pricing would thus harm the competitiveness relative to competitors using unheated production systems and increase carbon leakage risk. In contrast to other carbon leakage risks, competitiveness loss or subsequent production shifts to unheated systems could lower net global (energetic) emissions.
- **Carbon leakage to extra-EU heated production**: Competition from heated greenhouses outside the EU seem to be limited. This carbon leakage risk is therefore low, though data is missing to confirm.
- **Carbon leakage to extra-EU unheated production:** Outside the EU, most large competitors are unheated producers south of Europe (such as Kenya for flowers and Morocco for tomatoes). High extra-EU trade intensity (between 37% and 66% for subsectors) show that the carbon leakage risk can be quite high, although leakage to unheated production would in general also lower net global (energetic) emissions.

- **Carbon leakage to ETS companies:** carbon leakage to ETS companies is of limited relevance given that the sector is overwhelmingly non-ETS. Conclusions for the Dutch GHG horticulture sector is therefore similar to the ones for polymers and dairy products, with this carbon leakage risk considered to be low.

Carbon leakage risks under an EU approach

Compared to the unilateral Dutch approach, an EU approach would mitigate competitiveness loss to northern EU countries that produce in heated greenhouses. While an EU approach will mitigate the risk for carbon leakage to countries that primarily produce in heated greenhouses, the risk for competitiveness loss to unheated (southern) regions will remain unaffected for both a unilateral and an EU approach. After all, energy use and carbon pricing still have a negligible effect on unheated producers. Under an EU approach, carbon pricing could only lead to *production* leakage and not *carbon* leakage to unheated producers, since the climate policy is then the same for all EU countries; but this is mostly a matter of definition, given this negligible impact of carbon pricing on unheated production. Since extra-EU competitors are mostly unheated producers, the difference in impact between a unilateral Dutch and EU approach is also negligible.

Besides any potential carbon pricing, high (fossil) energy prices will also lead to competitiveness loss of heated greenhouses compared with unheated production. The competitive position of heated greenhouse production has partially relied on cheap energy and low energy taxes in order to compete with producers that do not need heating. Since 2021, natural gas and (fossil) energy prices have increased significantly in the EU. This already significantly widens the production cost difference between heated and unheated production. These high energy prices can also add to the incentive to decarbonise heating or reduce the heating demand of greenhouses.

5.4 Summary of sector specific carbon leakage assessments

The sector assessments confirm the carbon leakage risks in sectors selected for in-depth analysis, even when taking the stringency of climate policies in the key trading partners into account. A comparison of the effective carbon prices in each selected sector in the Netherlands against those in competing countries confirm the carbon leakage risks suggested by public statistics. The assessment did reveal nuances with regards to their carbon leakage risks as summarised in Table 5-5.

The Dutch non-ETS manufacturing of polymers sector faces carbon leakage risks primarily from non-ETS competitors in the EU, but extra-EU leakage is also present. In general, products within the sector are relatively trade and emission intensive and Dutch producers face higher the effective carbon prices than their competitors. However, non-ETS producers are more active in specialty products (instead of commodity plastics), which are less emission and trade intensive, which lowers the carbon leakage risks for non-ETS producers compared to the sector’s average.

Dutch non-ETS companies active in the manufacturing of dairy products sector are at risk of carbon leakage from non-ETS competitors within the EU as well as non-EU competitors. Certain commodity products produced by the sector (whey, milk powder and lactose) are particularly trade and emission intensive. As the current effective carbon price for non-ETS companies is higher in the Netherlands than in competing countries, these products are at risk of carbon leakage under unilateral Dutch carbon pricing. Specialty products–such as Gouda cheese and infant formula–face lower carbon leakage risks as they allow for more cost-pass through. Companies in this sector face relatively high competition from outside the EU, which implies that carbon leakage risks are also present under EU-wide non-ETS carbon pricing.

Non-ETS carbon pricing could significantly increase the risk of carbon leakage for Dutch non-ETS greenhouse horticulture companies to non-ETS and non-EU competitors, with in some cases a reduction in global CO_2 emissions. Most crops have a high share of energy related costs in total costs and limited room for cost pass-through, leading to a high risk of competitiveness loss and carbon leakage. However, a distinction is made between carbon leakage towards countries with heated (greenhouse) and unheated production. While carbon leakage from heated Dutch greenhouses to unheated production in warmer climates negatively affects production levels in the Dutch sector, it may lead to lower global CO_2 emissions due to lower carbon footprints per unit of product. This is not the case for leakage in colder climates using heated greenhouses like the Netherlands.

Carbon leakage risks to ETS competitors are very low in all three sectors, as the effective carbon rates for companies under the EU ETS are much higher. The sector analyses show that in the sectors, effective carbon prices are substantially higher in ETS sectors compared to non-ETS sectors. Expected ETS revisions are likely to further strengthen ETS policies, thereby contributing to a greater asymmetry between ETS and non-ETS climate policies. Only if the new non-ETS carbon pricing policy would be more stringent than the EU ETS, could it lead to carbon leakage.

Table 5-5 Summary of key indicators in-depth sector specific assessments

Results - *implications for CL risk from stricter climate policies*	Manufacturing of polymers	Manufacturing of dairy products	Greenhouse horticulture
% non-ETS emissions - *Non-ETS carbon pricing relevance*	10%	Dairy: 29% Infant formula: 62%	>90%
Emission intensity (EI) - *Higher EI indication of high costs from carbon pricing*	**Average 1.81 kg CO_2/€ GVA -** *Less for non-ETS (more specialty products)*	**Average: 0.44 kg CO_2/€ GVA -** *Mostly for whey, milk powder and lactose*	**Average: 1.0-1.7 kg CO_2/production value,** *vegetables slightly higher than flowers and plants*
Trade intensity (TI) - *High TI (>0.3) indication of low ability to passthrough costs*	**High -** *More for commodity plastics than for specialty products*	**High -** *Mostly for milk powder, whey and milk (intra-EU only).*	**High - Comparably** *high for both vegetables, flowers and plants*
CL indicator (TI x EI) - *High CL risk if CL $\geq$ 0.2*	**High -** *Lower for non-ETS due to lower EI and TI*	**High -** *Mostly for whey and milk powder*	**High**
Effective carbon price (ECP) - *ECP indication of stringency of policies*	**€44.8/tCO_2 -** *higher than competing EU countries*	**€42.3/tCO_2 -** *higher than competing EU countries*	**~€7/tCO_2 [84]- Comparable with competing EU countries. (excl. DE).**
CHP use - ECP in NL CHPs is **€0/tCO_2**	**Yes, common**	**Yes, but not common**	**Yes, 85% of gas used in CHPs[85]**
Differences between Dutch ETS and non-ETS companies	**Different -** *ETS more commodity plastics, non-ETS more specialty products*	**Comparable -** *ETS: milk powder, whey, infant formula, cheese and butter. Non-ETS also produce other dairy products*	Not relevant sector in the EU: >95% non-ETS.
Product differentiation in Dutch non-ETS sectors *-more room to passthrough costs*	Specialty polymers, incl. special (coating) resins	Gouda cheese and infant formula. Several products integrated in the value chain	Limited. Slightly more room for cost pass-through for specialty flowers and plants

[84] Average ECP, taking into account the high share of CHP use, which has an ECP of €0/tCO_2
[85] WUR (2021). Energiemonitor glastuinbouw 2020.

6 Conclusions on carbon leakage risks

This chapter combines the insights from the different assessments made to conclude on the carbon leakage risks of Dutch non-ETS sectors. First, the conclusions with respect to carbon leakage risks under unilateral Dutch carbon pricing on fuel consumption in non-ETS sectors are provided. Then, the carbon leakage risks an EU wide approach could potentially mitigate are discussed. Finally, this section ends with some final remarks to put the results into context.

6.1 Carbon leakage risks under unilateral Dutch carbon pricing

An analysis of public statistics finds that up to 208 NACE-4 sectors could potentially be at risk of carbon leakage with the introduction of carbon pricing on fossil fuel consumption in Dutch non-ETS sectors, accounting for about 9% of the Dutch ESR emissions. This also means that 91% of the Dutch ESR emissions—associated with 407 NACE-4 sectors—are considered not to be at risk of carbon leakage. About three-quarters of the emissions potentially at risk are related to non-ETS agriculture and about a quarter to non-ETS manufacturing. For non-ETS agriculture, this comes down to about 6.8 MtCO_2 from fossil fuel consumption potentially at risk of carbon leakage, with non-ETS agricultural emissions concentrated in horticulture sectors. For non-ETS manufacturing, about 2 MtCO_2 could be at risk of carbon leakage, with the emissions spread out over a large variety of sectors. The total of 8.7 MtCO_2 of non-ETS emissions from fuel consumption potentially at risk corresponds to about 9% of Dutch ESR emissions.

About two-thirds of the non-ETS emissions of these 208 sectors are estimated to potentially be at risk of carbon leakage to competitors in the EU and a third to competitors outside of the EU. This assumes that carbon leakage would occur in the same proportion as current intra-EU and extra-EU trade flows, with the entire domestic production at risk of being displaced. Additionally, it assumes that emission intensity of goods traded within and outside of the EU within a sector is the same. In practice, there are many factors that determine where production and emissions may shift to. Nonetheless, this provides an overall indication of the magnitude of non-ETS emissions at risk of intra-EU leakage compared to extra-EU leakage. A further division of carbon leakage risks within the EU between non-ETS and ETS competitors is not possible due to the absence of data to make such a split.

The presence of carbon leakage risks of Dutch non-ETS sectors to non-ETS competitors in Europe are confirmed by the climate policy assessment and by the in-depth sector assessments. Carbon leakage risks do not only depend on the emission intensity and trade intensity reflected by the carbon leakage indicator. They are also affected by, among others, on the stringency of climate policies and the availability of cost-effective abatement options. The analysis on effective carbon prices in the Netherlands and key European trading partners–Belgium, Germany, France, Spain and the UK–reveal that non-ETS climate policies on fossil fuel consumption are in general slightly more stringent in the Netherlands than in most key trading partners. Moreover, the sector specific assessments show that abatement options are unlikely to fully prevent cost increases resulting from these climate policies. This confirms that carbon leakage risks to these countries may already be present and more stringent climate policy on fuel consumption in Dutch non-ETS sectors could increase this risk.

On the other hand, carbon leakage risks of Dutch non-ETS sectors to ETS competitors in the EU are considered low, lowering the non-ETS emissions potentially at risk. In contrast to non-ETS companies, companies under the EU ETS face more stringent climate policies than Dutch non-ETS companies, even when free allowances are considered. In fact, non-ETS climate policies so far are relatively lenient compared to the EU ETS. Expected ETS revisions are likely to further strengthen the EU ETS, thereby contributing to a greater asymmetry between ETS and current non-ETS climate policies. Any new climate policy on Dutch non-ETS sectors would therefore need to go beyond the stringency of the EU ETS to increase the risk of carbon leakage. For that reason, carbon leakage risks towards ETS competitors are very low.

Some important nuances should be placed with these conclusions on non-ETS emissions at risk of carbon leakage. These nuances are relevant for carbon leakage risks to competitors inside and outside of the EU, but focus on the European countries investigated in this study:

- **The 9% of Dutch ESR emissions potentially at risk of carbon leakage should be considered an upper limit and is likely lower.** In this study, the presence of carbon leakage risks under a unilateral Dutch approach for 6 selected NACE-4 sectors was confirmed in an in-depth assessment (see Sections 3.3 and 5.4). These 6 NACE-4 sectors can be grouped into the sectoral categories polymers, dairy products and (greenhouse) horticulture and represent 66% of the non-ETS emissions potentially at risk. This still leaves the risk of about 3% of Dutch ESR emissions related to fossil fuel consumption in non-ETS sectors unconfirmed, spread over 202 NACE-4 sectors. While the majority of sectors have a high trade intensity as presented in Section 3.2, it is uncertain whether their emission intensity will be sufficiently high for the carbon leakage indicator to meet the threshold to be considered at significant risk of carbon leakage.
- **The total non-ETS emissions at potential risk of carbon leakage are likely to be lower even if a sector is considered at significant risk, because certain products within a sector are less affected by carbon leakage risks.** In-depth assessments on the manufacturing of polymers and dairy products sectors show non-ETS companies have higher market shares in specialty products than in commodity products. Specialty products have relatively low emissions and trade intensities, which are indications of a lower carbon costs and more room to passthrough costs. As such, the actual fossil fuel emissions at risk of carbon leakage for non-ETS sectors is likely lower.
- **Companies using CHPs face very low effective carbon rates across the EU, including in the Netherlands, lowering the risk of carbon leakage for these sectors.** The effective carbon rate for CHPs in the Netherlands (€0/tCO_2) is lower than in Germany and France. CHPs are used in many non-ETS sectors, including the chemistry industry and greenhouse horticulture sector. Only if unilateral Dutch carbon pricing would increase the effective carbon rate for CHPs beyond Germany and France, would it increase the risk of carbon leakage to these countries. However, the tax exemption for CHPs is set to be phased out in the Netherlands.
- **Carbon leakage risks are also affected by non-pricing policies, such as subsidies and regulations, which have not been considered in the effective carbon prices in comparing policy stringency.** All countries have subsidy schemes in place to support the decarbonisation of non-ETS sectors. These help lower the cost of companies to reduce emissions, improve their competitiveness and lower the risk of carbon leakage. However, it is complex to compare the influence that subsidies might have on competitiveness and the effective carbon price.
- **All key EU trading partners as well as the UK are expected to strengthen their non-ETS climate policies substantially, which lowers carbon leakage risks.** The analysis on policy stringency based on effective carbon rates is based on what is in place now. Meanwhile, there are still miles between the expected emissions reductions under existing policies and the required emission reductions corresponding with the ESR targets proposed in Fit For 55 and renewed

national climate ambitions. As such, in all key trading partners in Europe, stricter non-ETS climate policies are expected. This implies that competitors of Dutch non-ETS sectors are likely to face more stringent climate policies in the near future, which lowers carbon leakage risks for Dutch sectors under unilateral Dutch carbon pricing.

Carbon leakage from Dutch non-ETS sectors can also lead to lower global CO_2 emissions. A popular argument for the need of measures preventing carbon leakage is that it would otherwise harm local production levels (with corresponding economic damage) without reducing global CO_2 emissions. This is not necessarily the case as shown in the case of greenhouse horticulture, one of the largest Dutch non-ETS sectors where at least 61% of the non-ETS emissions from fossil fuel use potentially at risk is located. The CO_2 emissions associated with products grown in unheated production systems can be much lower than in heated greenhouse production systems. This means that despite the negative economic impacts of carbon leakage from heated Dutch greenhouses towards competitors in warmer climates, it can actually result in a reduction in global CO_2 emissions.

6.2 Mitigation of carbon leakage effects under an EU-wide approach

An EU-wide carbon pricing for non-ETS sectors could reduce the non-ETS emissions from fuel consumption potentially at risk of carbon leakage by up to two-thirds—down to 3% of the Dutch ESR emissions. This is based on the estimated non-ETS emissions at risk of carbon leakage from competitors outside the EU. Some minor gains are from sectors which have a very low extra-EU trade intensity and are therefore not considered at risk of carbon leakage. This would reduce the NACE-4 sectors potentially at risk to no more than 196 sectors. However, the major reduction in emissions at risk comes from the fact that an increase in intra-EU leakage risk would be mitigated. Under an EU approach such as an all-fuels ETS, Dutch non-ETS producers would face the same increase in effective carbon prices as their EU competitors for their fuel consumption. Assuming that the domestic production that could have been displaced by intra-EU production would not be displaced by extra-EU production instead, the non-ETS emissions from fuel consumption at potential risk of carbon leakage would decrease by two-thirds compared to a unilateral approach.

The remaining emissions at increased risk of carbon leakage under an EU-wide approach are related to extra-EU leakage, with the impact varying per sector. An EU-wide approach does not mitigate carbon leakage risks towards non-EU competitors. For some products (e.g. milk powder and whey), extra-EU trade intensity exceeds intra-EU trade intensity. This is an indication that international competition from outside the EU is more relevant than competition from within. Assuming that climate policies are stricter in the Netherlands than in key non-EU trading partners, the risk of production and investment shifts translates more often in carbon leakage risks in the global context than in the European context. However, the stringency of climate policies in trading partners outside Europe have not been assessed in this study.

