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What stands in the way becomes the way
– Drawing lessons from the EU ETS for overcoming barriers to an ETS for agricultural GHG emissions in Europe through feasible policy sequencing

Sophie Alisa Theresa RÖHRL

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Author’s declaration

No portion of the work referred to in this thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

Sophie Röhrl

Sophie Alisa Theresa RÖHRL

CENTRAL EUROPEAN UNIVERSITY

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Sophie Alisa Theresa RÖHRL

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Agricultural emissions account for about 13.2% of total greenhouse gas (GHG) emissions in the EU. However, existing command-and-control measures, such as the Land Use, Land Use Change, and Forestry (LULUCF) Regulation, and the Common Agricultural Policy (CAP) have been largely ineffective in reducing agricultural GHG emissions. Market-based instruments, such as an Emission Trading System (ETS), could be pivotal to realizing the full mitigation potential of agriculture as suggested by its effectiveness in sectors currently covered under the EU ETS. However, so far this potential is untapped, and multiple barriers such as transaction costs, leakage risks, and distributional impacts hinder an implementation. Yet, the magnitude of these barriers critically depends on policy design. The introduction of the EU ETS in other sectors suggests that policy sequencing as a result of internal policy feedback, cross-policy feedback, and external effects could be pivotal to overcoming these barriers over time. This study aims to explore feasible pathways to gradually phase-in an ETS for the agricultural sector in the EU by learning from the existing EU ETS in other sectors and accounting for the unique features of agriculture. It utilizes desk research, 18 semi-structured interviews, and a stakeholder workshop with experts and key stakeholders along the agricultural value chain. The policy sequencing framework based on Leipprand et al. 2020 guides this analysis. Learning from the policy evolution of the EU ETS, this research suggests that a gradual phase-in of an EU ETS for agricultural emissions through policy sequencing, could reflect the heterogeneity of actors and emissions sources and be conducive to reducing economic, political, and administrative barriers over time. An initial high share of allowances allocated via grandfathering and a focus on emission sources with high mitigation potential but low transaction costs (i.e. N_2O and CH_4 from animal husbandry) focusing on large farms or up-and down-stream actors could lead to learning and constituency-building effects facilitating ratcheting-up of policy stringency. Moreover, the use of price management tools and strategic compensation measures is crucial for uptake. Alignment with other instruments, such as the CAP as well as political leadership and societal momentum could also be conducive. Finally, this approach emphasizes the importance of early action, a clear long-term roadmap, and strong policy signals to achieve substantial climate mitigation in the agricultural sector in the long run.

Keywords: Emission trading system, ETS, market-based instruments, carbon pricing, agriculture, farming, EU, barriers, feasible pathways, policy sequencing

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List of Abbreviations

AFOLU	Agriculture, Forestry, and Other Land Use
CAC	Command-and-control
CAP	Common Agricultural Policy
CBAM	Carbon Border Adjustment Mechanism
CCS	Carbon Capture and Storage
CDM	Clean Development Mechanism
CEECs	Central and Eastern European Countries
CH_4	Methane
CO_2	Carbon Dioxide
CO_2eq	Carbon Dioxide equivalent
CORSIA	Carbon Offset and Reduction Scheme for International Aviation
DG AGRI	Directorate-General for Agriculture and Rural Development
DG CLIMA	Directorate-General for Climate Action
DG ENV	Directorate-General for the Environment
ECA	European Court of Auditors
EC	EC
EFTA	European Free Trade Agreement
ETS	Emission Trading System
ESR	Effort Sharing Regulation
EU	European Union
EU-27	27 EU Member States
EU ETS	European Union Emissions Trading System
EU RED	European Union Renewable Energy Directive
GHG	Greenhouse gas(es)
ICAO	International Civil Aviation Organization
IED	Industrial Emissions Directive
ILR	Integrative Literature Review
IPCC	Intergovernmental Panel on Climate Change
JI	Joint Implementation
JRC	Joint Research Center
LRF	Linear Reduction Factor
LULUCF	Land Use, Land Use Change, and Forestry
MAC	Marginal Abatement Costs
MBI	Market-based instruments

MRV	Monitoring, Reporting and Verification
MSR	Market Stability Reserve
MS	Member States
Mt	Million tons
N_2O	Nitrous Oxide
NAPs	National Allocation Plans
NER	New Entrants' Reserve
NZ ETS	New Zealand Emissions Trading System
PFCs	Perfluorocarbons
RGGI	Regional Greenhouse Gas Initiative
RQ	Research Question
SCF	Social Climate Fund
SOC	Soil Organic Carbon
SMEs	Small-and medium-sized enterprises
TC	Transaction Costs
TCA	Thematic Content Analysis
TFEU	Treaty of the Functioning of the European Union
UNFCCC	United Nations Framework Convention of Climate Change
WTO	World Trade Organization

1 Introduction

1.1 Context

Agriculture is one of the main contributors to climate change. Globally, the Intergovernmental Panel on Climate Change (IPCC) estimates that agricultural activities and associated land-use change are responsible for 23% of total greenhouse gas (GHG) emissions while the overall food system may contribute even 21-37% of global GHG emissions (Shukla et al. 2019). In the EU, agriculture accounted for 426 million tons (Mt) of net-CO_2eq representing about 13.2% of the total EU-27 GHG emissions in 2021(EEA 2023b; 2023c; Mielcarek-Bocheńska and Rzeźnik 2021). Even more importantly, agriculture is the single largest source of anthropogenic highly potent[1] non-CO_2 GHG emissions, notably nitrous oxide (N_2O) and methane (CH_4), accounting for 81% and 44% of total GHG emissions worldwide (Shukla et al. 2019), and 79% and 54% in the EU, respectively (Mielcarek-Bocheńska and Rzeźnik 2021). Climate change mitigation in the agricultural sector is, therefore, essential to keep the goal of limiting global warming to 1.5°C within reach (Shukla et al. 2019). The IPCC's model pathways that "limit global warming to 1.5°C with no or limited overshoot" include substantial reductions in agricultural GHG emissions from 11% to 30% in CH_4 emissions, and -3% to 21% reduction in N_2O emissions by 2030 (IPCC 2018). Similarly, on the EU level, several studies point out that achieving the EU's target of reaching net-zero emissions by 2050 will not be possible without substantial reductions in the agricultural sector (Delbeke 2024).

However, despite the importance of the agricultural sector in reaching the goals of the Paris Agreement, the IPCC (2022) has reported that mitigation policy coverage remains limited for

[1] Compared to CO_2, N_2O and CH_4 have a 310 and 21 times higher warming potential, respectively (IPCC 2018).

agricultural emissions. In the EU, agricultural GHG emissions are currently governed under three overlapping regulatory frameworks, mainly consisting of *top-down command-and-control measures*: The Effort Sharing Regulation (ESR), The Land-Use, Land-Use Change and Forestry Regulation (LULUCF), and the Common Agricultural Policy (CAP). So far, these have largely failed to reduce emissions from the agricultural and land-use sectors: Between 2010 and 2021, agricultural emissions have remained relatively stable, and are expected to decline by only 4% by 2030 compared with 2005 levels under existing measures (EEA 2023b). This 4% reduction falls short of the aforementioned global reductions in agricultural GHG emissions needed to limit global warming to 1.5°C as well as the EU's 2030 mitigation target, which would require an estimated decline in agricultural emissions of 25% by 2030 compared with 2015 levels (Meessen et al. 2020). Moreover, given that GHG emissions from other sectors in the EU, such as energy, industry, or transport, are set on a path to substantially decarbonize until 2050, current emissions trajectories indicate that agricultural emissions by then may well constitute one-third of total EU emissions (Delbeke and Vis 2019).

These trends suggest the need for additional policy measures at the EU level to facilitate agricultural practices that mitigate climate change going beyond command-and-control instruments. While the current EU CAP is expected to be reformed toward including more climate change related measures, it seems largely inadequate as a catalyst for the widespread adoption of climate-smart agriculture in the EU (Verschuuren, 2018). Market-based instruments, such as emission trading systems (ETS), usually perform better than direct command-and-control measures due to their cost-efficiency and flexibility (e.g. Stavins (2011)). Indeed, one of the most reliable regulatory mechanisms in the EU's toolbox for reducing its GHG emissions is its EU ETS. Since 2005, the EU ETS has helped to reduce emissions from power and industry plants by a notable 36%. In fact, the politically defined mitigation targets are achieved in the ETS area (albeit with the participation of various other climate policy instruments), whereas they have so far been missed in the non-ETS area, including agriculture (Isermeyer, Heidecke, and Osterburg 2019, i). As stated by Verschuuren (2022) and Leach (2022), given this central role of the EU ETS in the EU's climate policy as well as this proven success in reducing GHG emissions in other sectors, introducing an EU ETS for agricultural GHG emissions should be taken into serious consideration as a central policy measure to govern agricultural emissions in the EU post-2030. This is also supported by a recent report by the European Court of Auditors (ECA), which concludes that the EU law does not apply the polluter-pays principle to agricultural emissions and recommends that the European Commission (EC) should "assess the potential of applying the polluter-pays principle to agricultural emissions and reward farmers for long-term carbon removals" (ECA 2021a). Also, from an economics perspective, Grosjean et al. (2018) point out that the heterogeneity of mitigation potential and transaction costs (TC) across actors and emissions sources make agriculture a prime candidate for a sector where carbon pricing policies could perform better than direct regulatory instruments.

1.2 Problem Definition

However, apart from the agrochemical fertilizer industries[2], the EU's agricultural sector is currently almost entirely excluded from the EU ETS (Leach 2020). So far, EU policymakers have been reluctant to govern further agricultural GHG emissions under an ETS given many barriers the introduction of this instrument faces in the sector: high transaction costs threaten the cost-effectiveness and leakage risks, adverse distributional impacts on farmers as well as the strength of the agricultural lobby undermine the political feasibility (e.g. Grosjean et al.

[2] However, it is important to note that only CO_2 emissions from the production of agro-chemical fertilizers is currently covered under the EU ETS but not the emission of CO_2, N_2O, and CH_4 produced from the use of respective fertilizers.

2018). However, as Grosjean et al. (2018) note, the magnitude of the barriers toward an EU ETS in agriculture significantly hinges on policy design. As examples of the energy and transport sectors show, carefully timing policies and gradually introducing abatement options could be crucial noting the risk of long-term capital investments becoming locked in, as well as socioeconomic resistance and transitional costs (e.g. Bertram et al. 2015, Ha-Doung, Grubb and Hourcade 1997). While the agricultural sector is less affected by capital lock-ins due to the reversible and volatile nature of its mitigation options, socioeconomic inertia is comparatively higher (e.g. Grosjean et al. 2018). Therefore, applying a temporal lens seems to be a promising avenue for exploring options to overcome barriers to introducing an EU ETS for agriculture.

1.3 Aim and Research Questions

Aim: This master's thesis research aims to contribute to the development of a regulatory framework that allows to overcome the barriers to an Emission Trading System (ETS) for agricultural GHG emissions at the EU level through a gradual phase-in.

Different research approaches are feasible to achieve this aim: Given that an EU ETS for agriculture does not exist currently serves as a prime example of a quantitative approach utilizing economic modeling. However, the limited understanding of the factors involved in a gradual phase-in calls for first applying a qualitative approach gathering an in-depth understanding of the relevant patterns, themes, and variables.

Such a qualitative research approach could be to derive lessons from existing EU ETS schemes. This could take two angles: First, lessons could be derived from other jurisdictions that cover or attempt to cover agricultural GHG emissions under an ETS scheme. However, as explained in **Section 3**, this currently only includes New Zealand, Australia, California, USA and Alberta, Canada. While such studies exist for some design dimensions of an EU ETS (e.g.

MRV (Fleurke 2022), carbon offsetting (Verschuren 2017)), this approach has its limitations. The socio-political, economic, and legal embeddedness of an ETS system shapes what is technically feasible. As such the ability to transfer lessons on technical design aspects from empirical experiences in other jurisdictions to the unique supranational environment of the EU is limited. Moreover, as Leipprand et al. 2020 note, the EU ETS is a prime example of overcoming barriers to an EU ETS through gradual policy phase-in.

Therefore, the latter approach is chosen in this study, deriving lessons from a retrospective analysis of the establishment of the existing EU ETS in other sectors which could illuminate the path forward for the gradual introduction of an EU ETS for agricultural GHG emissions.

To achieve the research aim, this thesis, therefore, addresses two research questions (RQs) with two sub-RQs respectively, which help to find an answer to the overarching RQs. The RQs are interrelated in the sense that identifying the lessons learned from RQ1 will inform the establishment of feasible pathways under RQ2.

RQ1: What can be learned from the existing EU ETS for overcoming barriers through the gradual phase-in of an effective Emission Trading System (ETS)?

> *RQ1.1:* What were the barriers to the introduction of the existing EU ETS?
>
> *RQ1.2:* What policy design pathways were chosen to overcome these barriers?

RQ2: Based on these lessons learned (and other evidence), what are feasible pathways to overcome barriers through the step-wise introduction of an Emission Trading System (ETS) for agricultural GHG emissions in the EU (and their trade-offs)?

> *RQ2.1:* What are the barriers to the introduction of an EU ETS for agricultural GHG emissions?
>
> *RQ2.2***:** What policy design pathways could be used to overcome these barriers?

1.4 Scope and Delimitations

Various delimitations are set for this study. First, while agricultural emissions can be mitigated from both the supply (production) and demand (consumption) sides, this research focuses on the application of carbon pricing on the supply side of agricultural mitigation given that this is likely more cost-effective and politically feasible (Yue et al. 2017).

Next, while a carbon tax would in theory be also a viable market-based instrument to consider for mitigating agricultural GHG emissions, this study focuses solely on the introduction of an ETS. As noted by Leach (2022), the EU has limited competency to legislate a top-down carbon tax since achieving an agreement on the necessary legislation for implementing a taxation instrument would require unanimity in the Council, which poses great political and legal challenges.[3] An ETS for agriculture emissions can, therefore, be seen as the most viable market-based instrument on the EU level (Verschuuren, 2022).

Moreover, this study investigates the establishment of an EU-wide ETS and does not consider the possibility of introducing a member state (MS) level ETS. While some studies look into the establishment of national market-based instruments for reducing agricultural emissions (e.g. Germany Isermeyer, Heidecke, and Osterburg (2019) for Germany and Bakam and Matthews (2009) for Ireland), several reasons speak against such an approach in practice: Given the potential distortion of competition arising from national carbon pricing, assigning the responsibility for market policies as an exclusive competence to the EU level is a logical implication of the EU's common market (Treaty of the Functioning of the European Union

[3] In fact, an attempt to introduce a carbon/energy tax for sectors covered under the current EU ETS in 1992 failed for exactly that reason (EC 2001).

(TFEU), Article 3)[4]. Also, while for agriculture, the EU and MS theoretically hold shared competencies in accordance with the subsidiarity principle (TFEU, Article 4), in reality, the EU has been playing a central role in shaping agricultural policies from the establishment of the European Economic Community onward through the Common Agriculture Policy (CAP) (Grethe et al. 2008).

Finally, this study focuses on the establishment of a separate EU ETS for agriculture instead of including agricultural emissions into the existing EU ETS. Despite the possible cost-efficiency of a joint approach, GHG emissions from fossil fuels need to reach zero eventually, while emissions from agriculture cannot be entirely eliminated due to the natural nutrient cycle and for reasons of biodiversity. Following the argument of Weishaupt et al. (2020), this contradicts a uniform approach from the outset.