6.3 Final remarks on the impact of non-ETS carbon pricing on carbon leakage

From an economic and climate perspective, it is more effective to implement stricter non-ETS climate policies across the EU than unilaterality. EU carbon pricing for non-ETS sectors would strengthen climate policies for non-ETS companies across the EU, reinforce the level playing field, and effectively mitigate carbon leakage to non-ETS competitors within the EU. EU climate policies are considered economically more efficient than a unilateral policy as they limit the room and lower the incentive for national governments to reduce carbon prices for national economic reasons. From a climate perspective, it is considered more effective as the impact on CO_2 emissions reductions of EU policies is likely to exceed the accumulated impacts of that of national policies, as not all countries may voluntarily implement climate policies as strict as the EU. This is confirmed by our analysis on the stringency of climate policies, which shows that all analysed countries have various tax exemptions and reductions in place for economic reasons.

There are various ways to achieve stricter climate policies for Dutch non-ETS sectors next to carbon pricing, while mitigating the risk of carbon leakage to EU competitors. At EU level, climate policies can for instance be reinforced by changes in energy taxation. Alignment of climate policies with the main EU trading partners could also make room to increase stringency, while mitigating potential carbon leakage affects. It is noted that all key EU trading partners are expected to implement stricter non-ETS climate policies to meet national climate goals and renewed ESR targets, which lowers carbon leakage risks.

Low carbon leakage risks do not imply that production and investment could not shift; competitiveness depends on many factors, including energy costs. This study is limited to carbon leakage risks: emissions reduction policy inadvertently causing an increase in emissions in other jurisdictions, which do not have equivalent emissions reduction policies, due to mainly shifts of production and investments to those jurisdictions. In practice however, other factors play a much stronger role. Particularly, the sharp increase in energy costs over the past months may affect competitiveness much more than climate policy. The conclusions from this study should therefore be considered as only one component, if used in the context of the overall competitiveness of non-ETS sectors.

Annex I Methodology

I.1 Data sources

The table below provides an overview of the data sources used for the analysis of carbon leakage risk at NACE-4 sector level.

Table I-1 Overview of data sources

Indicator	Dataset	Source	Years	NACE level	NACE code	Region/ Country	Hierarchy
Trade	DS-059268- EU trade since 2002 by CPA 2.1	Comext, Eurostat	2016-2018	2-4	A-U	NL, EU27	N/a
	DS-043227 - EFTA trade since 1995 by SITC	Comext, Eurostat	2016-2018	2-4	A-U	IS, NO, LI	N/a
Production	Verkopen van industriële producten, waarde en hoeveelheid	CBS	2016-2018	2-4	B-E	NL	3
	Annual detailed enterprise business statistics	SBS, Eurostat	2016-2018	1-4	B-N	NL, EU27, IS, NO, LI	1
	Economic aggregates of forestry	Eurostat	2016-2018	2	A02	NL, EU27, NO	2
	Aquaculture production in tonnes and value	Eurostat	2016-2018	3	A032	NL, EU27, IS, NO	2
	Economic accounts for agriculture	EU, Eurostat	2016-2018	3-4	A01	NL, EU27, IS, NO	2
Gross value added	Annual detailed enterprise business statistics	Eurostat	2016-2018	1-4	B-N	NL, EU27, IS, NO, LI	1
	Gross value added of the agricultural industry	Eurostat	2016-2018	2	A01	NL, EU27, IS, NO	2
	Gross value added of the forestry industry	Eurostat	2016-2018	2	A02	NL, EU27, NO	2
	Productie- en inkomenscomponenten bbp; bedrijfstak; nationale rekeningen	CBS	2016-2018	2	A01-03	NL	2
Energy use	Netto-energiegebruik land- en tuinbouw licht gestegen	Agrimatie, Wageningen University	2016-2018	1-4, limited	A01	NL	1
	Energiebalans; aanbod en verbruik, sector	CBS	2016-2018	1-4, limited	A-H	NL	4
	Complete energy balances	Energy statistics, Eurostat	2016-2018	1-3, limited	A-H	NL, EU27, IS, NO	6
Carbon emissions	Broeikasgassen, koolstofdioxide, per bedrijf	Emissiesregistratie, RIVM	2015, 2018,2019	4	A-U	NL	2
	Emissies naar lucht op Nederlands grondgebied	CBS	2016-2018	1-4, limited	A-H	NL	3
	Air emissions accounts by NACE Rev. 2 activity	Eurostat	2016-2018	1-2	A-U	NL, EU27, IS, NO	5
ETS emissions	Trinomics database, based on EUTL	Trinomics, EUTL	2016-2018	4	A-U	NL, EU27, IS, NO, LI	N/a
Emissions factors	The Netherlands list of fuels, January 2020	RVO	2018-2020	n/a	n/a	n/a	N/a

Source: Trinomics (2022).

I.2 In-depth description of data limitations

A good first assessment of carbon leakage was made possible through combining multiple data sources, as for some carbon leakage indicators individual data sources were incomplete. Because the level of detail necessary for assessing carbon leakage risk for non-ETS sectors (detailed sector level and ETS vs non-ETS) and the several statistics necessary to assess risk (emissions, trade, production and gross value added), data from several sources need to be used in order to fill gaps in the data. The lack of data is most noticeable for GVA and emissions.

The analysis is based on sectors as a whole because none of the data for total emissions (at sector level), trade, production or GVA is distinguished between ETS and non-ETS. Notably, there is no comprehensive public data on non-ETS emissions since there are no obligations on monitoring emissions outside of the EU ETS. Literature on non-ETS emissions examined for this study all estimate non-ETS emissions by taking the total GHG emissions and subtracting ETS emissions. This is generally done on aggregated NACE-2 level.

There are no public statistics on non-ETS emissions at NACE 3 or 4-digit level, so some manual checks on the emissions data at company level were done to make it consistent with other data sources on ETS emissions. The emissions data at company level from the *Emissieregistratie* is the most detailed Dutch emissions data publicly available. It does not contain the GHG emissions of all companies though incomplete. Furthermore, at the time of this study, the sector classifications for companies are not consistent with the public information available on NACE codes per ETS installation.[86] Because total emissions data is incomplete, the total emissions values may be an underestimate, though due to differences in NACE classification, the total emissions value could be overestimated. Nonetheless, about 77% of the non-ETS CO_2 emissions potentially at risk of carbon leakage could be traced back to individual NACE-4 sectors. For the sector specific assessment, the emissions calculations are manually adjusted to take these inconsistencies into account.

Beyond the limitations already discussed, there are also several other limitations to the data. These limitations include:

- For some sectors, there is not trade data or production value data available from Eurostat or CBS. This could be for a multitude of reasons including confidentiality, lack of confidence in the data or limited data, but this was not always clear from statistics. The trade intensity for these sectors could therefore not be determined;
- There is no correction for re-imports/exports; and
- Production values from the CBS are total sold production, not total production. These values are therefore an underestimate of total production.

I.3 Additional results

Table I-2 Sectoral breakdown of NACE-4 sectors potentially at risk of carbon leakage

NACE code	Sector	High trade intensity	Low trade intensity	Unknown trade intensity
1-3	Agriculture	10	3	22
4-9	Mineral extraction	2	0	3
10-12	Food industry	12	2	2
13-15	Textiles, clothing, leather industry	12	0	5
16, 23	Wood and building materials industry	8	5	4
17-18	Paper and printing industry	2	2	6
19-22	Refineries and chemicals industry	9	0	0
24-25	Metal industry	13	6	10
26-28	Electrical and machinery industry	36	0	2
29-30	Transport equipment industry	10	0	1
31-33	Other industry	7	1	12
	Total	**121**	**19**	**67**

Note: High trade intensity is a total trade intensity and extra-EU trade intensity greater than 30%; low trade intensity is <30% for total trade intensity or extra-EU trade intensity.

[86] European Commission (2018). NACE matching table.

Table I-3 Carbon leakage indicators for Dutch non-ETS sub-sectors (NACE 4-level) based on trade intensity and emission intensity, 2016-2018 averages

Non-ETS sector (NACE 4-level)	Dutch trade intensity Intra-EU + extra-EU %	Dutch trade intensity Extra-EU %	Emission intensity $kgCO_2$/€ GVA	Carbon leakage indicator Intra-EU + extra-EU	Carbon leakage indicator Extra-EU
2016 Manufacture of plastics in primary forms	111%	42%	1.81	2.02	0.76
1200 Manufacture of tobacco products	182%	78%	0.07	0.12	0.05
1011 Processing and preserving of meat	126%	53%	0.07	0.09	0.04
1082 Manufacture of cocoa, chocolate and sugar confectionery	111%	51%	0.05	0.06	0.03
2060 Manufacture of man-made fibres	86%	39%	0.02	0.05	0.02
2910 Manufacture of motor vehicles	128%	61%	0.06	0.05	0.02
1107 Manufacture of soft drinks; production of mineral waters and other bottled waters	105%	48%	0.04	0.04	0.02
2120 Manufacture of pharmaceutical preparations	195%	148%	0.03	0.03	0.03
1610 Sawmilling and planing of wood	97%	59%	0.04	0.03	0.02
1012 Processing and preserving of poultry meat	76%	32%	0.04	0.03	0.01
1013 Production of meat and poultry meat products	67%	32%	0.04	0.03	0.01
1061 Manufacture of grain mill products	90%	37%	0.02	0.02	0.01
1721 Manufacture of corrugated paper and paperboard and of containers of paper and paperboard	70%	14%	0.01	0.02	0.00
1072 Manufacture of rusks and biscuits; manufacture of preserved pastry goods and cakes	90%	31%	0.02	0.01	0.00
2030 Manufacture of paints, varnishes and similar coatings, printing ink and mastics	92%	40%	0.01	0.01	0.00
2229 Manufacture of other plastic products	115%	59%	0.00	0.00	0.00
2361 Manufacture of concrete products for construction purposes	29%	8%	0.00	0.00	0.00
2899 Manufacture of other special-purpose machinery n.e.c.	98%	88%	0.00	0.00	0.00
3101 Manufacture of office and shop furniture	17%	4%	0.00	0.00	0.00

EU refers to defined as the EU27, Iceland, Liechtenstein and Norway in this report

EU ETS carbon leakage threshold > 0.2

A similar analysis was performed at NACE 3-digit level, which did not lead to additional insights on sectors that may be at risk or not at risk of carbon leakage.

I.4 Methodology for sector selection for in-depth analysis

In the first step, of the 208 NACE-4 sectors that were deemed potentially at risk of carbon leakage, the NACE-4 sectors where no data was available to determine the emission intensity (on the basis of gross value added or production value) were filtered out. Hereby the statistics were analysed at both NACE-4 and NACE-3 level to ensure all available data was taken into account.

In the second step, sectors that have not been filtered out are ranked on the basis of emission intensity, where possible on the basis of gross value added. Due to lack of data, in most cases on the basis of production value.

The top 25 sectors from step 2 were then ranked on the basis of total trade value (intra-EU + extra EU as well as extra-EU separately) and production value for the Netherlands. Some sectors are removed from the top list because they turned out to be overwhelmingly ETS upon further analysis of the statistics by comparing the installation level data from *Emissieregistratie* with the European Union Transaction Log (e.g. manufacturing of oils and fats, manufacturing of other inorganic basic chemicals and manufacturing of beer). Additional manual checks on the total non-ETS emissions, production value and trade statistics were done to ensure no sectors with (potentially) significant non-ETS emissions in public statistics were omitted. This resulted in the sectors in the table below.

Table I-4 Top six non-ETS Dutch NACE-4 sectors based on total extra-EU trade value and production value

Rank	Sector
1	2016 Manufacture of plastics in primary forms
2	1051 Operation of dairies and cheese making
3	0113 Growing of vegetables and melons, roots and tubers
4	0119 Growing of other non-perennial crops
5	0130 Plant propagation
6	1086 Manufacture of homogenised food preparations and dietetic food

Annex II Relevant non-ETS climate policies

This Annex summarises the key components of non-ETS climate policies in the EU, the Netherlands and the top five European trading countries for the selected sectors. These are Germany, Belgium, UK, France and Spain as discussed in Section 3.3. This forms the basis for the comparison of sector-specific effective carbon rates in Chapter 4. Per country, key characteristics of climate policies are summarised. At the end of each country description, fiches are provided of the most relevant policies that have been taken into account. The effective carbon rates calculated in these fiches are only determined for pricing policies (thus, direct carbon pricing and energy taxes). These rates have been calculated by converting the nominal rates related to fossil fuel use to tCO_2 equivalents using emissions factors from national sources. The effective carbon rates include exemptions relevant to the non-ETS sectors considered in this report.

II.1 The Netherlands

The main pricing instruments on fossil fuel use for Dutch non-ETS sectors are the energy tax and the sustainable energy surcharge (ODE). The energy taxation rates ('*energiebelasting*') differ per fuel type and decrease with consumption, i.e. the higher the volume of fuel consumption, the lower the applicable tax rate. For natural gas, there are four consumption brackets which each have a specific (regressive nominal) tax rate. Two tax regimes are in place for natural gas: a regular regime and a reduced tax regime for the greenhouse horticulture sector. Under the reduced tax regime, lower volumes of consumption face a 3-6 times lower tax rate than under the regular tax rate. The Sustainable Energy Surcharge (ODE-'*Opslag Duurzame Energie- en Klimaattransitie*') is used to finance climate related subsidies and is on top of the general natural gas and electricity taxes. The greenhouse horticulture sector also has a reduced tax rate for natural gas use under the ODE tax. In addition, there is a flat tax rate for coal. Transport fuels such as diesel and gasoline are mainly priced via the excise duty on mineral oils, but are less relevant for sectors other than transport.

Next to the reduced tax rate for natural gas in greenhouse horticulture, natural gas used in CHPs is exempted from the energy tax and ODE. Numerous processes and applications are exempted from the energy and coal tax. The most relevant one is the full exemption of the energy tax for natural gas used in CHPs. Other exemptions that are relevant in theory (but in practise less so for the Dutch non-ETS businesses), are the full exemptions of the energy tax for natural gas used for metallurgic and mineralogic processes, and the full exemption of the coal tax if coal is used in dual use processes.

The most relevant subsidies and tax rebates for non-ETS industry and greenhouse horticulture are the SDE++, the EIA, MIA/Vamil and, specifically for greenhouses the Greenhouse as Energy Source programmes. The Dutch government provides financial support to the industrial and agricultural sectors in various ways. The most relevant support programmes are the SDE++ (*Stimulering Duurzame Energieproductie en Klimaattransitie*), which stimulates investments in renewable energy and climate mitigation projects, including projects in industry and greenhouse horticulture. The EIA (*Energie-investeringsaftrek*) is a tax rebate for energy efficiency investments, and MIA/Vamil (*Milieu-investeringsaftrek/ Willekeurige afschrijving milieu-investeringen)* are similar support schemes for certain environmentally friendly investments. Most non-ETS companies also have to comply with the energy savings regulation (*energiebesparingsplicht*), which obliges companies to take any energy saving measure that pays itself back in less than 5 years. As of 2023, this obligation is broadened to CO_2-reduction measures.

For the greenhouse horticulture sector, various support programmes are in place. Most of those are coordinated within the KaE (*Kas als Energiebron* – Greenhouse as Energy Source) programme. In addition, Dutch non-ETS greenhouses fall under a sectoral CO_2-pricing system, but in practice greenhouses rarely face a price under this system, making the effective carbon price under this system practically zero.[87]

By 2025, various relevant amendments within Dutch energy taxation are foreseen, including less degressive energy taxation tariffs, abolishing the reduced tax regime for greenhouse horticulture, and increased budgets for support schemes. In December 2021, the plans of the Dutch government for the next couple of years were published, including the energy and climate plans.[88] Various proposals are relevant for the climate costs for non-ETS businesses. To start with, gradually increased tariffs for natural gas consumption for the highest consumption volumes are proposed, starting in 2023. Second, as of 2025, the reduced tax regime for greenhouse horticulture will be abolished. In that same year, the exemption on natural gas use in CHPs will be limited to the share of natural gas that is used to generate electricity for the grid and the exemptions for natural gas used for metallurgic and mineralogic processes will be abolished. Fourth, the tax rate for natural gas for the lowest consumption volumes will be increased (and the rate for electricity will decrease). At the same time, increased budgets are reserved for subsidies and tax rebates, including the EIA and the MIA. Furthermore, the Dutch government plans to (partially) compensation the greenhouse horticulture sector and the industrial sector for ODE-costs that increased in 2020, for which 25 million per year is reserved.[89] In return, these sectors need to take more emission reduction measures.

Energy tax, coal tax and sustainable energy surcharge	
Policy name	Energiebelasting & kolenbelasting & Opslag Duurzame Energie- en Klimaattransitie (ODE)
Status as of 1 January 2022	In force
Type of measures	Pricing
Description	The energy tax sets out the energy taxes for natural gas and electricity in the Netherlands levied within the framework of the EU Energy Taxation Directive (ETD). The coal tax does so for coal. The ODE is used to finance climate related subsidies and is on top of the energy tax. All these taxes contribute to the financial incentive to reduce energy consumption in general and may contribute to fuel switch.
Covered fuels	All fuels
Covered sectors	All sectors
Relevant exemptions & rebates[90]	Under the following conditions, agents are completely exempted from the energy tax or coal tax (only conditions relevant for this study are presented): • Renewable energy produced and consumed on site. • Coal used for dual use. • Natural gas consumption for: electricity generation, efficient CHPs, metallurgical/ mineralogical processes, used as non-fuel and used as an additive or filler products. Until 2020, the energy intensive industry was partially exempted if they participated in certain energy efficiency programs. This exemption is not available anymore. The

[87] Rijksoverheid (2020). Kamerbrief over ETS in relatie tot de glastuinbouw
[88] VVD, D66, CDA en ChristenUnie (2021). *Budgettaire bijlage coalitieakkoord 2021-2025* .
[89] Ministry of Economic Affairs & Climate Policy (2021). *Contouren ODE-compensatieregeling industrie en glastuinbouw*.
[90] Only the exemptions relevant to the selected sectors for sector analysis have been listed. Some exemptions include administrative conditions or a minimum threshold, which have not been listed. In addition to the exemptions listed, there are many other exemptions under the German Energy Tax.

<table>
<tr><td></td><td>greenhouse horticulture sector faces significantly lower tax rates on natural gas than the regular rates, both under the energy tax and the ODE. The so-called reduced tariff for the first bracket is more than 6 times lower than the regular rate and the reduced rate in the second bracket is almost 3 times lower than the regular rate. The reduced rates in brackets 3 and 4 are identical to the regular rates. In 2022, the total forgone tax income is budgeted at €131 million.[91]</td></tr>
<tr><td>Nominal rate (pricing policies only)</td><td>
<table>
<tr><th></th><th colspan="4">Consumption brackets</th></tr>
<tr><td>Gas (m^3)</td><td>0-0.17 mln</td><td>0.17- 1 mln</td><td>1 mln - 10 mln</td><td>>10 mln</td></tr>
<tr><td>Energy tax</td><td>€ 0.36322</td><td>€ 0.06632</td><td>€ 0.02417</td><td>€ 0.01298</td></tr>
<tr><td>Energy tax, red.</td><td>€ 0.05833</td><td>€ 0.02503</td><td>€ 0.02417</td><td>€ 0.01298</td></tr>
<tr><td>ODE</td><td>€ 0.0865</td><td>€ 0.0239</td><td>€ 0.0236</td><td>€ 0.0236</td></tr>
<tr><td>ODE, red.</td><td>€ 0.0139</td><td>€ 0.0090</td><td>€ 0.0236</td><td>€ 0.0236</td></tr>
<tr><td>Coal</td><td colspan="4">Rate per 1000 kg coal</td></tr>
<tr><td>Coal tax</td><td colspan="4">€15.94</td></tr>
<tr><td>CNG</td><td colspan="4">Rate per m^3</td></tr>
<tr><td>CNG</td><td colspan="4">€ 0.17203</td></tr>
</table>
</td></tr>
<tr><td>Effective carbon rate (pricing policies only)</td><td>In 2022, for industry the effective carbon[92] rates are:
• Between €29.2 and €32.6/tCO_2 for natural gas use in large installations (between 10-14 million m^3 per year), between €32.6 and €84.9/tCO_2 for natural gas use in medium installations (between 1-10 million m^3 per year), between €84.9 and €251.2/tCO_2 for small installations (between 0.17-1 million m^3 per year) and around €251.2/tCO_2 for very small installations (less than 0.17 million m^3 per year). Natural gas used in CHP is 100% exempted from the energy and ODE tax.
For greenhouse horticulture the effective carbon rates (with reduced rates) are:
• Between €24.7 and €26.4/tCO_2 for natural gas use in large installations (between 10-14 million m^3 per year), between €22.7 and €26.4/tCO_2 for natural gas use in medium installations (between 1-10 million m^3 per year), between €22.7 and €40.4/tCO_2 for small installations (between 0.17-1 million m^3 per year) and around €40.4/tCO_2 for very small installations (less than 0.17 million m^3 per year). Natural gas used in CHP is 100% exempted from the energy and ODE tax.
For coal, the effective carbon rate is €0.69/tCO_2. Dual use coal is 100% exempted.</td></tr>
</table>

National emission trading scheme for non-ETS greenhouse horticulture	
Policy name	CO_2-regeling voor de glastuinbouw
Status as of 1 January 2022	In force
Type of measures	Pricing
Description	In order not to violate the European Commission's state aid guidelines when introducing the reduced tariffs for the energy tax and ODE for the greenhouse horticulture sector, the Dutch government needed to design additional climate policies for the sector. In response, the national CO_2 trading scheme was implemented. All greenhouse cultivation companies, except 15 companies that are part of EU ETS, are part of this trading scheme.

[91] Tweede Kamer (2021). *Bijlagen Miljoenennota 2022*.
[92] Cumulative nominal rates (energy tax + ODE) are converted to effective carbon rates after taking into account exemptions. For natural gas, the calorific value and emissions factors as reported by RVO have been used.

	The ceiling for this system has been determined by the government in agreement with sector organisations. Until 2019, no charges were collected under this mechanism.[93,94]
Covered fuels	All fuels
Covered sectors	Greenhouse horticulture
Effective carbon rate	€0/tCO_2 (as it has not led to real costs so far)

Tax deduction for energy investments	
Policy name	Energieinvesteringsaftrek (EIA)
Status as of 1 January 2022	In force
Type of measures	Tax deduction
Description	The EIA is a deduction scheme from fiscal profits to promote investments in energy efficient technologies. Entrepreneurs may deduct up to 45.5% of the investment costs from their fiscal profits. Each year, a list is published with applicable technologies and criteria. In 2022, **€149 million** is reserved in the national budget for the EIA.
Covered fuels	All fuels
Covered sectors	All sectors

Energy efficiency obligation	
Policy name	Energiebesparingsplicht
Status as of 1 January 2022	In force
Type of measures	Regulation
Description	Dutch companies are required to implement energy saving measures for companies which use more than 50,000 kWh electricity or 25,000 m^3 gas if the payback period is less than five years. In the Netherlands, efforts have been intensified to implement and monitor this obligation. Until recently, the national regulation was not deemed very effective. The budget for implementation and monitoring has now been increased. Furthermore, as of 2023 the obligation is broadened to CO_2-reduction and not only energy savings.
Covered fuels	All fuels
Covered sectors	Industry

Stimulation of sustainable energy production and climate transition (SDE++)	
Policy name	SDE++
Status as of 1 January 2022	In force
Type of measures	Subsidy scheme
Description	The SDE++ grants a premium on top of the market price for non-bankable renewable energy and/or CO_2-reducing projects. Relevant technologies include various forms of renewable energy production, electrification, CCS, green hydrogen and CCUS in the greenhouse horticulture sector. Each year, new technologies can become eligible to apply. The SDE++ is available for all consumers, including those in non-ETS sectors. In 2022, the expected disbursements of the SDE++ and its predecessors are slightly below **€2.5 billion.**[95]
Covered fuels	All fuels
Covered sectors	Electricity producers, industry and greenhouse horticulture

[93] NRC (2019). *Overheid hielp tuinders Europese CO_2-prijs te ontwijken*. & *De CO_2-heffing die nooit werd geïnd*.
[94] Trinomics (2021). *Energiegebruik en de CO_2-uitstoot van de Nederlandse en Vlaamse land- en tuinbouwsector.*
[95] RVO (n.d.). *Feiten en cijfers SDE(+)(+)*.

Other tax deductions for industry	
Policy name	MIA & Vamil and VEKI
Status as of 1 January 2022	In force
Type of measures	Tax deduction
Description	MIA (Milieu-investeringsaftrek) and Vamil (Willekeurige afschrijving milieu-investeringen) are tax deduction for investments in environmentally friendly measures, which are listed on the 'Milieulijst'. Investments which have tax deduction under the EAI are not eligible for additional deductions under MIA/VAMIL. In 2022, the budget for MIA equals **€144** million and Vamil **€25 million**. The VEKI (Versnelde Klimaatinvesteringen Industrie) is an investment subsidy for emission reducing investments in industry. The budget was **€82 million** in the last round.
Covered fuels	All fuels
Covered sectors	All sectors

Various subsidies and support programmes for greenhouse horticulture	
Policy name	(1) Kas als energiebron (KaE), which includes Subsidieprogramma marktintroductie energie-innovaties glastuinbouw (MEI) en RNES-aardwarmte. Energiebesparing in de glastuinbouw (EG). (2) Subsidieregeling CO_2-levering glastuinbouw and (3) Reservering warmtesysteem Westland
Status as of 1 January 2022	In force
Type of measures	Subsidy schemes
Description	Greenhouse as energy source (KaE) is overarching programme from the Ministry of Agriculture, Nature and Food Quality and the national industry association for greenhouse horticulture. It has been active since 2005. The programme is focussed on improving energy efficiency and promoting the uptake of renewable energy in the sector. KaE includes various programmes, of which the most relevant are: • MEI provides investment grants for innovative technologies in greenhouse horticulture. The yearly budget is around **€7 million**. • RNES-aardwarmte provides guaranties for geothermal projects in greenhouse horticulture. • EG provides investment grants for investments in energy efficiency in the sector. For 2022, a budget of **€16 million** has been reserved. Other relevant supporting mechanisms are the subsidy scheme for external CO_2 supplies for the sector (budget: **€23 million**) and the development of a district heating system in the main greenhouse horticulture region in the Netherlands (budget: **€15 million**).
Covered fuels	All fuels
Covered sectors	Greenhouse horticulture

II.2 Germany

Climate policy in Germany is centred around its Climate Protection Programme 2030.[96] The Climate Protection Programme 2030 combines sector-related and overarching policy measures. It comprises four components to achieve the necessary GHG emissions reduction: 1) support programmes and incentives for reducing GHG emissions, 2) carbon pricing, 3) reinvestment of carbon pricing revenues in measures promoting climate action or returning it to citizens, and 4) regulatory measures. The aim of the

[96] Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (2019). *Climate Action Programme 2030.*

programme to enable Germany to achieve its national GHG emission reduction of at least 55% by 2030 compared to 1990 levels. In the meantime, Germany has increased its climate target to at least 65% GHG emission reduction by 2030 and carbon neutrality by 2045.[97] To meet the increased target, the German government initiated a new climate protection investment programme with additional funding.

The climate-related policy costs in the fuel consumption of the German non-ETS sectors are mainly related to its national ETS and energy tax. The German national ETS (nEHS) is one of the main climate policy measures in the sectors not covered under the EU ETS. The nEHS was implemented in 2021 and covers emissions from fuels for transport and heating, including combustion of fossil fuels in non-ETS industrial facilities. Industrial sectors on a national carbon leakage list can receive compensation between 65% and 95% of nEHS costs depending on the sector's emission intensity. The carbon leakage list is primarily based on the EU CL list of phase 4 and is therefore similar, with some differences.[98] The nEHS costs come on top of the energy tax that all energy users must pay. There are a large number of (partial) exemptions to fossil fuel under the energy tax though. These include a partial exemption on natural gas and gas oils used in manufacturing and agriculture companies and a full exemption for high-efficiency CHP installations.

The Germany government is supporting German companies in the non-ETS sectors in their transition towards carbon neutrality primarily through several funding programmes. The main funding programme relevant for the fuel use in the non-ETS sectors is the *federal funding programme for energy and resource efficiency in the economy*. The programme finances measures that significantly increase electricity or heat efficiency and thus contribute to reducing energy consumption: from highly efficient standard components to complex system solutions. Companies can apply for loans for measures with the loan repayment partially subsidised or obtain investment grants through competitive bidding. Specifically for agriculture and horticulture, there is also a federal programme on increasing energy efficiency and reduce CO_2 emissions in those sectors. This programme focuses on knowledge transfer, but also funds demonstration projects. Germany also has funding programmes targeted at industrial sectors, but these are mainly focussed on sectors or companies that fall under the EU ETS. Finally, highly efficient new, modernised or retrofitted CHP systems are also subsidised through a CHP surcharge on electricity consumers.

National emissions trading system	
Policy name	Nationale Emissionshandelssystem (nEHS)
Status as of 1 January 2022	In force
Type of measures	Pricing
Description	Germany implemented its national Emissions Trading System (nEHS) in 2021. The nEHS aims to provide a financial incentive to reduce emissions outside the sectors covered by the EU ETS. It obligates fuel distributors to acquire emission rights in the form of certificates, paying for the emissions that result from the subsequent burning of the fuels.
Covered fuels	Until 2022: petrol, diesel, heating oil, liquefied petroleum gas and natural gas From 2023: all fuels
Covered sectors	All sectors except for EU ETS installations
Relevant exemptions and rebates	Sectors and subsectors on the national carbon leakage list can receive compensation between 65% and 95% of their costs due to the nEHS, depending on their emission

[97] Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (2021). *Bundes-Klimaschutzgesetz*. Available at: https://www.bmuv.de/themen/klimaschutz-anpassung/klimaschutz/bundes-klimaschutzgesetz.
[98] dEHst (2022). Retrospective recognition of sectors eligible for state aid

	intensity.[98] Current sectors on the national carbon leakage list are the same ones that are on the EU ETS Phase 4 carbon leakage list. Sectors can apply to get on the national carbon leakage list with evidence of meeting the eligibility criteria. These eligibility criteria are similar to the EU ETS phase 4 criteria, only made specific to German sectors.
Nominal rate	€30/tCO$_2$e in 2022, rising to €55/tCO$_2$e in 2025. After 2026, the carbon price is determined by supply and demand within a price corridor above €55/tCO$_2$e.
Effective carbon rate	In 2022: • **€30/tCO$_2$** for sectors not on the carbon leakage list (including 01.13, 01.19, 01.30 and 10.86 for now until a sector submits an application with evidence that it meets the criteria to be included on the national carbon leakage list) • **€10.5/tCO$_2$** for 20.16 and selected subsectors in 10.51 (65% is compensated)

Energy tax	
Policy name	Energiesteuer
Status as of 1 January 2022	In force
Type of measures	Pricing
Description	The Energy Duty Act sets out the energy taxes in Germany levied within the framework of the EU Energy Taxation Directive (ETD). Energy taxes contribute to the financial incentive to reduce energy consumption.
Covered fuels	All fuels
Covered sectors	All sectors
Relevant exemptions and rebates[99]	• Manufacturing industries and agricultural companies can apply for tax relief for properly marked gas oils, refinery gas, lubricating oils and other oils, natural gas and liquefied gas used for heating purposes. • Manufacturing industries can receive further tax relief if the tax burden remains greater than the pension payment reduction compensated by the contributions from the energy and electricity tax revenues, minus a €750 deductible. The tax relief is conditional on the implementation of an approved energy or environmental management system. • Agriculture companies can apply for tax relief for gas oils used in tractors, machineries and special vehicles. • CHP installations can receive a full tax exemption for coal, petroleum coke, properly marked gas oils, heating oils, natural gas, and liquefied gas and other solid fossil fuels used for the combined generation of heat and power if they meet the EU criteria of being highly efficient and have a utilisation rate of at least 70%. Full tax exemption is only provided until the main components of the CHP installation are fully depreciated. CHP installations that do not meet the high efficiency criteria receive a partial tax exemption. • Energy used in metallurgical and mineralogical processes and inputs not used as fuel are exempt from the energy tax.
Nominal rate (pricing policies only)[100]	Nominal rates vary per fuel type, with the nominal rates for the relevant fuel types as follows in 2022: • Natural gas: €5.5/MWh for use as heating fuel

[99] Only the exemptions relevant to the selected sectors for sector analysis have been listed. Some exemptions include administrative conditions or a minimum threshold, which have not been listed. In addition to the exemptions listed, there are many other exemptions under the German Energy Tax.
[100] Bundesministerum der Justiz (2006). Energiesteuergesetz.