1.5 Audience & Potential Outcomes

This research is anticipated to generate new knowledge on feasible pathways for the gradual introduction of an ETS for agricultural emissions at the EU level. These findings can provide useful knowledge for policymakers to inform the development of a feasible EU ETS design for the agricultural sector. In particular, this research will be of immediate interest to the European Commission given that agriculture has gained more prominence in the EU climate policy-making discourse due to the recently proposed certification of carbon removals from the land-use sector (EC 2022) and a recent report by the European Court of Auditors urging the EC to step up climate mitigation efforts in the agricultural sector (European Court of Auditors 2021a). The European Commission has recently also conducted an exploratory study with the aim of identifying potential options to apply the "polluter pays principle" to GHG

[4] https://eur-lex.europa.eu/EN/legal-content/summary/division-of-competences-within-the-european-union.html#:~:text=Exclusive%20competences%20of%20the%20EU%20(Article%203%20of%20the%20Treaty,EU%20to%20implement%20these%20acts

emissions in European agriculture (Trinomics 2023). Finally, while the knowledge generated through this research is specific to an ETS at the EU level, its relevance is not limited to the EU context. Since to date no country in the world requires to surrender allowances for agricultural emissions into an ETS, the insights gained will be of use to policymakers around the world.

1.6 Thesis Structure

This thesis is structured as follows. The next section provides a background on the European agriculture sector, including its activities, emission profile, mitigation potential, and current regulatory framework, as well as on the functioning of an emissions trading system (ETS) including the EU ETS specifically (**Section 2**). **Section 3** gives an overview of the current academic thinking on the introduction of an ETS for agricultural emissions, including benefits, barriers, and potential design options to overcome these. **Section 4** introduces the analytical framework used to guide this analysis, including its limitations. This is followed by a detailed explanation of the research design, including the methods used to collect and analyze the data as well as their limitations and ethical considerations taken into account (**Section 5**). **Section 6** analyzes and discusses the results, first summarizing the lessons learned from the gradual introduction of the EU ETS in other sectors (RQ1), followed by how these can be applied to a step-wise phase-in of an ETS in European agriculture (RQ2). Finally, **Section 7** concludes this thesis by providing a summary, highlighting its practical implications, and providing recommendations for future research.

2 Background

The EU agriculture sector is unique in its structure and emissions profile, which determines its mitigation potential as well as the challenges and benefits associated with the application of market-based instruments such as an ETS. To be able to conceptualize the introduction of an EU ETS for agriculture it is, therefore, crucial to gain an understanding of the sector's structure including its activities **(Section 2.1.1)**, emissions profile **(Section 2.1.2)**, and mitigation potential **(Section 2.1.3**) as well as the current regulatory framework on an EU level **(Section 2.1.4)**. This also applies to the functioning of an ETS in general **(Section 2.2.1)** and the EU ETS more specifically **(Section 2.2.2).**

2.1 The European agricultural sector

2.1.1 Activities and emission sources

GHG emissions related to agriculture stem from a wide variety of sources and activities and are, therefore, much more complex than those in many other sectors. Agricultural activities emit both CO_2 and non-CO_2 emissions, namely methane (CH_4) and nitrous oxide (N_2O). These fall into two different categories of emissions under the United Nations Framework Convention of Climate Change (UNFCCC) reporting system: (i) **agriculture** and (ii) **land use, land-use change, and forestry (LULUCF)** (IPCC 2006). The first category includes direct emissions from agriculture, mostly methane and nitrous oxide. Methane emissions originate primarily from livestock through enteric fermentation[5] and manure management (i.e. dung and urine) from beef, dairy, small ruminants, pigs, and poultry (ibid). Nitrous oxide stems mainly from the application of natural and mineral fertilizers to agricultural soils (ibid).

[5] *Enteric fermentation* occurs in the digestive system of animals, particularly ruminant animals such as cattle, buffalo, sheep, and goats. In the "fore-stomach", or rumen, microbial fermentation breaks down food into soluble products that can be utilized by the animal, therefore, allowing ruminant animals to digest coarse plant material. As a by-product of this fermentation process bacteria produce methane (Trinomics (2023) based on Section 10: Emissions from Livestock and Manure Management in IPCC (2006b)).

Both methane and nitrous oxide have a significantly higher global warming potential than carbon dioxide (21 and 310 CO_2eq, respectively, over a 100-year time horizon) (IPCC 2023). LULUCF emissions from agriculture comprise mainly carbon dioxide emissions from agricultural cropland and grassland[6] and are driven by soil management practices, which impact the capacity of soils to sequester carbon. This includes the constant drainage of organic soils[7] for agricultural use, especially peatlands, the loss of soil organic carbon (SOC) [8] in mineral soils[4], livestock overgrazing and tillage of grasslands, field burning of agricultural residues, or the clearing of natural vegetation (IPCC 2006). While agriculture is defined merely as a source, LULUCF is both a source and a sink of GHG emissions due to the ability of soils and plants to sequester carbon (ibid). However, since the distinction between both categories is not always clear, they are often merged and referred to as **agriculture, forestry, and other land use (AFOLU)**[9] (ibid). A notable feature of AFOLU emissions is also their dependence on local soil and climate conditions as well as management practices, in addition to the complexity of the underlying mechanisms, and the interaction between them (Vermont and De Cara 2010; Grosjean et al. 2018).

[6] Other LULUCF categories that are not directly relevant for agriculture include forests, wood products, wetlands, and settlements (IPCC 2006).

[7] Soils can be divided into two groups: *organic soils* are formed from sedimentation and are primarily composed of organic matter; *minerals soils* are formed from the weathering of rocks and are primarily composed of inorganic material (IPCC 2006).

[8] *Soil organic carbon (SOC)* = solid carbon stored in soils (IPCC 2006).

[9] Beyond that, the *agri-food system* covers all GHG emissions associated with the production, processing, distribution, preparation, and consumption of food. This includes CO_2 emissions related to energy use in buildings, equipment, and machinery for field operations as well as emissions from the manufacturing of animal feed and fertilizers. These emissions are not reported under the “agriculture” category but in the categories “energy” and “industrial processes”, respectively (IPCC 2006). Since GHG emissions from energy and industrial processes are already regulated under separate EU policy frameworks, this study focuses on AFOLU emissions only. This study generally refers to AFOLU emissions, except when it is necessary to distinguish between the two UNFCCC categories. For simplicity reasons, AFOLU will be referred to as agriculture in the following.

As shown in **Table 1**, almost 60% of the EU's agricultural GHG emissions stem from CH_4 and N_2O emissions from livestock, especially cattle from beef and dairy farming: In 2021, enteric fermentation accounted for 42.8% (182.5 Mt CO_2eq; CH_4-100%) of agricultural GHG emissions of which 85% came from cattle; manure management accounted for 14.8% (62.9 Mt CO_2eq; CH_4-65%, N_2O-35%) of which 46% came from cattle and 35% from pigs (EEA 2023b; Mielcarek-Bocheńska and Rzeźnik 2021). N_2O emissions from agricultural soils are the second biggest contributor to agricultural GHG emissions resembling 27.7% (118 Mt CO_2eq; N_2O-100%) of total GHG emissions in 2021 (ibid). Accounting for both emissions and removals, grasslands and croplands are a net source of emissions contributing 25 and 22.6 Mt net-CO_2eq, respectively, or 11.2% combined to agricultural emissions in 2021 (EEA 2023b). A particularly high share of emissions stems from drained peatlands (more than half of which is used for used for agricultural purposes), which emit approximately 220 Mt CO_2eq per year, resembling a remarkable 5% of total EU GHG emissions in 2017 (O'Brolchain, Peters, and Tanneberger 2020). The remaining sources, such as emissions from liming[10], urea[11] application, rice cultivation, and burning of agricultural residues accounted for less than 3.5% of total agricultural GHG emissions in 2021 (ibid).