	• Gas oils: €485.70 per 1000 litres with a sulphur content of more than 10 mg/kg, €470.40 per 1000 litres with a sulphur content of maximum 10 mg/kg • Coal: €0.33/GJ

Effective carbon rate (pricing policies only)	In 2022:[101]
	• **€22.6/tCO_2** for natural gas in agriculture and manufacturing sector, with the possibility for manufacturing companies to reduce their energy tax for natural gas to **€11.3/tCO_2**
	• **€95.5-101.2/tCO_2** for gas oil in agriculture depending on the sulphur content of the fuel
	• **€0.4/tCO_2** for coal in agriculture and manufacturing sector
	• For CHPs:
	  ○ **€0/tCO_2** for installations only using fossil fuel for high efficiency CHPs
	  ○ **€3.0/tCO_2** for natural gas and **€0.2/tCO_2** for coal in installations with CHPs not meeting the criteria for high efficiency

Federal program to increase energy efficiency and reduce CO_2 emissions in agriculture and horticulture	
Policy name	Bundesprogramm Energieeffizienz für Landwirtschaft und Gartenbau
Status as of 1 January 2022	In force
Type of measures	Subsidy
Description	The federal energy efficiency program for agriculture and horticulture has been promoting measures to improve energy efficiency and energy savings in primary production in agriculture and horticulture since 2016.[102] The program focuses on knowledge transfer and information measures. It also funds demonstration projects to show the practicability of new technologies and processes for energy efficiency and CO_2 reduction.
Covered fuels	All fuels
Covered sectors	Agriculture and horticulture

Federal funding for energy and resource efficiency in the economy	
Policy name	Bundesförderung für Energie- und Ressourceneffizienz in der Wirtschaft
Status as of 1 January 2022	In force
Type of measures	Subsidy
Description	The funding programme finances measures that significantly increase electricity or heat efficiency and thus contribute to reducing energy consumption: from highly efficient standard components to complex system solutions.[103] The programme consists of a loans and repayment subsidy component and a competitive subsidy component. The loans and repayment subsidy component consists of five modules 1) cross-sectional technologies, 2) Process heat from renewable energies, 3) Measurement, control and regulation technology, sensors and energy management software, 4) Energy and resource-related optimization of systems and processes, and 5) Promotion of transformation concepts towards climate neutrality. The funding is a mix of loans and repayment subsidy. The competitive subsidy component focuses on energy and resource-related optimization of production plants and processes.

[101] Nominal rates converted to effective carbon rates after taking into account exemptions. For natural gas and gas oils, the calorific value and emissions factors as stipulated under the national ETS have been used. For coal, the emission factor for the federal funding programme for energy and resource efficiency in the economy has been used.
[102] Bundesanstalt fur landwirtschaft (2021). Bundesprogramm zur Steigerung der Energieeffizienz und CO2-Einsparung in Landwirtschaft und Gartenbau
[103] Kfw (2022). Bundesförderung für Energie- und Ressourceneffizienz in der Wirtschaft.

Covered fuels	All fuels
Covered sectors	All sectors with a focus on industry

Combined heat and power surcharge	
Policy name	Kraft-Wärme-Kopplung Zuschlag
Status as of 1 January 2022	In force
Type of measures	Subsidy
Description	Under the Combined Heat and Power Act, operators of highly efficient new, modernised or retrofitted CHP systems receive remuneration for the electricity fed into the grid.[104] In addition, heating and cooling networks connected to the CHP system are also funded. The aim is to expand CHP-based power generation in Germany to increase energy savings and reduce GHG emissions.
Covered fuels	All fuels
Covered sectors	All sectors

II.3 Belgium

The long-term climate strategy of Belgium consists of a combination of a federal and three regional climate plans.[105] . Belgium relies for a large part on European measures, such as the ETS, to reduce emissions. In addition, regional climate targets are set for 2030 and 2050.[106] However, policy to reach these targets is lacking, particularly in the non-ETS sectors. Notably, the Belgian National Climate plan that was submitted to the Commission in 2019 indicated a 16% reduction towards 2030 while a 35% reduction is needed to reach their European ESR target; the Commission also noted a lack of coherence between regional and federal policy plans.[107] In this section we will mostly focus on Flanders, as the selected sectors for the in-depth analysis are mainly located in Flanders.[108]

The main climate-pricing policies in Belgium for non-ETS sectors consists of a combination of federal energy taxes and excise duties for liquid fuels and natural gas. This pricing is combined with regional support schemes. Tax on natural gas use consists of two federal energy taxes: a degressive federal special excise duty (*bijzondere accijns*) and energy contribution (*energiebijdrage*). In Flanders these federal contributions are combined with a regional charge to finance renewable energy production (*Energiefonds*), but this is only charged for electricity and not for natural gas. Excise duty on liquid fuels face higher implicit carbon prices—similar to in other countries, although a reduced rate exists for all commercial use.

There are several relevant exemptions for the federal energy taxes, with exemptions for fuel use in the agricultural sector and for CHPs being significant. Since 2022, fuel use in CHPs is fully exempted from the federal energy taxes.[109] All fuel use in the agricultural sector is exempted of the

[104] Bundesamt fur wirtschaft (2022). Zulassung von KWK-Anlagen.
[105] Belgium (2021). Belgische langetermijnstrategie klimaat
[106] 2050 target Flanders:85% reduction in 2050 compared to 2005, 95% reduction in Wallonia in 2050 compared to 1990, Net zero emissions in Brussels in 2050.
[107] European Commission (2020). Assessment of the final national energy and climate plan of Belgium.
[108] Plastic production is mainly located in Flanders and close to the port of Antwerpen (based on ETS emission database); No data on where dairy processing takes place, but dairy *production* is relatively spread over Flanders and Wallonia (BCZ 2021); zuivel in cijfers);
96% of greenhouse area in Belgium is in Flanders (Statbel (2021). Landbouwgegevens 2021).
[109] Before 2022, fuel use in CHPs was only exempted from the energy contribution and partially exempted from the federal contribution for the natural gas used for generating electricity injected into the grid. From 2022, the federal contribution was transposed to the federal special excise duty. Since fuel use in CHPs is exempt from all excise duties, this resulted in CHPs being fully exempt.

energy contribution (*Energiebijdrage*). Energy-intensive industry can acquire tax reductions for the energy contribution (about 40% reduction of the energy contribution) in case they sign up to covenants on energy efficiency. Although detailed data is not available, it seems many energy-intensive industrial companies use this tax reduction.

Non-ETS sectors are supported via several funding programmes, including operational subsidies for renewable energy production and CHP use (in Flanders), as well as several investment subsidies. While the main taxes are federal, most support programmes are regional. Similar to other countries, most support is provided via operational subsidies for renewable energy production in both Flanders and Wallonia. This support scheme uses renewable electricity certificates which the grid operator is obliged to buy for a government-determined minimum price of producers (*Groenestroomcertificaten* in Flanders). Additionally, a similar scheme exists for dual production (heat and electricity) in CHPs in Flanders, although Flanders has plans to gradually phase out new subsidies as of 2023.[110] Moreover, there are several other measures to stimulate emission reductions, including a tax deduction for energy saving investments and the VLIF fund with $8 million reserved for emission reduction specifically in greenhouses.

Federal levy (Federale bijdrage)	
Policy name	Federale bijdrage (Federale Bijzonder Accijns as of 2022)
Status as of 1 January 2022	In force
Type of measures	Pricing
Description	Main federal tax for both natural gas and electricity
Region	Federal
Covered fuels	Natural gas and electricity
Covered sectors	All sectors, different rates based on total gas/electricity use.
Relevant exemptions and rebates	• Electricity production in CHPs is exempted[111]
Nominal rate	• Main levy rate ranging from €0.66/MWh (<20 GWh use) to €0.15/MWh (>2500 GWh).
Effective carbon rate	• Ranging from €3.27/t CO_2 to €1.55/t CO_2 for large gas users.

Federal Energy Levy (Energiebijdrage)	
Policy name	Energiebijdrage
Status as of 1 January 2022	In force
Type of measures	Pricing
Description	Federal tax on natural gas and electricity.
Region	Federal
Covered fuels	Natural gas and electricity
Covered sectors	All sectors, exemption for agriculture.
Relevant exemptions and rebates	• Whole agricultural and fisheries sector exempted. • CHPs in all sectors are exempted • Reduced tariff for energy-intensive industry involved in energy efficiency covenant
Nominal rate	• Standard rate of €0.998/MWh, • Reduced rate for energy-intensive industry (under a covenant): €0.054/MWh.
Effective carbon rate	• €4.95/t CO_2

[110] Flemish government (2021). Bijkomende maatregelen klimaat.
[111] Federal government Belgium (2022). Programmawet, art.429.

Excise Duty on liquid fuels	
Policy name	Brandstofaccijns
Status as of 1 January 2022	In force
Type of measures	Pricing
Description	Excise duty on liquid fuels, most notably gasoline and gas oil/diesel.
Region	Federal
Covered fuels	Gasoline, diesel, heating oil, lpg, propane, all transport fuels.
Covered sectors	All.
Relevant exemptions and rebates	Reduced rate for non-consumer use of Diesel. Exemptions for sectors not relevant to this non-ETS assessment (including consumer use exemptions of e.g. heating oil).
Nominal rate	Nominal rate: €602/1000 L Reduced rate for commercial (non-consumer) users: €375/1000 L in 2022.
Effective carbon rate	Nominal rate: €225/t CO_2 Reduced rate for professionals: €140/t CO_2

Trade in obligatory green certificates (GSC)[112]	
Policy name	Green Certificate Scheme (Groenestroomcertificaten/GSC) and CHP certificate Scheme
Status as of 1 January 2022	In force
Type of measures	Operational subsidy/certificate trade scheme
Description	-Main renewable energy support scheme in Flanders. Producers of renewable energy (solar, wind, biomass, etc) can receive green certificates. Certificates have a monetary value through which the certificates subsidize production of renewable energy. -A similar system exists for energy production through CHPs to stimulate efficient use of energy. -A similar system exists for energy production through CHPs to stimulate efficient use of energy. The CHP certificates will be phased out and it is expected no certificates will be given to new installations as of 2023.[113]
Region	Flanders, but Wallonia has a similar certificate trade system though.
Covered fuels	Renewable electricity and gas
Covered sectors	Energy production sector
Nominal rate	-Minimum price for a 1 certificate is €93. Producers receive 1 certificate per MWh produced energy, multiplied by a 'banding factor' that is always between 0 and 1. Minimum price per MWh is thus around ~€70/MWh. This is a minimum price though and higher prices are normal as the certificates can be traded. -For natural gas CHPs the minimum price of certificates is around €26/MWh produced electricity.[114] Trading design is similar to green certificates.

Tax deduction for energy-saving measures	
Policy name	Investeringsaftrek energiebesparende investeringen[115]
Status as of 1 January 2022	In force
Type of measures	Investment tax deduction/subsidy
Description	Tax deduction for investments that result in energy-savings.

[112] Vlaio (2022). Vlaamse groenestroomcertificaten (GSC)
[113] Flemish government (2021). Bijkomende maatregelen klimaat.
[114] COGEN (2021). Steunmechanismen WKK.
[115] Vlaanderen (2022). Verhoogde investeringsaftrek.

Covered fuels	N/A
Covered sectors	All sectors
Nominal rate	**Sole proprietors and small businesses**: 25% investment tax deduction. **Other entities**: 13.5% investment tax deduction

Several support mechanisms for climate-related investments in industry and agrilcuture	
Policy name	• VLIF investment fund (VIF investeringsfonds) • GLITCH innovation greenhouse production • Ecological premium (Ecologiepremie & strategische ecologiesteun)
Status as of 1 January 2022	In Force
Type of measures	Investment and innovation subsidies
Description	Flanders stimulates climate-related investments in greenhouses and agriculture via several funds and initiatives. There is a large investment agricultural fund (VLIF) in which **€8.1** million is reserved for emission-reduction measures. GLITCH supports innovative measures partially aimed at energy-efficiency and emission reduction in greenhouses in the Netherlands and Belgium. The total budget 2018-2021 was **€4.3 million.** Budget of the Ecological premium and strategic ecological support: **€29 million** for industry in 2018.[116]

II.4 United Kingdom

The *Net Zero Strategy: Build Back Greener* sets out the UK's vision for meeting its net zero ambitions by 2050.[117] The strategy is a long-term plan with policies and proposals centred around four key principles: 1) working with the grain of consumer choice, 2) ensuring the biggest polluters pay the most for the transition, 3) ensuring that the most vulnerable are protected through Government support, and 4) work with businesses to continue delivering deep cost reductions in low carbon tech. The strategy aims enable the UK to meet its carbon budgets, which are set over five-year period towards net zero emissions by 2050 enshrined in its Climate Change Act. Additionally, the UK has set high intermediate goals of 63% in 2030 and 75% in 2035 (compared to 2005), which are higher than in most EU countries.

While measures under the Net Zero Strategy affecting non-ETS sectors in the UK[118] are still being shaped, the main climate pricing policies in non-ETS sectors are the Climate Change Levy (CCL) and Fuel Duty. The CCL is a UK-wide tax on electricity, natural gas, liquid petroleum gas and solid fuels and the Fuel Duty covers mainly liquid fuels used in vehicles or for heating, forming a comprehensive tax coverage on energy. Both taxes consist of a main levy rate applicable to all covered fuels and a Carbon Price Support (CPS) rate only applicable to fuel used in power stations and CHPs to generate electricity that is not used onsite. The CCL contains various exemptions and tax discounts, including a full exemption from the main CCL levy rate for efficient CHPs and a reduced tariff for energy-intensive businesses including ones in manufacturing and agriculture sectors that have entered into a Climate Change Agreement— voluntary agreements to reduce energy use and CO_2 emissions. Energy used in metallurgical and mineralogical processes and inputs not used as fuel are also exempted from the CCL. Relevant exemptions under the Fuel Duty are a full exemption of oils not used as fuels, heavy oils (e.g. diesel) used for heating and sterilisation for growing horticultural produce. Heavy oils used in vehicles

[116] Bond Beter Leefmilieu (2020). Van een defensief naar een offensief industrieel klimaatbeleid
[117] https://www.gov.uk/government/publications/net-zero-strategy
[118] The UK established its own ETS following Brexit largely mirroring the EU ETS with the same sectoral coverage. In this study, we consider the non-ETS sectors in the UK activities that are not covered under the UK ETS.

and machinery used in agriculture, horticulture, fish farming and forestry are taxed at a reduced Fuel Duty rate.

Non-ETS sectors in the UK can apply for various funding from research to installation of equipment in the transition to a decarbonised economy. There are a wide range of funding programmes in the UK to support businesses and households. Research and innovation in net zero technologies are funded through two main mechanisms 1) the business-wide funding programme *Industrial Strategy Challenge Fund* that is relevant for all non-ETS sectors and 2) the *Net Zero Innovation Portfolio* that aims to accelerate the commercialisation of low-carbon technologies, systems and business models limited to power, buildings, and industry. This is complemented with funding programmes for the development of technologies and installation of equipment. Manufacturing companies can apply for grants under the *Industrial Energy Transformation Fund* (IETF) that aims to reduce the payback period of more transformative energy efficiency measures and de-risking decarbonisation technologies in industry. In the agriculture sector, companies can apply for grants under the *Farming Investment Fund* for the cost of equipment and technology to improve their productivity in a sustainable way. Furthermore, renewable energy production (e.g. wind and solar) is stimulated through operational subsidies in the form of contracts for difference (CFDs).[119]

Climate Change Levy	
Policy name	Climate Change Levy (CCL)
Status as of 1 January 2022	In force
Type of measures	Pricing
Description	The CCL was introduced in 2001 and is a UK-wide tax on electricity, gas, LPG and solid fuels supplied to businesses and public sector consumers. The CCL consist of a main levy rate and a Carbon Price Support (CPS) rate. The main levy is applicable to all covered fuels, whereas the CPS only has to be paid by electricity generating stations or operators of CHPs. The CCL incentivises energy efficiency and emission reductions on one hand through its price incentive, and on the other hand through the discounts on the CCL it offers to businesses that sign up to voluntary agreements and exemptions to efficient CHPs.
Covered fuels	Natural gas and solid fuels
Covered sectors	Electricity, industrial, commercial, agricultural and public services
Relevant exemptions and rebates	• Fuels that are supplied to CHPs registered under the CHP quality assurance (CHPQA) programme (and are therefore considered energy efficient) are exempted from the main CCL rate. For CHP stations not meeting the threshold efficiency percentage, the fuel qualifying for exemption is scaled back based on the efficiency of the CHP. • Fuel used in CHPs to generate electricity that is used onsite and fuel to produce useful heat are exempted from the CPS rate. • Energy-intensive businesses whose sector have entered into a Climate Change Agreement (CCA)—voluntary agreements made between UK industry and the Environment Agency to reduce energy use and CO_2 emissions—can receive an increased discount on the CCL of 83% on gas and solid fuels and 77% on LPG if they sign up to the CCA. Relevant sectors with a CCA include chemicals, dairy products, and horticulture. • Energy used in metallurgical and mineralogical processes and inputs not used as fuel are exempt from the CCL.