Across the EU, more than half of the agricultural GHG emissions come from France, Germany, Spain, and Poland, while Luxembourg, Cyprus, and Malta only account for 0.3% of total EU GHG emissions (Mielcarek-Bocheńska and Rzeźnik 2021). Within Member States the sector's share on total GHG emissions varies accounting for the largest share in Ireland (32.7%), Denmark (22.9%), Latvia (22.3%), and Lithuania (21.1%) and the lowest share in

[10] *Liming* = the application of calcium- and magnesium-rich materials in various forms, including marl, chalk, limestone, burnt lime, or hydrated lime, to soil to neutralize soil acidity (Trinomics (2023) based on IPCC (2006)).

[11] *Urea* = a white crystalline solid containing 46 % nitrogen that is used as an animal feed additive and fertilizer (Trinomics (2023) based on IPCC (2006)).

Malta (3%), Cyprus (5.7%), Slovakia (6.3%), Luxembourg (6.5%), and the Czech Republic (6.7%) (ibid). With regard to LULUF emissions, Romania, Sweden, Spain, Italy, Poland, and France were responsible for the largest cumulative net removals in the past ten years, contributing to approximately 87% of the EU's LULUCF sink, while Denmark, the Netherlands, and Ireland were a net source of emissions in the past decade (EEA 2023c).

Table 1 Overview of EU-27 agricultural emissions by source in 2021 (own calculations based on data derived from the EU-27 greenhouse gas inventory submitted to the UNFCCC (EEA 2023a); share of GHGs on emissions source from Mielcarek-Bocheńska and Rzeźnik (2021)).

Source of Emission	CH_4	N_2O	CO_2	Amount (Mt CO_2eq)	Percentage [%]
Enteric fermentation	x			182.5 (CH_4-100%)	42.8
Manure Management	x	x		62.9 (CH_4-65%, N_2O-35%)	14.8
Nutrients on agricultural soils		x		118 (N_2O-100%)	27.7
Grassland			x	25 (CO_2-100%)	5.9
Cropland (organic soils)	x	x	x	22.6 (no information)	5.3
Cropland (mineral soils)			x		
Other, such as:				15	3.5
- Liming			x	5.63 (CO_2-100%)	1.3
- Urea application			x	3.5 (CO_2-100%)	0.8
- Rice cultivation	x		x	2.74 (no information)	0.6
- Burning of agricultural residues	x	x		0.7 (CH_4-73%, N_2O-27%)	0.1
Total GHG emissions	**x**	**x**	**x**	**426 (CO_2-2.6%, CH_4-53.7%, N_2O-43.7%)**	**13 (of total GHG emissions)**

2.1.2 Historic and projected GHG emissions under current policy framework

In 2021 agriculture accounted for 426 million tons (Mt) (CO_2-2.6%, CH_4-53.7%, N_2O-43.7%) of net-CO_2eq representing about 13.2% of the total EU-27 GHG emissions (11.7% from agriculture and 1.5% from land use emissions and removals from cropland and grassland) (EEA 2023b; 2023c; Mielcarek-Bocheńska and Rzeźnik 2021). As shown in **Figure 1**, agricultural emissions have decreased by a notable 25% between 1990 and 2010, with the largest fall between 1990 and 1994 (ibid). This was primarily because of a decline in livestock numbers resulting from a reorganization of agricultural practices in Eastern Europe caused by reforms of the Common Agricultural Policy (CAP), and a reduction in the use of nitrogen fertilizer caused by policies under the EU Nitrates Directive (Westhoek et al. 2012; Schäfer 2012). Moreover, since the 1990s mitigation policies and advancements in efficiency have reduced the emissions intensities[12] of some agricultural products, however, this has been offset by a steady increase in agricultural production, especially of milk, poultry, meat, and pork. Subsequently, agricultural emissions have remained relatively stable since 2010 decreasing by only 3% between 2010 and 2021 (EEA 2023b). Under existing measures, this trend is expected to continue for non-CO_2 agricultural emissions with a projected decline of only 4% by 2030 compared with 2005 levels and of 8% if currently planned additional measures are implemented (ibid). This falls short of the EU's 2030 mitigation target, which would require an estimated decline in agricultural emissions of 25% by 2030 compared with 2015 levels (Meessen et al. 2020). For LULUCF emissions, the total sink of all LULUCF sectors was -328.2 MtCO_2eq, while emissions totaled +97.5 Mt CO_2eq, resembling a net sink of -230.7 Mt CO_2eq in 2021, corresponding to the absorption of 7% of the EU's total GHG emissions (EEA 2023c). Overall, CO_2e net-removals have decreased in the past ten years and Member State projections suggest that this trend will continue until 2030 with net r-movals of 240 Mt CO_2eq under existing measures and 260 Mt CO_2eq with planned additional measures (ibid). The EU is, therefore, not on track to meet its 2030 net-removal target of -310 Mt CO_2eq (ibid).

[12] *Emission intensity* = the level of GHG emissions emitted per unit of product.

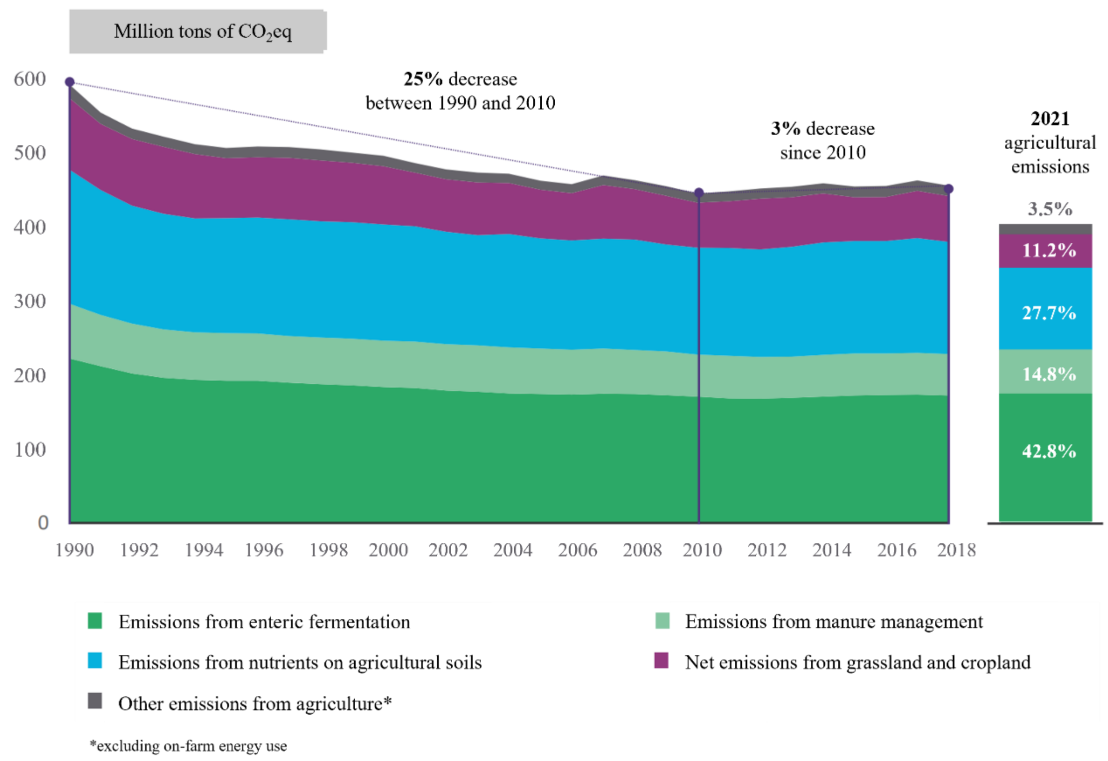

Figure 1 Development of EU-27 agricultural greenhouse gas emissions since 1990 (data derived from the EU-27 greenhouse gas inventory submitted to the UNFCCC (EEA 2023a) and figure adapted from European Court of Auditors (2021b).

2.1.3 Mitigation potential

The GHG mitigation potential in agriculture can generally be categorized into technical and economic potential (OECD 2019a): The technical mitigation potential is defined as the maximum mitigation possible with full implementation of all available mitigation measures and ignoring barriers to adoption. The economic mitigation potential includes the costs and benefits of different mitigation measures showing mitigation potential at a given carbon price.

Technical mitigation potential

As pointed out by P. Smith et al. (2007; 2008) and Bakam and Matthews (2009), agriculture holds a significant, yet uncertain, technical potential to reduce GHG emissions in a relatively short time span. Globally, the technical mitigation potential is estimated to be 5.5-6 $GtCO_2$eq per year by 2030 based on the maximum use of available emissions reduction and soil carbon sequestration measures (P. Smith 2012). Mirroring the complex biological processes of agricultural GHG emissions, the sector provides a large range of potential mitigation options (e.g. P. Smith et al. (2008)): Enteric methane emissions can be reduced through the adaptation of technological innovations such as improved feeding practices, the use of feed additives, or targeted breading practices (P. Smith, Reay, and Smith 2021). However, these measures may only lead to a reduction of GHG emissions of 10% (Mielcarek-Bocheńska and Rzeźnik 2021) to 15% (Hedenus, Wirsenius, and Johansson 2014). Without a reduction in herd sizes and changes in consumption patterns, technological improvements will, therefore, not sufficiently reduce emissions from livestock (Weishaupt et al. 2020; Hedenus, Wirsenius, and Johansson 2014). For instance, Bellarby et al. (2013) estimated that a reduction of cattle numbers alone could decrease emissions by an additional 10-15% in the EU. Moreover, emissions from manure could be significantly reduced through better manure management and storage practices. This includes improving or changing the livestock housing system as well as covering manure and slurry storage, which may lead to emissions reductions of up to 30% (Samsonstuen et al. 2020; Witkowska et al. 2020) and 10% (Amon, Kryvoruchko, and Amon 2006; Kupper et al. 2020), respectively. However, increasing volumes of manure to be managed due to an ongoing intensification of livestock production may counteract these reductions (Mielcarek-Bocheńska and Rzeźnik 2021). Through reduced and optimized (synthetic) fertilizer application, nitrous oxide emissions from agricultural soils can be reduced between 13% (K. Smith et al. 2012) and 20% (Roe et al. 2021). Retiring and re-wetting peatlands could reduce emissions from organic soils by 51.7 MtCO_2eq per year by 2030 (Pérez Domínquez et al. 2020) and by an average 54 MtCO_2eq per year between 2020 and 2050 (Roe et al. 2021). Maintaining and enhancing SOC in cropland through practices such as reduced tillage, cover cropping, or improved crop rotation (McDonald et al. 2021) could lead to an emissions reduction ranging from 9 MtCO_2eq (Frank et al. 2015) to 58

$MtCO_2eq$ (Lugato et al. 2014) to 70 $MtCO_2eq$ per year (Roe et al. 2021). Protecting and restoring grasslands could sequester an additional 27 $MtCO_2eq$ per year (Roe et al. 2021). Avoiding the burning of crop residues through legal prohibition or alternative agricultural residues management could reduce emissions in this area by as much as 70% (Mielcarek-Bocheńska and Rzeźnik 2021). Emissions from urea application, could go down by 60-90% through the application of urease and nitrification inhibitors (ibid). Finally, the reduction of liming emissions, is a complex process and the level of GHG emission reduction may only be at 0-5% in the next 10 years (ibid).

Economic mitigation potential

A substantial body of literature has emerged on the economic mitigation potential of agricultural GHG emissions. Overall, modeling studies observe a substantial theoretical mitigation potential at a relatively low cost (P. Smith et al. 2007). However, estimates vary widely depending on the economic model used to estimate marginal abatement costs sometimes revealing a 20-fold difference in mitigation potential for 20€ per ton (Vermont and De Cara 2010). Yet, the elasticity[13] of agricultural emissions in response to a carbon price does not necessarily differ from other sectors (Pérez Dominguez, Britz, and Holm-Müller 2009; Vermont and De Cara 2010). Earlier studies, find a mitigation potential for non-CO_2 emissions of 15% by 2030 at a price of 40€ per ton CO_2eq across different world regions (Vermont and De Cara 2010). Moreover, P. Smith et al. (2014) estimate a global emission reduction potential of 0.03–2.6 GtCO2eq at 50$ per ton CO_2eq and of 0.2–4.6 $GtCO_2eq$ at 100$ per ton CO_2eq in 2030. For the EU, Höglund-Isaksson et al. (2012) identify a mitigation potential of 22% by 2050 at a price rising to 180€ per ton CO_2eq by 2050. More recent

[13] The elasticity of emissions with respect to carbon pricing is used in economics to measure the responsiveness of GHG emissions to changes in the price of carbon, i.e. it quantifies the percentage change in emissions resulting from a one percent change in the price of carbon (e.g. Rafaty, Dolphin, and Pretis 2020).

studies, find a global total mitigation potential for AFOLU emissions of 8–12 GtCO2eq at 65–220€, respectively (Ben Henderson, Frezal, and Flynn 2020). The global potential for non-CO_2 emissions has been modeled as 1 GtCO_2eq at 25$ per ton CO_2eq by 2030 and 2.6 GtCO2eq at 100$ per ton CO_2eq by 2050 (Frank et al. 2018). The global potential for soil carbon sequestration is estimated to be high but exhibits considerable uncertainty. P. Smith (2016), for instance, reports a global mitigation potential of 1.5 GtCO_2 per year and 2.6 GtCO_2 per year at carbon prices of 20$ per ton CO_2eq and 100$ per ton CO_2eq, respectively. For the EU, Isbasoiu, Jayet, and De Cara (2021) estimate a mitigation potential for non-CO_2 emissions of 10–39% at a carbon price of 50–200€ per ton CO_2eq, while OECD (2019b) find a total reduction potential of 51.4% at a carbon price of 50€ per ton CO2eq. Moreover, Pérez Domínquez et al. (2020) identify a mitigation potential of 15 and 35 MtCO_2eq for non-CO_2 emissions and of 37 and 45 MtCO_2 for LULUCF emissions at a carbon price of 20 and 100€ per ton CO_2eq, respectively, making up a total mitigation potential of up to 80 MtCO_2eq at 100€ per ton CO_2eq.