[119] UK government (2016). Contracts for Difference.

Nominal rate[120]	Main levy rates: • £4.65/MWh for natural gas until 1 April 2022, increasing to £6.72 from 1 April 2023 • £36.4/kg for any other taxable commodity (including coal) until 1 April 2022, increasing to £52.58 from 1 April 2023 CPS levy rate (not applicable to the sectors in this study as it is only on electricity generation): • £18/tCO_2e until at least 31 March 2023
Effective carbon rate	• **€5.1/tCO_2** for natural gas and **€3.1/tCO_2** for coal in companies that signed up to a CCA, which could include the polymer, dairy products and horticulture sectors (the discount for businesses that entered in a CCA increases proportionally to the main levy rate increase to keep the effective rate the same other an increase in line with inflation). • **€0/tCO_2** for fuel input in CHPs registered under the CHPQA programme • **€30.2/tCO_2** in 2022 for natural gas and **€18.0/tCO_2** in 2022 for coal in companies that did not sign up to a CCA or not covered under the CHPQA programme in a CHP.

Fuel duty	
Policy name	Fuel duty
Status as of 1 January 2022	In force
Type of measures	Pricing
Description	The most relevant legislation underpinning the fuel duty on fossil fuels is the Hydrocarbon Oil Duties Act. The fuel duty consists of a main levy and a Carbon Price Support (CPS) rate. The main levy is applicable to all covered fuels in the covered sectors, whereas the CPS only has to be paid by electricity generating stations or operators of CHPs. The fuel duty incentivises more efficient use of fuels through its price incentive.
Covered fuels	Gaseous fuels used in vehicles and liquid fuels
Covered sectors	All sectors
Relevant exemptions and rebates[121]	• Heavy oil (which is mainly diesel and fuel oil) used to grow horticulture produce qualifies for relief if it is used in the heating of any building or structure, or the earth, or any other growing medium in the earth, to help grow horticultural produce primarily with a view to growing that produce for sale, or to sterilise that earth or other growing medium. • Gas oil (Diesel), fuel oil, heavy oil and biodiesel used for off-road purposes are currently taxed at a lower rate. From 1 April 2022 onwards, the entitlement to use these taxed at a lower rate is removed from most sectors. Only fuels used in certain vehicles and machines in the agriculture, horticulture, fish farming and forestry sectors, fuels used in vehicles used on railways and fuels used for non-commercial electricity generation and heating will be taxed at the lower rate. • Oils that are supplied to CHPs registered under the CHP quality assurance (CHPQA) programme (and are therefore considered energy efficient) are exempted from the fuel duty. For CHP stations not meeting the threshold efficiency percentage, the fuel qualifying for exemption is scaled back based on the efficiency of the CHP. • Oils used in CHPs to generate electricity that is used onsite and oils to produce useful heat are exempted from the CPS rate of the fuel duty.

[120] https://www.gov.uk/government/publications/changes-to-rates-for-the-climate-change-levy-for-2022-to-2023-and-2023-to-2024/changes-to-rates-for-the-climate-change-levy-for-2022-to-2023-and-2023-to-2024
[121] https://www.gov.uk/government/publications/reform-of-red-diesel-entitlements/reform-of-red-diesel-and-other-rebated-fuels-entitlement

Nominal rate[122]	Main levy rates: • £0.5795/litre for heavy oils such as diesel until at least 31 March 2023 CPS levy rate (not applicable to the sectors in this study as the CPS levy only applies to electricity generation): • £18/tCO_2e until at least 31 March 2023
Effective carbon rate	• **€48.1/tCO_2** for fuel oil used in vehicles and machines in the agriculture, horticulture, fish farming and forestry sectors. • **€0/tCO_2** for heavy oil used to grow horticulture produce and fuel input in CHPs registered under the CHPQA programme. • **€250.3/tCO_2** in 2022 for fuel input not covered under the CHPQA programme.

Industrial Energy Transformation Fund	
Policy name	Industrial Energy Transformation Fund (IETF)
Status as of 1 January 2022	In force
Type of measures	Subsidy
Description[123]	The IETF is a programme that supports the development and deployment of technologies that enable businesses with high energy use to transition to a low carbon future through investment in energy efficiency and low carbon technologies. The IETF aims to reduce the payback period of more transformative energy efficiency measures and de-risking decarbonisation technologies for industry through grant funding. The funding can cover feasibility and engineering studies as well as deployment projects to install new equipment or technology.
Covered fuels	All fuels
Covered sectors	Mining, manufacturing, recovery and recycling of materials, and data centres

Industrial Strategy Challenge Fund	
Policy name	Industrial Strategy Challenge Fund (ISCF)
Status as of 1 January 2022	In force
Type of measures	Subsidy
Description[124]	The ISCF is a business-wide funding programme aiming to addresses the big societal challenges that UK businesses face today. It is backed by £2.6 billion of public money, with £3 billion in matched funding from the private sector. The ISCF is centred around four themes: 1) clean growth, 2) ageing society, 3) future of mobility and 4) artificial intelligence and data economy. The ISCF funds projects from research to development of innovative technology encouraging businesses and academia to work together. The most relevant theme for non-ETS manufacturing and agriculture sectors is related to clean growth. This ranges from large infrastructure and cluster projects on CCUS and hydrogen to innovative sector-specific technologies for manufacturing or transforming food production. Funding is provided in the form of grants either directly through the ISCF or via specific programmes such as the Farming Innovation Programme.
Covered fuels	All fuels
Covered sectors	All sectors

[122] https://www.gov.uk/government/publications/rates-and-allowances-excise-duty-hydrocarbon-oils/excise-duty-hydrocarbon-oils-rates
[123] https://www.gov.uk/government/collections/industrial-energy-transformation-fund
[124] https://www.ukri.org/our-work/our-main-funds/industrial-strategy-challenge-fund/

Net Zero Innovation Portfolio	
Policy name	Net Zero Innovation Portfolio
Status as of 1 January 2022	In force
Type of measures	Subsidy
Description[125]	The Net Zero Innovation Portfolio is a £1 billion fund to accelerate the commercialisation of low-carbon technologies, systems and business models in power, buildings, and industry. The portfolio consists of 10 priority areas, for which the most relevant one for the non-ETS manufacturing sectors is industrial fuel switching. The focus of the portfolio in these areas is the development of pre-commercial technologies through grant funding for the development and demonstration of technologies.
Covered fuels	All fuels
Covered sectors	Power, buildings and industry.

Farming Investment Fund	
Policy name	Farming Investment Fund (FIF)
Status as of 1 January 2022	In force
Type of measures	Subsidy
Description[126]	The FIF is a grant programme to improve productivity and bring environmental benefits in the agriculture and forestry sector. It consists of two funds. The Farming Equipment and Technology Fund provides grants towards the cost of equipment and technology to improve the productivity of farms in a sustainable way. The Farming Transformation Fund provides grants towards large capital items to help businesses improve water management, farm productivity and profitability, and environmental sustainability.
Covered fuels	All fuels
Covered sectors	Agriculture and forestry

II.5 France

The revised National Low-Carbon Strategy[127] (SNBC - *la Stratégie nationale bas-carbone révisée*) is the guiding roadmap for France's climate mitigation policy. The SNBC provides the nation's strategy for transitioning to a low-carbon economy, across all sectors, and defines the country's climate targets to reduce GHG emissions by 40% in 2030 compared to 1990 and ultimately achieve carbon neutrality by 2050. France's pathway to carbon neutrality is set up across three five-year carbon budgets and additional measures needed to achieve the SNBC targets are laid out in two five-year energy investment plans (PPE – *la progammation pluriannuelle de l'énergie*).

The French climate fiscal policy on domestic fuel consumption for non-ETS sectors is mainly related to its energy taxation, which informally includes a carbon component. Since 2022, the taxes levied on energy products (including natural gas, coal and oil products) now all fall under the tax code on goods and services (CIBS – *Code des impositions sur les biens et services*).[128] The French energy tax has an informal carbon component, which was introduced in 2014.[129] This carbon component was created to gradually increase from €7/tCO_2 in 2014 to €100/tCO2 in 2030. However, in response to the Yellow Vest

[125] https://www.gov.uk/government/collections/net-zero-innovation-portfolio
[126] Government UK (2022). Farming Investment Fund.
[127] Ministère de la Transition Écologique et Solidaire (2020). Stratégie nationale bas-carbone.
[128] Previously, these taxes fell under separate consumption taxes under the Customs code. In the current framework, the energy tax is split into five fractions: electricity, natural gas, mainland France on energy product other than natural gas and coal, overseas on energy products, other than natural gas and coal and coal.
[129] Article 32 of the finance law for 2014

(*Gilets Jaunes*) movement, the carbon price has been frozen at €44.6/tCO_2 since 2018. Furthermore, the carbon price is effectively lower for many energy consumers due to partial and full exemptions. Namely, companies in agriculture and forestry sectors pay taxes at a significantly reduced rate for natural gas, diesel, heavy fuel oil and LPG (combustible).[130] For example, agricultural companies effectively pay €2/tCO_2.[131]

Non-ETS companies subject to carbon leakage[132] also pay taxes at a reduced rate for natural gas, combustible natural gas, heavy fuel oil, domestic fuel oil and coal.[133] Companies subject to carbon leakage are also exempt from taxes on combustible LPG. There is a total exemption for taxes on natural gas when it is used for dual use—for chemical reduction, metallurgical, electrolysis processes, used for mineralogical processes or used for the production of energy products.[134]

The French government supports non-ETS sectors to become carbon-neutral through several funding schemes as well as public funding in research on new energy technologies. Namely, the PPE includes several funding programs. The Heat Fund (*Fonds chaleur*) supports renewable heat production projects across all sectors, including agriculture and industry. The fund allows for renewable heat to be competitive with heat produced from conventional energies. The fund was strengthened by the 2019-2028 PPE, which included a budget of €307 million in 2019 and €350 million in 2020 and 2021. The PPE also includes measures to promote renewable gas and hydrogen. The 2020-22 Recovery Plan includes €1.2 billion of support for the decarbonisation of industry in the form of: investment aid for energy efficiency projects; investment aid for electrification of industrial processes; investment and operational aid for renewable heat; and grants for small and medium-sized projects.[135] For agriculture and the food processing industry, the agriculture and forestry component of the Grand Investment Plan (GPI – *le volet agricole et forestier du Grand Plan d'Investissement*) is a funding source to support renewable energy and energy savings investments in these sectors.[136] Furthermore, in 2019, about €635 million of public research funding were dedicated to new energy technologies (renewable energy, energy efficiency, CCU, storage and networks).[137] About 3% of this funding is dedicated to energy efficiency in industry.[138]

Carbon taxation	
Policy name	La composante carbone dans la fiscalité des énergies fossiles
Status as of 1 January 2022	In force (as part of the energy taxation)
Type of measures	Pricing
Description	The carbon component of domestic consumption taxes was introduced in 2014, informally, by increasing the overall energy tax rates (TICPE, TICGN, TICC) (article 32 of the finance law for 2014). The carbon tax was set at €7/tCO2 in 2014 and it to gradually increase to €100/tCO2 in 2030. The carbon tax was frozen in 2018 in response to the Yellow Vest (Gilets Jaunes) movement. From 2018 to 2021, the price has remained at €44.6/tCO_2.

[130] Article L. 312-61 of the CIBS
[131] I4CE (2018). La composante carbone en France : fonctionnement, revenus et exonérations
[132] An energy-intensive company is defined based on Article 17 of Directive 2003/96/EC - company whose energy purchases are at least 3% of the value of production or whose annual energy taxes are more than 0.5% of the added value. Non-ETS companies subject to carbon leakage are defined as companies not subject to the ETS which carry out one or more activities listed in the appendix to Commission Decision 2014/746/EU of 27 October 2014 establishing, in accordance with Directive 2003/87/EC of the European Parliament and of the Council, the list of the sectors and sub-sectors considered to be exposed to a significant risk of carbon leakage.
[133] Article L. 312-77 of the CIBS
[134] Article L. 312-66 of the CIBS, Article L. 312-67 of the CIBS, Article L. 312-31 of the CIBS
[135] IEA (2021). France 2021 Energy Policy Review.
[136] This includes 5 billion euros of funding over 5 years (2018 to 2022), though covers a range of different investment priorities in the agricultural sector. Préfet de la Région Ile-de-France (n.d.). Le volet agricole et forestier du Grand Plan d'Investissement (GPI) présenté en Île-de-France.
[137] IEA (n.d.) France.
[138] About 13% of the total energy R&D funding is towards energy efficiency and 9% of that funding is towards industry. IEA (2021). France 2021 Energy Policy Review.

Covered fuels	All fuels
Covered sectors	All sectors except EU ETS installations
Nominal rate	€44.6/tCO_2
Relevant exemptions and rebates	See 'energy taxiation' fiche.
Effective carbon rate	See the effective carbon rate under Energy taxation (CIBS)

Energy taxation	
Policy name	Code des impositions sur les biens et services (CIBS)
Status as of 1 January 2022	In force
Type of measures	Pricing
Description	Until 31 December 2021, the excise duty on natural gas, coal and oil products in France resulting from the application of the ETD fell under separate consumption taxes. Since January 1, 2022, the excise duties levied on energy products no longer falls under the Customs Code. It is now detailed in the tax code on goods and services (CIBS) within the framework of the recodification. The energy tax is split up into five fractions: electricity, natural gas, mainland France on energy product other than natural gas and coal, overseas on energy products, other than natural gas and coal and coal.
Covered fuels	All fuels
Covered sectors	All sectors

Relevant exemptions and rebates	• Reduced rate for large energy-consuming companies subject to risk of carbon leakage and not in the EU ETS (including NACE 10.86 and 20.16, PRODCOM: 105121, 105122, 105153, 105154, 10515530)[139]
	  o Natural gas: €1.60/MWh
	• Reduced rate in agriculture and forestry activities:
	  o Natural gas: €0.54/MWh
	  o Diesel: €3.86/MWh
	• Reduced rate for natural gas consumed to dehydrate certain vegetables and aromatic plants, provided that consumption is greater than 800Wh per euro of added value: €1.60/MWh.
	• Total exemption for natural gas when: use other than fuel; gas has dual use; for extraction and production of natural gas; production of electricity.

Nominal rate	Natural gas: €8.41/MWh in 2022 Diesel: €67.64
Effective carbon rate	In 2022: Natural gas • **€2.9/tCO_2** for agriculture sectors • **€8.1/tCO_2** for 20.16, 10.86 and selected subsectors in 10.51 for natural gas Diesel • €14.48/tCO_2 for agriculture sectors

Heat fund	
Policy name	Fonds chaleur
Status as of 1 January 2022	In Force
Type of measures	Subsidy
Description	A fund, managed by the Ecological Transition Agency (ADEME), to finance renewable heating production for housing, community and businesses in all sectors.[140] From 2009 to 2020, the Heat Fund has supported 6,000 projects with €2.6 billion and produced 35.5 TWh/year of renewable heat.
Covered fuels	N/A
Covered sectors	All sectors

II.6 Spain

In 2021, the Spanish government adapted its climate law (*Ley de cambio climático y transición energética*), which aims to reduce overall GHG emissions by 23% in 2030 and ESR emissions with

[139] AIDA (2014). Décision n° 2014/746/UE du 27/10/14 établissant, conformément à la directive 2003/87/CE du Parlement européen et du Conseil, la liste des secteurs et sous-secteurs considérés comme exposés à un risque important de fuite de carbone, pour la période 2015-2019.
[140] ADEME (2022). Le Fonds Chaleur en bref.