Finally, given the heterogeneity across agricultural actors, emissions sources, and geographical locations, it is important to note the stark contrast between technical and economic mitigation potential in agriculture. Grosjean et al. (2018) estimate that more than 55% of the technical mitigation potential is in agricultural soils and manure management (agricultural soils: 38%, manure management: 23%, cropland & grassland: 18%, enteric fermentation: 14%), while more than 70% of the economic mitigation potential at 40€ per ton CO_2eq lies with agricultural soils and carbon sequestration in grassland and cropland agricultural soils: 49%, cropland & grassland: 23%, enteric fermentation: 13% manure management: 4%).[14]

2.1.4 The EU's current regulatory approach to reduce agricultural GHG emissions: ESR, LULUCF and CAP

The European Climate Law sets out the EU's legally binding commitment toward a climate-neutral economy by 2050, with an intermediate target to reduce GHG emissions by at least 55% by 2030 compared to 1990 levels (EC 2021c). The climate policy framework to achieve these emission reductions is set out in the EU's Fit for 55 package as part of the European Green Deal (EC 2019). However, in the EU there has always been a rather clear distinction between the EU's climate change policy and its agricultural policy. Agriculture has, therefore, long escaped environmental regulation, especially with regard to agricultural emissions (Leach 2022). The primary focus of the EU's climate policy has been reducing emissions from energy, industry, and transport through the EU ETS[15] (EC 2003). However, as mentioned before, emissions from agriculture, are not regulated through the EU ETS[16] but are governed under two separate regulatory frameworks: the Effort Sharing Regulation (ESR) and the Land-Use, Land-Use Change and Forestry (LULUCF) Regulation (**Figure 2**). The ESR regulates non-CO_2 emissions (i.e. N_2O and CH_4) and CO_2 emissions from agricultural energy use, as well as liming, urea application, and other carbon-based fertilizers from agriculture, along with emissions from transportation, buildings[17], and waste, which are collectively labeled as 'non-ETS' sectors (EC 2018b). Under the ESR agricultural GHG emissions are not

[14] This is based on the MAC curves of studies for France, Ireland, and the UK. The study also includes the technical (7%) and economic mitigation potential (11%) of energy use in agriculture, however, this is outside of the scope of this research.

[15] See **Section 6.1.1** for a detailed explanation of the EU ETS.

[16] With the exceptions of the agro-chemical and fertilizer industries.

[17] In 2023, however, a new, separate emissions trading system (EU ETS 2) was created, which will cover fuel combustion in buildings and transport as of 2027 (EC 2023a; see **Section 6.1.1**)

assigned a specific sub-target for agriculture, neither at the EU nor at the Member State level, but Member States must achieve a national emissions reduction target for the 2021-2030 period in the form of GDP-based annual emission allowances for all 'non-ETS' sectors together. This gives Member States the freedom to choose not only the type of instruments but also the sector to focus on. Recently revised, the ESR aims to reduce emissions from non-ETS sectors collectively by -40% by 2030 compared to 2005 levels (EC 2023). The LULUCF Regulation governs CO_2 emissions from land use applying the so-called "no-debit" rule. That is, EU Member States must ensure that accounted GHG emissions from land use, land use change, or forestry, including agricultural land use for arable crops and grassland, are balanced by at least an equivalent accounted removal of CO_2 emissions from the atmosphere over the 2021-2030 period (EC 2018a). Recently revised, the LULUCF Regulation established an EU-wide target for increasing the net-sink to -310 $MtCO_2eq$ by 2030 (EC 2023b). The LULUCF Regulation is linked to the ESR in the sense that Member States that not only balance emissions but achieve a surplus can, to a certain extent, use these surplus emission reductions to cover their emissions reduction target under the ESR (EC, 2018a, Article 7). The recently revised LULUCF regulation also proposes to include emissions from agriculture that are currently falling under the ESR in the scope of the LULUCF Regulation as of 2031 and to set a combined climate-neutrality target for the AFOLU sectors for 2035[18] (EC 2023b).

Outside of the Fit for 55 package, there are other policy instruments that influence or will influence climate change mitigation in agriculture, most importantly the Common Agricultural Policy (CAP). The CAP, however, is not a tool specifically designed for GHG emissions reductions but was established in 1962 with the primary goal of increasing

[18] However, the co-legislators could not reach an agreement on this proposal, and it was agreed that this legislative proposal will be discussed later in a separate negotiation process.

agricultural activity and supporting farmers through a range of payment schemes (EC 2012, Article 39). On the contrary, the CAP has been criticized for incentivizing climate-unfriendly practices such as livestock-intensive systems and monocultures through production-based direct payments (Alliance Environnement 2019). With the 2013 CAP reform, climate mitigation has become a strategic objective of the CAP, and climate-friendly practices and techniques were encouraged for the first time in the 2014-2020 funding period through new measures such as the cross-compliance mechanism for direct payments, a greening mechanism, and rural development programs (EC 2021d). However, as Blandford & Hassapoyannes (2015) note, even the reformed CAP has been remarkably ineffective in reducing agricultural GHG emissions thus far. This was also confirmed by an assessment of the European Court of Auditors in 2021, which found that the 100€ billion of CAP funds (resembling 26% of total CAP funds) spent between 2014 and 2020 with the aim of addressing climate change led to (shocking) 0% of GHG emission reduction from agriculture (ECA 2021b). The voluntary nature of the instrument, the short lifespan of CAP-financed projects, and the lack of robust monitoring systems are only some of the reasons for this (Verschuuren 2022). The European Court of Auditors (2021b) also observed that CAP tends to fund measures with a low mitigation potential (i.e. organic farming), while other measures that could have a much higher mitigation potential (i.e. reduction of livestock numbers) are rarely financed. The 2021 CAP reform introduced enhanced conditionality for direct payments, increased funding support for voluntary “eco-schemes” and environmentally friendly farming practices, and allocated 40% of its budget to “climate-relevant” expenditures (EC 2021d). However, as (Leach 2022) comments, it is too soon to tell whether these new measures will be effective in mitigating agricultural emissions.

Finally, several Directives and strategies will also have an impact on emissions reductions in agriculture: the Industrial Emissions Directive (IED) regulates, among others, methane emissions from large pig and poultry installations and potentially soon also emissions from cattle (EC 2010); the proposed Soil Monitoring Law aims to improve carbon monitoring in soils (EC 2023a); the proposed Carbon Removal Certification Framework should increase carbon sequestration through high-quality carbon removals (EC 2022b); and the Farm to Fork Strategy sets quantified targets to reduce nutrient loss and food waste, which also has climate implications (EC 2020).