37.7% and to reach climate neutrality in 2050. Prior to that, the Spanish government declared a climate emergency and announced an agenda with 30 lines of priority actions.[141] Specifically for the ESR sectors, it aims to reduce 37.7% in 2030 (compared to 2005).[142] Amongst others, the climate law prohibits new fossil fuel extraction on Spanish soils, requires businesses to submit climate action plans every five years, and also stresses the importance of the just transition in the industrial and agricultural sector.

Emissions in the most relevant non-ETS sector in this report for Spain—the horticulture sector—are indirectly taxed by the special tax on hydrocarbons in Spain, which contains reduced rates for industry and agriculture and exemptions for CHPs. The hydrocarbon tax is the equivalence of the energy tax in the Netherlands. Natural gas used in industry and agriculture is taxed at a significantly (10x) lower rate than the regular rate (for households). Likewise, diesel used in the agricultural sector is taxed at a lower rate (5x) than diesel used by consumers.

The just transition is a central component of the Spanish climate plans and various support schemes exist for the Spanish industrial and agricultural sectors. In the Spanish National Energy and Climate Plan (NECP), support programmes were announced to improve energy efficiency in e.g. agricultural machinery. For the 2021-2030 period, almost €1 billion is reserved for energy efficiency supporting mechanisms in the agricultural sector. In addition, grants exist to purchase more efficient tractors.

Energy taxation for hydrocarbons	
Policy name	Impuesto sobre hidrocarburos
Status as of 1 January 2022	In force
Type of measures	Pricing
Description	The hydrocarbons tax sets out the energy taxes in Spain levied within the framework of the EU Energy Taxation Directive (ETD). Energy taxes contribute to the financial incentive to reduce energy consumption.
Covered fuels	All fuels
Covered sectors	All sectors
Relevant exemptions, reductions and rebates	• Diesel used in the agricultural sector is taxed at a lower rate than the regular tax on diesel. • The tax rate for on natural gas 'special purposes', including its use in agriculture and industry, is a tenth of the regular tax rate for natural gas. • CHPs are exempted from taxation on natural gas. • Energy used in chemical reduction and electrolytic processes and inputs not used as fuel are exempted from the energy tax.
Nominal rate	Nominal rates vary per fuel type, with the nominal rates for the relevant fuel types as follows in 2021: • Natural gas: €5.05/MWh for use as heating fuel, €0.04/MWh used as heating fuels in particular professions (incl. in industry and agriculture). • Gas oils (incl. diesel): €0.31 per litre • Diesel in agricultural sector: €0.06 per litre • Coal: €0.04/MWh (Defined in separate *impuesto especial sobre el carbon* regulation)

[141] Gobierno de España (2020). *La declaración del gobierno ante la emergencia climática y Ambiental*.
[142] Spain (2020). NECP Spain.

Effective carbon rate	In 2021:[143] • **€2.7/tCO_2** for natural gas in (special purpose) agriculture and manufacturing sectors. • **€23.7/tCO_2** for gas oil in agriculture • **€2.7/tCO_2** for coal. For CHPs: • **€0/tCO_2** for installations using natural gas

Various subsidies and support programmes for horticulture	
Policy name	Plan RENOVE, Energy efficiency in farms, irrigation communities and agricultural machinery
Status as of 1 January 2022	In force
Type of measures	Subsidy schemes
Description	The Spanish government implemented various supporting mechanisms which are relevant for the agriculture sector: • Plan Renove is a national support scheme aiming to green the vehicle fleet in Spain by providing subsidies for vehicles with relatively low GHG emissions. It also includes grants for more sustainable agricultural machinery. • Energy efficiency in farms, irrigation communities and agricultural machinery (2.10 in NECP). Following measure 2.10 in the Spanish NECP, 929 million is reserved to improve energy efficiency in the agriculture sector for the period 2021-2030. It is estimated that this measure should save 1,203 ktoe energy between 2021-2030.
Covered fuels	All fuels
Covered sectors	e.g. horticulture

II.7 Gas and CHP use energy policies

Natural gas and CHPs are commonly used in many sectors, including plastics, dairy processing and greenhouse horticulture. Although detailed data is not available, CHPs are common for polymer production as well.[144] For dairy processing, CHPs are used but not on a significant scale; as an indication: 2 from the 9 Dutch ETS installations in the dairy processing sector use CHPs.[55] According to the sector association, no new CHPs have been used in the sector in the past 15 years.

In greenhouses the use of CHPs is very common. In the Netherlands 85% and in Belgium more than 60% of the natural gas use in the sector is valorised via CHPs.[145] Most large greenhouses use CHPs, while smaller producers generally use gas boilers. In other countries, CHP use is also common and still increasing and replaces the use of other, more CO_2-intensive fuels (e.g. fuel oil).

In many countries the use of CHPs is stimulated through several tax exemptions, leading to lower effective carbon rates. In Table II-1, the effective carbon rate for natural gas via CHPs are shown. The below tax exemptions are in place in the countries in scope of this study (more details in country fiches in annex II). We use effective carbon rates to compare the tax rates between countries.[146]

[143] Nominal rates converted to effective carbon rates after taking into account exemptions. For natural gas and gas oils, the calorific value and emissions factors as stipulated in the EU ETS have been used. For coal, the emission factor for the federal funding programme for energy and resource efficiency in the economy has been used.
[144] PBL & TNO (2021). Decarbonisation options for the Dutch polyolefins industry.
[145] Netherlands: Based on data from sector association. Belgium: Vlaanderen (2021). Energiebalans.
[146] Blueterra (2022). Notitie energiebelastingen, heffingen en netkosten voor tuinders in binnen en buitenland; to be published.

- **The Netherlands:** High efficiency CHPs in all sectors–including industry and agriculture–are fully exempted from all energy taxes (both ODE and energiebelasting) The whole greenhouse sector also has a lower rate for both energy taxes (ODE and energiebelasting), which also leads to a lower tax rate for the use of gas boilers in greenhouses.
- **Germany:** A major part of the effective carbon rates in Germany comes from the national ETS. In 2022 the polymer sector and parts of the dairy sector receive a reduced rate of €10.5/tCO_2. Fuel used in greenhouses is taxed the full tariff of €30/tCO_2. The nEHS also applies for fuel used in CHPs. Besides the nEHS,, CHPs receive several tax exemptions: high efficiency CHPs are fully exempt of energy taxes, while low efficiency CHPs have a reduced rate of €3/tCO_2. As a result, the effective carbon rate for CHPs is (almost) identical to the nEHS carbon rate. In addition, high efficiency CHPs also can receive an operational subsidy (KWK Gesetz).
- **Belgium:** Fuel used in CHPs is fully exempted for the energy contribution (energiebijdrage). For the other federal tax (federale bijdrage) only the gas used for producing electricity delivered to the grid is exempted. Furthermore, CHP use is stimulated through CHP-certificates–similar to the German operational subsidy —.
- **United Kingdom:** Sectors having a Climate Change Agreement (CCA) can acquire up to an 83% lower rate on the Climate Change Levy (CCL). The plastics, dairy and horticultural sector all have such an agreement, as well as many other sectors. Furthermore, high efficiency CHPs falling under the CHPQA criteria are exempted of the CCL. In practice, this means that the effective carbon rate is €0/tCO_2 for most CHPs used in the UK.
- **France:** In contrast to other countries, CHPs do not receive any significant exemptions in France, although the basis effective carbon rate is relatively low, especially in the horticultural sector.
- **Spain:** CHPs are fully exempted for energy taxes (specifically the Impuesto sobre hidrocarburos). In general, natural gas used in both industry and agriculture in Spain has a low effective carbon rate, resulting from a reduced tax rate for these sectors.

Table II-1 Overview of gas tax rates in industry and horticulture, as well as for CHPs in relevant countries in 2022 in €/tCO_2

Effective carbon rate for gas use (range)	NL	DE	BE	UK	FR	ES
Industry (e.g. polymers, dairy)	29-251	14-33[147]	4-8	5-30[148]	8	2.7
(Greenhouse) horticulture	25-40	53	3-3.3	5	2.7	2.7
Effective carbon rate when using CHPs						
Industry (e.g. polymers, dairy)	0	HE CHP: 10.5 LE CHP: 13.5	0	0	8	0
(Greenhouse) horticulture	0	HE CHP: 30 LE CHP: 33	0	0	2.7	0

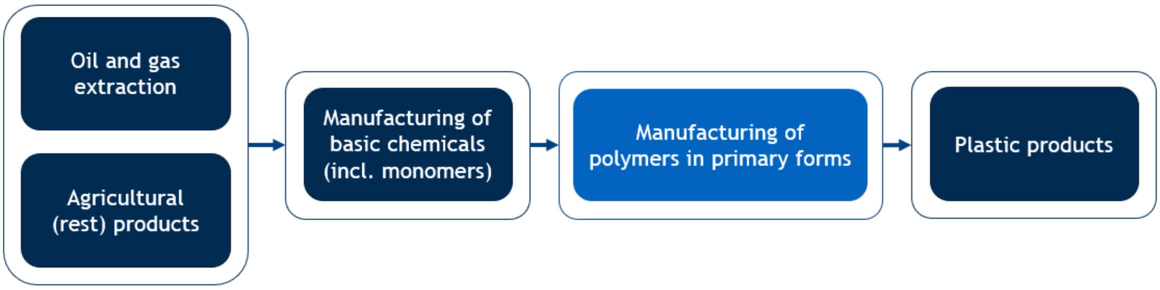
[147] Including German CO_2-tax of €30/tCO_2 for horticulture and €10.5/tCO_2 for relevant industrial sectors
[148] In practice most gas used in industrial sectors (including polymers and dairy) is taxed on the lower end of the range (close to €5/tCO_2), as most receive a large discount as a consequence of involvement in a CCA.

Annex III Sector characteristics

III.1 Manufacturing of polymers

The plastics value chain involves various links. The middle part of the chain includes the production of polymers out of basic primary chemicals. In the first link of the value chain, raw materials are produced, which involves oil and gas extraction or the use of agricultural products for bio-based plastics. In the second link, raw materials (naphtha) are processed to produce basic chemicals, such as monomers. The most common process used in this step is steam cracking, although low-carbon alternatives (such as electric cracking) are getting closer to be market ready. In the third link, polymers are manufactured using monomers as feedstock. The final step is to produce plastic *products*, such as plastic packaging products, furniture, or footwear.[149] The sector analysed in this report only covers the third step – the production of monomer plastics, which coincides with NACE[150] sector 20.16–manufacturing of plastics in primary forms.[151]

Figure III-1 Simplified diagram of the plastics value chain



With a gross added value of €2.4 billion in 2019, the Dutch polymer plastics manufacturing sector contributed substantially to the Dutch economy. In the same year, the sector emitted 1.3 $MtCO_2e$, of which 10% is estimated to be emitted by non-ETS installations. The sector's gross value added (GVA) of €2.4 billion corresponds with a 0.3% share in the Dutch GDP in 2019. Data on sales values data[152] of products within the sector, covering 58% of the total sales value in the sector, shows that the sales values of polymers of ethylene, polyacetals and polymers of propylene and other olefins account for relatively large shares of the total sales in the sector (38% in total). The total direct GHG emissions from ETS and non-ETS installations equalled 1.3 $MtCO_2e$ in 2019,[153] which corresponds with 2% of the Dutch industrial emissions in that year. According to our estimates, about 10% of the sector's GHG emissions are emitted in non-ETS installations, which corresponds with 1% of industrial ESR emissions and 0.1% of total ESR emissions.

[149] Principles for Responsible Investment (2019). The plastics landscape – risks & opportunities along the value chain.
[150] Eurostat (2008). NACE Rev. 2 - Statistical classification of economic activities in the European Community.
[151] NACE 20.16 covers the production of resins, plastics materials, and non-vulcanisable thermoplastic elastomers. It also includes mixing and blending of resins on a custom basis and the production of non-customised synthetic resins. Specific products: Polymers of ethylene, propylene, styrene, vinyl chloride, vinyl acetate and acrylics, polyamides, phenolic and epoxide resins and polyurethanes, alkyd and polyester resins and polyethers, silicones, ion-exchangers based on polymers and the manufacturing of cellulose and its chemical derivatives. The production of artificial and synthetic fibres, filaments and yarn, as well as shredding of plastic products are not covered by this sector
[152] CBS (2021). *Verkopen; industriële producten naar productgroep (ProdCom)*.
[153] Estimation based on total GHG emissions from *emissieregistratie*, corrected for emissions from installations Chemelot which are unrelated to NACE 20.16 and included ETS emissions from Dow related to NACE 20.16 and emissions from Chemours, Hexion, Indorama, Botlek (Shin-Etsu) and Covestro registered under NACE 20.16 in the emissions registration are removed (as they are classified in another NACE code in the installation list used to determine the ETS Phase 4 carbon leakage list).

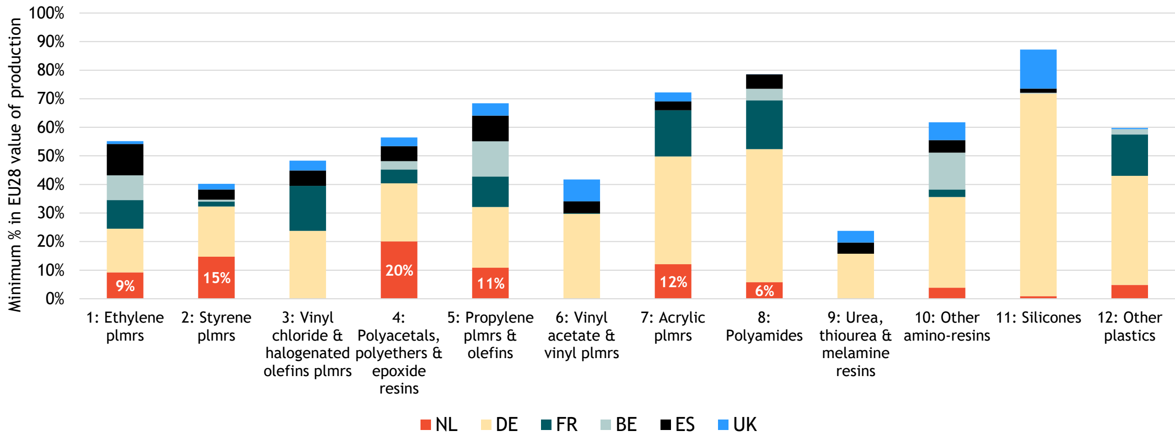
The Dutch market share within the manufacturing of plastics in primary forms is substantial, covering roughly 10% of European production.[154] Data on sold production (in €) of manufactured goods in 2019 shows that the Dutch plastics sectors has relatively high market shares in the sales of certain polymers, as shown in Figure III-2. Based on publicly available data, it is concluded that the market shares of Dutch business are particularly high for polymers of acetals/ethers (at least[155] 20% of EU28 sales value), styrene (15%), and acryl (12%) and propylene (11%).

Dutch non-ETS plastics manufacturing facilities predominantly produce specialty polymers—including (coating) resins—and polymers of propylene, styrene, and esters. As shown in Table III-1, the three largest non-ETS monomers plastics manufacturing companies[156] in the Netherlands in terms of direct GHG emissions are Allnex Netherlands, Ducor Petrochemicals and Synthos. Ducor is located within the industrial cluster of Rotterdam, Allnex close to Sabic in Bergen op Zoom (a large ETS-plastic manufacturer), and Synthos in Breda, without large industrial companies close by. Allnex produces (alkyd) coating used in e.g. the automotive industry, Ducor produces polypropylene, and Synthos produces expansible polystyrene. Other non-ETS facilities produce a variety of specialty products, including coating resins, (co)polyesters, expansible polystyrene. These products coincide with the following product groups in Figure III-2: coating resins and (co)polyesters are covered in product group 4 (polyacetals, polyethers & epoxide resins), polypropylene in group 5 (polymers of propylene and other olefins), expansible polystyrene in group 2 (polymers of styrene).

Table III-1 Largest non-ETS Dutch polymer manufacturers and corresponding products

Company	Products	Type
Allnex Netherlands	Resins, including coating resins and special purpose coating	Specialty products
Ducor Petrochemicals	Polypropylene and polyethylene and other polyolefins	Commodity plastics
Synthos	Expandable polystyrene	Commodity plastics
BASF Catalysts	Various catalysts	Specialty products
DSM (Neo)Resins	Coating resins	Specialty products
Rest	(Specialty) polyesters, resins, expandable polystyrene, nylon, methanol, formaldehyde	Both

Figure III-2 Sold production value (€) manufactured plastics in 2019 - minimum share per country as % of EU27+UK



Source: Eurostat (2021). Statistics on the production of manufactured goods.

[154] CE Delft (2021). Nationale heffing op virgin plastics.
[155] The statistics contain data gaps as several datapoints are not shown for confidentiality reasons. For this reason, the shares shown should be interpreted as minimum market shares–actual market shares may be substantially higher.
[156] Identified using data from *Emissieregistratie*. Companies with primarily EU ETS installations have been excluded.

*Note: Shares represent the **minimum** share, as in various cases no country specific data is available for subproducts due to data confidentiality. Missing data for NL per product: 1: 1/5 subproducts missing, 2: 2/5, 3: 5/6, 4: 5/11, 5: 0/2, 6: 2/3, 7: 0/3, 8: ½, 9: 2/2, 10: 1/3, 11: 0/1, 12: 3/6.*

Within the EU, German and Belgian manufacturers are the main competitors of Dutch plastics manufacturing facilities. As shown in Table III-2, Germany is the biggest trading partner both in terms of imports as well as exports. Germany is particularly relevant for Dutch exports. The value of exports to Germany is roughly equal to the sum of exports to the three biggest export countries following Germany. Other relevant countries for exports are Belgium, the UK, France and Italy. In terms of imports, Germany and Belgium are by far the most important trading partners—imports from these countries are 4-5 times bigger than imports from the third largest trading partner in terms of imports (France). Public trade statistics on the specialised products that non-ETS manufacturing facilities mainly produce (resins, polymers of propylene, styrene, and esters), confirm the relative importance of Germany and Belgium as trading partners. Other relevant trading partners are France, the UK, Italy and Poland (only for imports), but much less relevant than these neighbouring countries. As shown in Table III-2, German manufacturing facilities have particular high market shares.

Table III-2 Trade values (in million €) of the Dutch manufacturing of plastic in primary forms sector in 2019

Trading partner	Imports	Exports
Germany	1582	3233
Belgium	1241	1482
United Kingdom	276	972
France	301	997
Spain	198	440

Based on data from: Eurostat (2022). Comext: EU trade since 1988 by CPA 2008.

Manufacturing of polymer plastics requires electric and thermal energy for various processes. Even though some processes are exothermic (lowering the heat demand), natural gas is a commonly used fuel in the Dutch sector. The production of resins and polymers of propylene, styrene, and esters involves various processes, including compressing, mixing, polymerisation, and in some cases drying. Relevant polymerisation process technologies include high-pressure, solution, suspension, and gas phase polymerisation. Many polymerisation processes are exothermal and only require energy to initiate the process. Polypropylene is produced using a gas phase polymerisation process which requires 1.3 MJ electricity per kg of product and 0.6 MJ heat.[157] The production of polyesters requires thermal energy for conditioning of feedstock, for the production process and for reaction water treatment.[158] In addition, various electrical equipment, such as pumps and agitators use electricity. In the Netherlands, most of the required energy for these processes is produced by onsite combined heat power (CHP) installations fuelled by natural gas.

Decarbonisation options in the manufacturing of polymers sector include using renewable energy sources, recycling, modified process design, and CCS. Various decarbonisation options are mentioned in the literature. With the concept of fuel substitution, the same amount of electricity and heat is produced with different (low carbon) technologies, such as industrial electric heat pumps, biomass fuel for cogeneration or fuelling with hydrogen. A reduction in GHG emissions can also be achieved through modifications in product design aiming to reduce energy consumption. Options for improved process design include general energy efficiency gains, use of better catalysts and improved heat recovery. Carbon Capture and Storage (CCS) can serve as an end of pipe solution, although mostly in larger (ETS) installations. For various decarbonisation options, high costs remain the main barrier (e.g.

[157] PBL & TNO (2021). Decarbonisation options for the Dutch polyolefins industry.
[158] European Commission (2007). Reference Document on Best Available Techniques in the Production of Polymers.

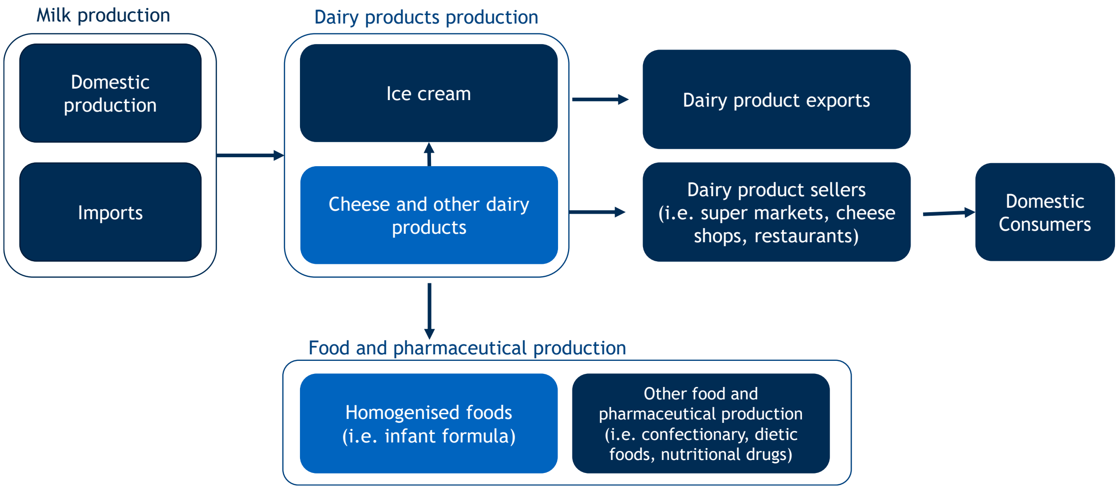
electrification and hydrogen). In some cases, availability is also an issue, for instance due to the lack of adequate infrastructure (hydrogen, CCS and even for electricity in some cases). For the plastics value chain as a whole, circular economy concepts (including, but not limited to recycling) are also relevant for decarbonisation.

III.2 Manufacturing of dairy products

The dairy value chain includes four main components: milk production, dairy product production and the further processing of other food/pharmaceutical products or the export/sale of dairy products (Figure 6-3). First, raw milk is produced at dairy farms. Then, the raw milk is processed to produce dairy products. Most of the raw milk used for dairy products is produced domestically.[159] The dairy products are either: i) exported, ii) sold to dairy product retailers, such as supermarkets and cheese shops, which are then sold to consumers, or iii) used for manufacturing other food or pharmaceutical products (including homogenised foods such as infant formula.

The sector analysed in this section covers two elements: the production of dairy products from raw milk, excluding ice cream (i.e. NACE 10.51) and manufacture of homogenised foods (NACE 10.86) (light blue boxes in Figure 6-3). For homogenised foods, only the production of infant formula[160] (milk powder) is addressed, as this is the largest product in the sector and the most energy-intensive product in the homogenised foods sector. Over half of the sold production in the dairy and cheesemaking industry is cheese and curd, of which most is cheese production (i.e. mainly gouda but also edam and semi-hard cheeses). The rest of the sector includes manufacturing of: fresh liquid milk (pasteurised, sterilised, homogenised and/or ultra-heat treated), milk-based drinks, cream, dried/concentrated milk, milk/cream in solid form, butter, yoghurt, whey, casein and lactose (not including ice cream).[161] As of 2021, there are 52 dairy product factories in the Netherlands,[162] of which half of the dairy industry factories are owned by FrieslandCampina.[163] Some actors in infant formula production are also in the dairy industry (such as FrieslandCampina and Vreugdenhil Dairy Foods).

Figure 6-3 Simplified diagram of the dairy value chain



[159] CE Delft (2018). Effecten van CO2-beprijzing in de industrie.
[160] Infant formula is a substitute for human milk which commonly contains a mixture of skimmed milk (turned in to a powder), whey, casein, lactose, oils and vitamins. Homogenised foods also includes baby foods and special diet foods (for weight loss, low-sodium, gluten-free, etc.), however, these are not in the scope of the study because they have relatively low emissions.
[161] CBS (2021). *Verkopen; industriële producten naar productgroep (ProdCom)*.
[162] ZuivelNL (2021), Zuivel in cijfers editie 2021.
[163] CE Delft (2018). Effecten van CO2-beprijzing in de industrie.

The Dutch dairy and homogenised foods manufacturing sector (excluding ice cream production) sold[164] €8 billion of dairy products in 2019 and emitted about 1 Mt CO_2 eq in the same year. The sold production from these sectors is about 0.5% of the total production value of the Dutch economy. In 2019, the processing of dairies and cheesemaking (NACE 10.51) and homogenised foods manufacturing (NACE 10.86) accounted for 16% of the food processing industry's sold production value.[165] In 2019, at least 0.76 million tCO2e of greenhouse gas emissions were attributed to these sectors[166] which corresponds to 1.4% of the Dutch industrial emissions in the same year. Because this estimate is based on registered emissions only, the actual emissions from these sectors are most likely higher. Namely, a study by Wageningen University estimates that milk processing led to 1 Mt CO_2 eq in 2019.[167] Almost all of the sector's GHG emissions are CO_2, with less than 1% being CH_4, N_20 and HFK-134a. It is estimated that about 29% of the dairy sector's GHG emissions and 62% of the homogenised foods sector emissions are non-ETS emissions, which corresponds with 3.3% of industrial ESR emissions and 0.35% of total ESR emissions.[168]

Emissions from dairy production and homogenised foods mainly come from the heat processes from the production of milk, whey powder and infant formula. Carbon emissions from dairy production are related to mainly steam production for pasteurization and sterilization as well as hot drying air production for milk powder production.[169] The most energy intensive dairy products are milk powder, lactose/lactose syrup and whey,[170] mainly due to the heating processes required to manufacture these products.[171] The manufacturing of infant formula requires similar heating processes[172], which is the main source of emissions for the homogenised foods sector.

Most of the dairy ETS installations produce milk powder and whey products as well as cheese and milk and the non-ETS dairy product facilities which produce the greatest emissions mostly produce milk powder. At least six of the eleven Dutch ETS installations in this sector produce milk powder and/or whey. However, not all dairy product facilities which produce milk powder and/or whey products are under ETS.

Table III-3 Top five Non-ETS dairy product facilities with the greatest GHG emissions

Dairy product facility	Main dairy product(s)
Vreugdenhil Dairy Foods Scharsterbrug	Milk powder
FrieslandCampina Kievit (Meppel)	Creamer, milk powder
Lyempf Kampen BV	Milk powder
FrieslandCampina Cheese (Gerkesklooster)	Cheese, milk powder (until 2022)[173]
Hochwald Nederland BV	Condensed milk

All emissions (ETS and non-ETS) from the homogenised foods manufacturing sector come from the production of infant formula. There is only one ETS installation in this sector (Abbott Laboratories B.V.) and two known non-ETS facilities which produce emissions (Mead Johnson B.V. and Nestle Nederland B.V.). All three of these facilities produce infant formula.

[164] Total production (sold and unsold) is not publicly available for NACE 10.51 due to insufficient data.
[165] CBS (2021). Verkopen; industriële producten naar productgroep (ProdCom).
[166] Based on data from the emissions registration emissions per company (CO_2, N_2O, CH_4, HFKs)
[167] Doornewaard et al. (2020). Sectorrapportage Duurzame Zuivelketen prestaties 2019 in perspectief.
[168] ESR emissions are based on total non-ETS GHG emissions and total non-ETS industry emissions in 2019, from RIVM (2022). Broeikasgasemissies: ETS versus niet-ETS.
[169] CE Delft (2018). Effecten van CO2-beprijzing in de industrie.
[170] *PBL, TNO (2020).* Decarbonisation options for the Dutch dairy processing industry.
[171] PwC (2020). Speelveldtoets 2020.
[172] VNFKD (2019) Nutrition in the first four years: a good start in life.
[173] FrieslandCampina (2020). FrieslandCampina beëindigt poederproductie in Dronrijp en Gerkesklooster.

There are several options for decarbonisation in these sectors, namely by first reducing energy needs and deploying renewables for heat and steam production. A study by TNO and the Netherlands Environmental Assessment Agency (PBL)[174] categorised types of decarbonisation options available for the Dutch dairy processing sector, including:

- *Process design*: implementing more energy efficient processes for currently energy intensive processes, such as using heat pumps for low-temperature heating processes; and
- *Use of residual energy*: re-using residual heat; and
- *Fuel/feedstock substitution*: electric, hydrogen or biogas boilers; geothermal energy

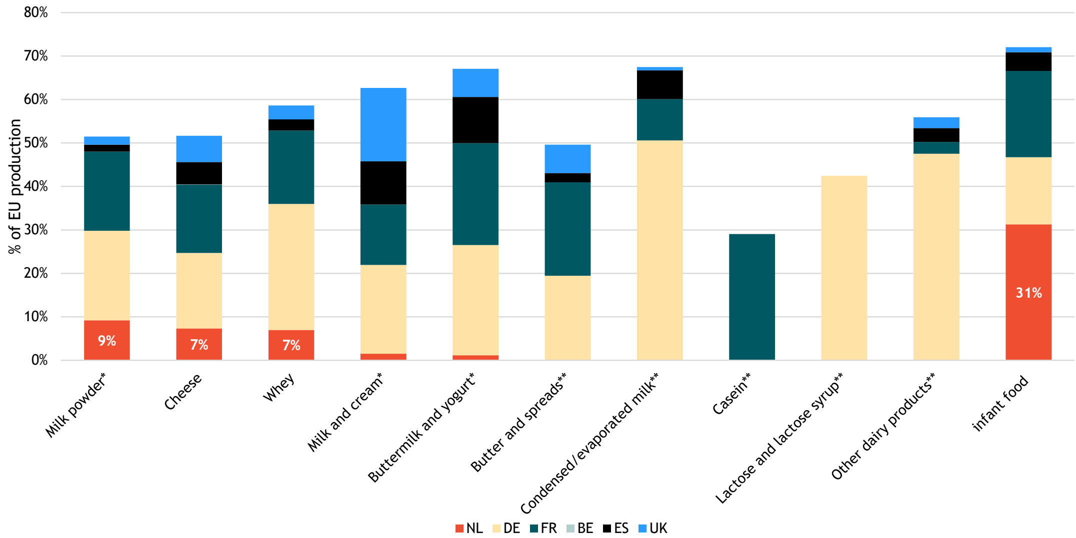
Carbon capture and utilisation or storage is also an option considered, however due to the relatively small-scale and location of dairy processing facilities, there does not seem to be great potential for CCU/CCS in this sector. Electrification can be an important decarbonisation pathway, but could be impeded by higher costs for increasing the electricity grid connection than on average, given that most dairy processing plants are in rural areas with limited current grid capacity.

The Dutch dairy industry has a strong international competitive position, including outside of the European market,[175] though the geographical scope of competition depends on the shelf-life of the product. Most of the Dutch dairy products are exported: 40% of the dairy products are exported within the EU and 25% is exported outside of the EU, mainly to China, South Korea and Japan.[176] 35% of the dairy products stay within the Netherlands. The geographical scope of competition depends on the properties of the product, where the relevant geographic market is smaller for fresh products like milk and cheese, whereas it is larger for long shelf-life products like milk powder and lactose.[177] About 80% of the exported baby milk powder is exported to Asia.[178]

Within the European market, Germany and France are the largest competitors for the Netherlands for milk powder and whey as well as for infant formula. Figure III-4 Within Europe, the Netherlands seems to play a larger role (>5% of EU sold products) in infant formula, milk powder, cheese and whey.[179] For these products, Germany and France seem to be the dominant competitors of the five countries considered. Ireland, Poland and Denmark are also important competitors in the European market.