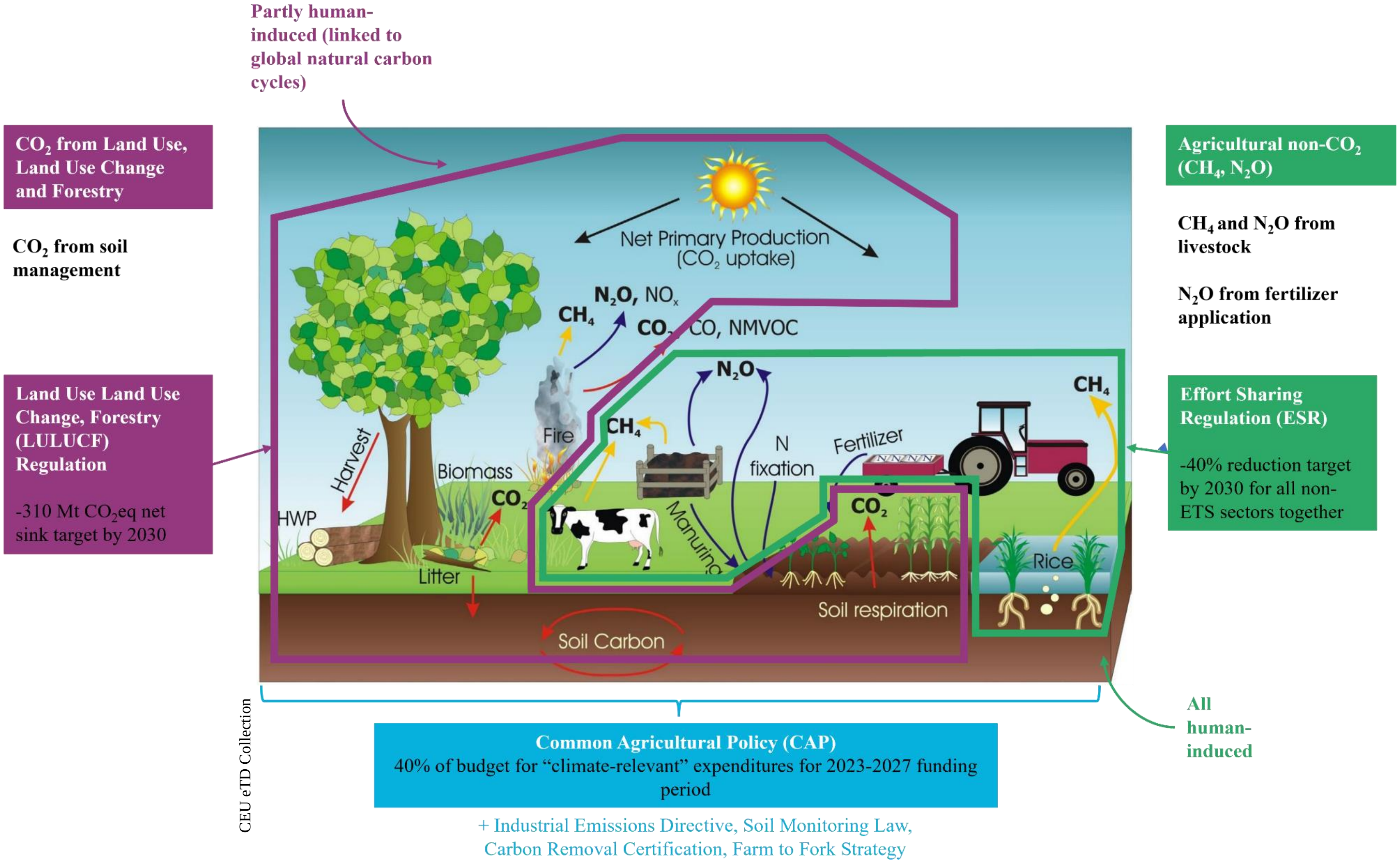

Figure 2 Schematic figure of GHG emissions sources from agriculture and overview of command-and-control regulatory frameworks governing GHG emissions from agriculture in the EU (adapted after IPCC (2006b) and Delbeke and Vis (2019))

2.2 Emission Trading Systems

2.2.1 Emission Trading Systems: Definition and functioning

In general, policy instruments to reduce GHG emissions can be categorized under two major types: command-and-control (CAC) instruments and market-based (economic) instruments (MBIs) (e.g. Stavins (2011)). Command-and-control regulations set specific emissions reduction targets and achieve this by mandating uniform technology- or performance-based standards onto polluters. Market-based policy instruments, on the other hand, use market incentives, i.e. price signals, to encourage polluters to reduce their emissions and leave the choice of emission reduction strategy to the polluter (ibid). By putting a price on carbon ("carbon pricing"), they internalize the negative externalities of GHG emissions, i.e. their unintended adverse impacts on third parties that are not (fully) reflected in the price of a good or service generating these emissions (based on work by Pigou (1946) who introduced the so-called "Pigouvian tax"). This follows the "polluter-pays-principle", namely that the party responsible for producing pollution should bear the costs of managing it to prevent damage to the environment or human health. Ideally, the carbon price should be equal to the "social cost of carbon", i.e. the costs of the damage caused by each additional ton of carbon emissions. Moreover, MBIs are based upon the rationale that the effect of GHG emissions is the same, regardless of the point of emissions source and point of mitigation. In comparison to CAC measures, MBIs are, therefore, considered to be more flexible, cost-effective, and to encourage innovation (Stavins 2001). They also create revenues, which can be used to invest in climate measures or compensate vulnerable firms or households, for instance (ibid).

The advantage of market-based policies over direct regulation increases with the heterogeneity of actors regarding their abatement potential, i.e. the magnitude of potential GHG emission reduction achieved through appropriate mitigation measures and marginal abatement costs (MAC), i.e. the cost of reducing GHG emissions by one ton (Newell and Stavins 2003). The cost to reduce each additional unit of GHG emissions usually increases with every ton of additional emission reduction. Economists graphically represent this in the form of an upward-sloping marginal abatement cost curve. The steepness of the MAC curve is shaped by factors such as access to alternative technologies, the extent of investment in research and development, and the structure of the economy. The advantage of MBI instruments over CAC measures, therefore, also increases with the heterogeneity in the steepness of the MAC curves among actors (Newell and Stavins 2003). However, these advantages are influenced by transaction costs (TC) (as first introduced in Coase's (1960) "The Problem of Social Costs"), i.e. the time and expenses associated with searching, negotiating, designing, implementing, administrating, complying, monitoring, and enforcing a policy as experienced by both the regulating entity (i.e. government departments or agencies) and the regulated private sector (e.g. McCann et al. 2005). High TC might impede the efficiency gains from MBI, which makes measures to mitigate TC essential to harness the full potential of MBIs (R. N. Stavins 1995).

The two most common market-based instruments are carbon taxes and emission trading systems (ETS) (e.g. Stavins (2001)). While carbon taxes are price-based (i.e. the price is fixed and the quantity is determined by the market), an emissions trading system (ETS) is quantity-based (i.e. the quantity of emissions is fixed at a desired level and the price is determined by the market). An ETS, therefore, provides high certainty about the environmental outcome (ibid). Moreover, building on seminal works by Coase (1960), Dales (1968), and later Montgomery (1972) emissions trading will eventually lead to a Pareto efficient outcome reducing emissions where they cause the lowest economic costs. The most commonly used

ETS is a cap-and-trade system[19] (icap 2023). That is, the legal authority imposes an upper limit (cap) on total allowable emissions in a specific jurisdiction or industry and reduces this cap over time according to a desired GHG emission reduction pathway. Under this cap, regulated entities are issued permits, or allowances, each representing a specific amount of permissible emissions. These allowances must either be purchased from the government ("auctioning") or are received for free ("free allocation") based on past emissions ("grandfathering"), annual emissions ("proportional allocation"), annual production ("output-based allocation"), or industry-specific emission benchmarks ("benchmarking"). In the specific case of agriculture, permits could also be allocated based on the agricultural area ("area-based allocation") (Trinomics 2023). Once allocated, allowances are also tradable in a secondary market, allowing entities with high abatement costs to buy emission rights from polluters that can abate at lower costs (trade). Unused permits may also be stored for future compliance (the so-called "banking" of allowances). In theory, an ETS is of particular value in sectors where MACs are less than the carbon price and transaction costs combined (icap 2023).

2.2.2 ETS in practice: The EU ETS: An overview

To date, emission trading is the most common policy instrument used to reduce GHG emissions globally (Van Asselt, Mehling, and Kehler Siebert 2015). In 2023, there are 28 ETSs in place across five continents which cover 17% of global GHG emissions, namely in the 27 EU member states and the three European Free Trade Agreements (EFTA) countries (Iceland, Liechtenstein, and Norway) in the form of the EU ETS, Switzerland, Germany,

[19] The other main type of emission trading system is a "baseline-credit system", i.e. there is no fixed limit on emissions, but polluters that reduce their emissions more than they are obliged to can earn 'credits' that they can sell to others who need them in order to comply with regulations they are subject to (icap 2023). However, since the EU ETS is a cap-and-trade system and an EU ETS for agricultural emissions would most likely follow this scheme, this will not be discussed in more detail in this study.

Austria, the United Kingdom, Montenegro, Mexico, Republic of Korea, China, Kazakhstan, New Zealand, 12 states in the Unites States, including the Regional Greenhouse Gas Initiative (RGGI) of 11 north-eastern states and California, the Canadian provinces of Quebec (linked to the California ETS), and Nova Scotia, the Japanese cities of Saitama and Tokyo, and the Chinese cities of Beijing, Chongqing, Shanghai, Shenzhen, and Tianjin (ICAP 2023).