[174] PBL, TNO (2020). Decarbonisation options for the dutch dairy processing industry.
[175] CE Delft (2018). Effecten van CO2-beprijzing in de industrie.
[176] ZuivelNL (2021), Zuivel in cijfers editie 2021.
[177] PwC (2020). Speelveldtoets 2020.
[178] VNFKD (n.d.). Export Zuigelingenvoeding.
[179] Due to data confidentiality, the Dutch share of the EU market for many of the products are underestimated. This is also an significant issue for estimating the share for Belgium and the UK.

Figure III-4 Minimum share per country of EU sold production of dairy products and infant food, 2019



Source: Eurostat (2021). Statistics on the production of manufactured goods.
Note: Shares represent the minimum share, as in various cases no country specific data is available for subproducts due to data confidentiality.
*Some of the production values for products in this group are confidential for the Netherlands, therefore production values are underestimated
**All of the production values for the products in this group are confidential for the Netherlands, therefore production values for the Netherlands are unknown.
Infant food excludes homogenised composite food preparations (food preparations consisting of finely homogenised mixtures of two or more basic ingredients such as meat, fish, vegetables, fruit or nuts for sale as infant food)

The main European trading partners for the Netherlands in these sectors are Germany and Belgium for both imports and exports Table III-). Within the Dutch dairy production market as well as the homogenised foods sector, the Dutch industry competes most with Germany and Belgium. These countries mainly import milk & cream and cheese, but also whey and butter to the Netherlands.

Table III-4 Trade values (in million €) of the Dutch manufacturing of dairy and cheese sector & homogenised foods sector in 2019

Trading partners for the dairy sector	Imports to NL	Exports from NL
Germany	1452	1970
Belgium	759	1230
France	328	819
United Kingdom	157	241
Spain	41	286
Trading partners for the homogenised foods sector	**Imports to NL**	**Exports from NL**
Germany	43	21
Belgium	12	24
United Kingdom	2	14
France	24	17
Spain	7	15

Based on data from: Eurostat (2022). Comext : EU trade since 1988 by CPA 2008.

III.3 (Greenhouse) horticulture

About a fifth of the Dutch agricultural production value was produced in greenhouses in 2018, in which a large variety of products are cultivated.[180] 58% of Dutch horticultural production value is

[180] CBS (2021). Landbouw; financiele gegevens landbouwbedrijven; agricultural sector refers to agricultural production sector. Thus, theproduction of e.g. agricultural machinery production is not included.

produced in greenhouses.[180] Dutch greenhouse production is characterised by closed agricultural systems where climatic conditions are controlled, such as temperature, humidity and CO_2 concentrations. Greenhouses are centralised in several locations in the Netherlands. Most can be found in the provinces of North and South Holland, with the largest in the Westland region.

Total production value of crops in Dutch greenhouses was €5.7 billion in 2018. Greenhouse horticulture can be divided in two main categories: a) vegetables and fruits and b) ornamentals (including cut flowers and (potted) plants). The production value of vegetables was highest in 2018 (€2.1 billion), followed by (potted) plants (€1.4 billion), flowers (€1.4 billion) and other greenhouse production (€0.8 billion).[180] Common crops in greenhouses are flowers (2048 ha), tomatoes (1652 ha), bell pepper (1504 ha), cucumber (540 ha) and strawberries (489 ha) on a total production area of close to 10,000 hectares in 2019. [181]

Fuel emissions in greenhouse horticulture are significant and mainly the result from heating the greenhouses with mainly natural gas via CHPs. Greenhouse production accounts for 80% (27.7 TWh) of total energy use and 83% (6.0 Mton CO_2) of energetic emissions in the Dutch agricultural sector in 2019.[182,183] The rest of the energetic emissions are mainly from open field agriculture due to e.g. transport fuel for vehicles (tractors) and heating of buildings/barns. Because of the Dutch climate, the large majority of greenhouses in the Netherlands are heated. This leads to an (energetic) emission intensity of between 0.7 and 1.5 kg CO_2/€ of production value. Emission intensity of the production of flowers and plants on average is lower than of vegetables.[182] Since production value is always higher than gross value added, this shows that emission intensity per GVA is clearly higher than the 0.2 kg CO_2/€ threshold for the European CL criteria. Since 2000, the use of local CHP plants has been financially stimulated as the produced energy can be used efficiently: heat is used in the greenhouses, the by-product CO_2 is used in the greenhouse to stimulate crop growth and the residual electricity is then sold on the electricity market. Even in summer CHPs are sometimes used solely for the CO_2 and to generate electricity (*zomerstook*); the produced heat is then not used.[184] The market share of greenhouse CHPs in the Dutch electricity market is significant: in 2019 9.3% of the total Dutch electricity production came from CHPs at greenhouse locations.[185]

More than 90% of the sector in the Netherlands is not part of the ETS. In fact, the share of ETS installations has reduced significantly in recent years. In 2019, an estimated share of only 5-10% of total energetic emissions from greenhouse horticulture falls under the ETS.[186] While in 2012 90 out of 3500 greenhouse sector companies were under the ETS, this has reduced to 15 as a result of producers that do not fall within the ETS definition anymore (splitting of companies, limiting the capacity of CHPs under the ETS limit, new back-up regulation).[187] As a result, energetic emissions of greenhouses are responsible for 5.6% of total Dutch ESR emissions in 2019.[188] Instead of the ETS, Dutch non-ETS greenhouses do fall under a sectoral CO_2-pricing system, which in practice does not lead to any

[181] CBS (2021). Landbouw; gewassen, dieren en grondgebruik naar regio.
[182] Trinomics (2021). Beknopte vergelijkende analyse van het energiegebruik en de CO2-uitstoot van de Nederlandse en Vlaamse land- en tuinbouwsector.
[183] Land use and methane emissions are not within scope.
[184] WUR (2019). Zomerstook voor CO_2-dosering.
[185] CBS (2021). Elektriciteitsbalans; aanbod en verbruik; CBS (2021). Elektriciteit; productie en productiemiddelen.
[186] Trinomics (2021) Database, based on EUTL.
[187] Nea (2018). Ingetrokken emissievergunningen 2012-2017.
[188] Emissieregistatie (2021). Broeikasgasemissies: ETS versus niet-ETS. This includes emissions of other GHG's such as methane.

significant pricing.[189] In other countries with production in heated greenhouses the share of ETS companies is even smaller and lower than 5%.[190]

Some (Southern) European competitors of Dutch greenhouse producers have significantly different production characteristics, including a much lower energy and emission intensity, resulting from the different climate in which they operate where no external heating is required. Crops that are produced in heated greenhouses in the Netherlands are produced in open fields or in unheated greenhouses in countries with warmer climates. Therefore, the production characteristics and subsequent fuel use and emissions also are very different. In Europe three production systems are identified for crops that are produced in greenhouses in the Netherlands: a) heated high-tech greenhouse production–similar to the Dutch production system, b) unheated plastic greenhouse production and 3) open field production.[191] Limited data is available to get an accurate overview of which crops are produced in which system in which country though. In general, heated greenhouses are mostly found in Northern Europe (e.g. UK, Netherlands, Belgium, Germany, Northern France) and all use a large share of natural gas. In the south[192], unheated greenhouses and open field production is dominant (e.g. Spain and South of France). Also, production in unheated and open field agriculture is generally more seasonal than production in heated greenhouses, although not all heated greenhouses produce in winter because of higher heating costs. In general, the energy and fuel use in unheated and open field production is significantly lower than in heated greenhouse production as no additional heating is required. Thus, unheated production is basically all non-ETS.

Decarbonisation options for heated greenhouses include the use of geothermal energy, improved energy efficiency and the use of residual heat. Fossil fuel use can be replaced by several renewable techniques. Geothermal has a large potential for the Netherlands and is already exploited on commercial scale in some clusters. Additionally, there is potential for electrification of the heat supply via heat pumps in combination with thermal energy storage or for the use of residual heat depending on the local context. Biogas can also be used instead of natural gas in CHPs.[193] In case CHPs are not used anymore, it is also necessary to find an alternative source of CO_2. In general, energy use is already optimised in heated greenhouses as energy costs form a large part of total production costs. However, energy demand could be further reduced by e.g. improved heat retention. The practice of using CHPs in summer (zomerstook) also shows that there is still room for further improving energy efficiency. The need for decarbonisation is less relevant for production in open field and unheated greenhouses as energy use is significantly lower, although these production methods are also paired with wider sustainability challenges that are out of scope of this report.[194]

Dutch greenhouse production is predominately destined for the export market. Germany, the UK and Belgium are the largest European trade partners. A significant share is exported to non-EU-countries. Although there is no export data for only greenhouse production, the Dutch export value of the three NACE sectors that are dominated by greenhouse production in the Netherlands totalled €18 billion in 2019. In the same year, imports in these sectors equalled €5.2 billion (as shown in the table

[189] GlastuinbouwNL (2020). Wat is het CO2-sectorsysteem en wat betekent het voor de glastuinbouw?
[190] EUTL (2021). Carbon Leakage List Phase 4, through a Trinomics database.
[191] Bio Greenhouse (2016). Sensible use of Primary Energy in Organic Greenhouse Production
[192] Fuel use was more varied in the past but in recent years there is a clear trend towards the use of gas
[193] Trinomics (2021). Beknopte vergelijkende analyse van het energiegebruik en de CO2-uitstoot van de Nederlandse en Vlaamse land- en tuinbouwsector.
[194] Specifically for unheated greenhouses: Castro et al (2019) Six Collective Challenges for Sustainability of Almería Greenhouse Horticulture.

belowTable III-).[195] A significant proportion (~30%) of exports are extra-EU for all three NACE code sectors.

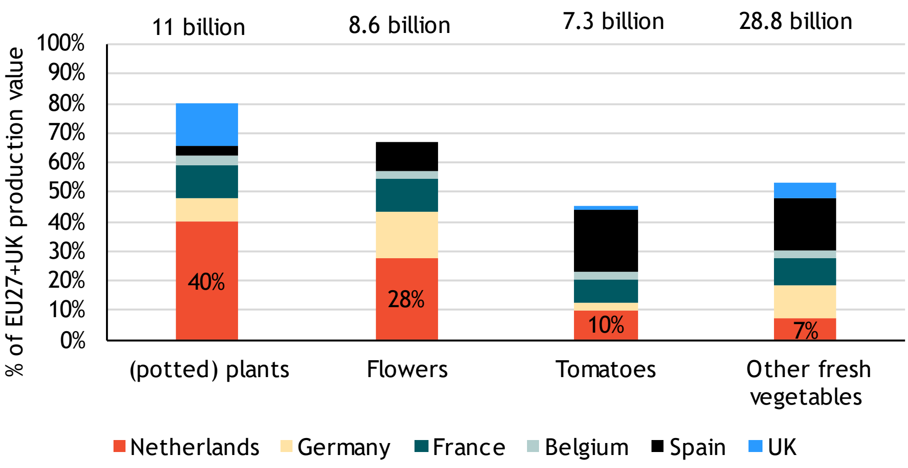
Table III-5 Trade values (in million €) in 2019 with main trading partners of the Dutch horticulture production in NACE codes 1.13 - growing of vegetables and melons, roots and tubers;1.19 - Growing of other non-perennial crops; 1.30 - Plant propagation.

Trading partner	Imports	Exports
Germany	687	5010
Belgium	611	1339
United Kingdom	78	1989
France	283	1377
Spain	758	470
Total (intra-EU, excl. UK)	**2781**	**11863**
Total (extra-EU)	**2113**	**5205**

Based on data from: Eurostat (2022). Comext : EU trade since 1988 by CPA 2008.
Note that these NACE categories are broader than only greenhouse production.

The main European competitors for Dutch greenhouse production are Spain, Germany and France. The figure below shows the market shares in terms of production value in more detail. The Netherlands is especially a large player in the production of plants and flowers. Competition for fresh vegetables in terms of production value is more dispersed which is largely because these crops are less export oriented.

Figure III-5 Production value of the main trading partners for the main relevant horticulture categories as a percentage of total EU27+UK production in 2019. In addition, total EU27+UK production value is given (in billion €) above the table.[196]



Source: Eurostat (2021). Economic accounts for agriculture. Values at current prices.

[195] The trade balance of the three NACE codes (€13.3 billion) seems large compared with the production value of €5.7 billion of Dutch greenhouses in 2018. This does show that exports are significant, but note that also non-greenhouse production falls under these NACE codes, such as potatoes.

[196] The used data is different from the data used for production value in Dutch greenhouses for the sake of comparability between countries. Categories above are in source data called nursery plants (potted plants), ornamental plants and flowers (flowers), tomatoes (tomatoes) and other fresh vegetables excluding cauliflower (other fresh vegetables). While the scope of the used categories does differ slightly, the overall picture is similar to what was used for the Dutch greenhouses. Only the 'other fresh vegetables' category is substantially broader and also includes many vegetables that are produced in open field instead of in greenhouses in the Netherlands.

III.4 Comparison of energy use and CO_2 emissions for tomato production in different production systems

A wide range of literature exists on the life cycle impacts of tomato production in different production circumstances. Tomato is the most grown crop in (heated) greenhouses and serves as a representative crop for analysing the difference in energy use between production systems, albeit energy use per m^2 for tomato is on average slightly higher than for many other vegetables and flowers.

Pineda et al (2021)[197] have reviewed a large collection of tomato LCAs and summarise their conclusions among others on the energy use and GHG emissions of tomato production. Most importantly, the literature review helps to get an overall assessment of the differences in (fossil) energy use for both production in heated and unheated systems.

Based on the literature review, cumulative energy demand (CED) per m^2 for heated greenhouses lies between 170-690 kWh/$m^{2,}$ while for unheated greenhouses this is between 0.2-1.0 kWh/m^2; about 200 times lower. This huge difference is partially compensated by the larger yields per m^2 in greenhouses and (often) year-round production. As a consequence, per kg tomato produced – the unit that we eventually want to compare – cumulative energy demand for heated production is between 12 and 25 kWh/kg tomato (for production using fossil fuels only) while for unheated greenhouse production energy demand is between 0.7-3.9 kWh/kg tomato. It is expected that open field energy demand is similarly low. Thus, (fossil) energy use for heated production is at least 5 to 10 times higher. **It is therefore safe to conclude that all-fuels carbon pricing will have a significantly bigger impact on heated production.**

In terms of total CO_2 eq. emissions literature values are between 2.0-3.6 kg CO_2 eq/kg tomato for heated production with natural gas and other fossil fuels. With CHPs this can be lowered to around 0.9 kg CO_2 eq/kg tomato, when compensating for avoided emissions for electricity production. Additionally, the use of renewable energy can further significantly reduce the emission intensity. For unheated production CO_2 eq. emissions are also about 5 to 10 times smaller than for heated: between 0.2 and 0.5 kg CO_2 eq/kg tomato.

Although the general difference between heated and unheated production is clear, energy demand and CO_2 emissions are influenced by many factors. Below some of the major factors are listed:

- **Energy use scope**: Most studies include energy use for heating but also irrigation, electricity, machinery use, etc. However, in general more than 90% of all energy use is for heating.
- **Fuel use**: Emissions depend on the fuel used (natural gas, fuel oil, geothermal, renewable energy). There are also methodological considerations per LCA, specifically for CHP use: how are the emissions of electricity production allocated to electricity and heat?
- **Production characteristics**: type of greenhouse used and energy saving characteristics of the greenhouse, use of fertilizers, etc.
- **Cropping cycle**: e.g. Is there production during winter when heat demand is highest? Energy use and emissions can differ depending on when the crop is produced.
- **Transport**: In most studies this is not included, which corresponds with this reports objective: after all, transport is independent from the type of production system and transport fuels are out of the scope of this report.
- **Location**: e.g. production in colder climates requires more heat during winter.

[197] Pineda et al (2021). Review of inventory data in life cycle assessment applied in production of fresh tomato in greenhouse

Besides CO_2 emissions, LCAs also discuss many other relevant impact categories which are out of scope of this study. In broad terms, (heated) greenhouse production seems to score better on e.g. water footprint and pesticide use.

Annex IV List of interviewees

The following organisations have been interviewed for this study:

- Plastics Europe
- Glastuinbouw Nederland
- Blueterra Energy Experts
- Nederlandse Zuivel Organisatie

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