Set up in 2005, the European Union Emissions Trading System (EU ETS) is the world's first international emissions trading system and operates as the cornerstone of the EU policy framework to combat climate change and reduce GHG emissions cost-effectively. The cap-and-trade system covers the GHGs carbon dioxide, nitrous oxide, and perfluorocarbons (PFCs) from some 10,000 stationary installations in the energy and industry sectors, and some 400 aircraft operators in the EU, representing around 38% of the EUs total GHG emissions (EC 2023). As of 2024, emissions from maritime transport will be introduced into the EU ETS. From 2027 fuel combustion in buildings, road transport, and small industry will be regulated under a newly established ETS2 (EC 2023a).[20]

Between 2005 and 2021, emissions from stationary installations covered by the EU ETS decreased by 36% (EEA 2022b). Moreover, Bayer and Aklin (2020) found that the EU ETS saved more than 1 billion tons of CO_2 between 2008 and 2016 (3.8% of total EU GHG emissions) relative to a world without the EU ETS. Finally, since 2005 the EU ETS has accrued over 152 billion € in revenues, which are used to fund investments in energy transformation and decarbonization as well as social programs that facilitate the green transition (EC 2023). To date, it is the largest carbon market worldwide and serves as an example for the development of other ETSs around the world (icap 2023).

[20] The development and current design of the EU ETS is explained in more detail in **Section 6.1.1.**

3 Literature Review – Introducing an Emission Trading System for (European) Agriculture

This section presents a review of the existing literature. In general, pricing agricultural emissions has sparked controversy in the literature and policy discussions. While multiple studies highlight the benefits of market-based instruments over direct regulations, also for European agriculture, other views the direct inclusion of the agricultural sector into an ETS as problematic due to multiple barriers that could hamper its effectiveness. This section reviews the structural specificities of agriculture that are conducive to introducing an ETS, including examples from applications around the world (**Section 3.1**) as well as the associated challenges and underlying drivers (**Section 3.2**). Finally, it provides an overview of the current academic and policy thinking on potential policy design responses that could support overcoming these obstacles (**Section 3.3**).

3.1 The case for an ETS in (EU) agriculture

Several studies point out the cost-effectiveness and efficiency gains of using flexible market-based instruments with the potential to perform better than direct command-and-control measures for agriculture in general, and for European agriculture in particular (e.g Pérez Domínguez and Fellmann 2015; Pérez Dominguez and Holm-Muller 2007; S. De Cara and Jayet 2011; Grosjean et al. 2018; Verschuuren 2018; 2022). In fact, Grosjean et al. (2018) point out that the heterogeneity of mitigation potential and transaction costs (TC) across actors and emissions sources make agriculture a prime candidate for a sector where carbon pricing policies could perform better than direct regulatory instruments.[21] For instance, larger farms benefitting from economies of scale might have better access to emission reduction options such as anaerobic digesters or machines for precision fertilization than smaller farms

[21] As described in **Section 2.2.1**.

(Grosjean et al. 2018). Moreover, biological processes vary considerably among emission sources influencing their abatement potential and cost (ibid). The advancement and readiness of technologies among mitigation options can also differ significantly. Höglund-Isaksson et al. (2012) and Grosjean et al. 2018, for instance, note that mitigation options for manure management and agricultural soils are already accessible on the market (e.g. anaerobic digestion for manure management or reduced and optimized fertilizer application for agricultural soils), while mitigation options for enteric fermentation remain far less developed (e.g. genetic engineering in feed plants or vaccination against methanogenic bacteria). Finally, the literature points out the heterogeneity of MACs within countries due to differences in soil conditions, farm systems, climates, and yields (Dequiedt and Moran 2015). Antle et al. (2003), for instance, show that offering fixed payments 'per hectare' to reward sustainable agricultural practices in the United States might be up to five times costlier than using incentives 'per t CO_2' due to spatial heterogeneity. In the specific case of the EU, this is also true for MACs among EU MS, where scholars locate the highest MAC in MS such as Austria, the Netherlands, and Sweden while the lowest MACs are found in new MS such as Greece, Romania or Hungary (S. De Cara and Jayet 2011; Pérez Domínguez and Fellmann 2015). Pérez Dominguez, Britz, and Holm-Müller (2009) find that the regional costs within Europe vary by up to a factor of 9. The studies also show a high heterogeneity of MAC within MS, which is particularly high for Italy, Poland, and Germany. For these reasons, a European ETS for agriculture can be considered much more cost-effective compared to the strict implementation of each country's climate target or national trading schemes. To achieve a 10% emissions reduction, for instance, MACs would be lower by a factor of 2-3 as De Cara and Jayet (2011) find. Other studies suggest that MACs overall would be 8.00% (Pérez Dominguez and Holm-Muller 2007), 10.81% (Pérez Domínguez and Britz 2010), or even

13.48% (Pérez Dominguez, Britz, and Holm-Müller 2009) lower in an EU-wide ETS compared to national markets (Perez et al., 2007)

Beyond this economic perspective, Verschuuren (2022) conducts a comparative policy analysis of different mitigation policy options for agricultural emissions in the EU and concludes that, given the central role and success of the EU ETS in existing EU climate policy, an ETS should be put into focus, alongside, inter alia, a reform of the CAP and an expansion of the LULUCF Regulation. From a legal perspective, Leach (2022) argues for a high feasibility of including agricultural emissions into the EU ETS pointing out a number of regulatory and policy 'win-wins' such as aligning agricultural and environmental policy goals more closely. Peters (2015) even goes a step further and reasons that the exclusion of agriculture from the EU ETS is a legal violation of the EU's obligations to reduce GHG emissions under the Kyoto Protocol and the United Nations Framework Convention on Climate Change (UNFCCC).

Despite these benefits, to date, most countries have been opposed to pricing agricultural emissions by incorporating them into an ETS (Cooper, Boston, and Bright 2013; Heidecke, Wollenberg, and Rees 2021; Leahy, Clark, and Reisinger 2020). New Zealand was the only country that tried to include agriculture under its national cap-and-trade scheme in 2008 (*NZ Emissions Trading Scheme*, NZ ETS), however, ultimately had to reverse this decision following a successful lobbying effort by the agricultural sector due to concerns primarily about international competitiveness and carbon leakage (Bullock 2012; Cooper, Boston, and Bright 2013; Kerr and Sweet 2008). After this failed attempt, the New Zealand government recently published a new plan in 2022 to introduce a farm-level split-gas levy system[22]

[22] A levy-system is essentially a carbon tax, where regulated entities pay a specific price per unit of carbon emissions. Contrary to a cap-and trade system, there is no upper limited of total allowed emissions (e.g. Leining,

starting with a mandatory reporting period from Q4 2024 and moving onto mandatory pricing from Q4 2025 (New Zealand Government 2023). Beyond that, most of the other few examples of including agricultural emissions in an ETS have been implemented via offsets, i.e., by permitting regulated industries to purchase allowances from agricultural offsets (that is, either avoided emissions or enhanced sequestration). This is the case for the *Alberta Emission Offset System* (2012) (Van Wyngaarden 2023; FAO 2020), California's *Compliance Offset Program* and *Low Carbon Fuel Standard* (2014), under Quebec's, Ontario's, Japan's, and China's ETS (Sun et al. 2016) as well as the RGGI scheme (Verschuuren 2017; FAO 2020). Similarly, the Australian government rewards agricultural emission reductions through its *Carbon Farming Initiative* (2011) (Maraseni 2009; Verschuuren 2017; Saddler and King 2008). In the EU, France is the only Member State (MS) with a national scheme to accredit agricultural offsets (Label bas Carbone), which can be used on the voluntary carbon market (Ministère de la transition énergétique 2022). However, effectively these offset schemes are subsidy programs rather than proper pricing mechanism and their voluntary nature limits their uptake and efficacy (Benjamin Henderson and Frezal 2019). Finally, the current Danish government has recently expressed its commitment to propose a national pricing system for agricultural emissions (Statsministeriet 2022).

3.2 Barriers to an (EU) ETS for agriculture

The theoretical efficiency gains mentioned above that could be derived from an EU ETS for agriculture critically depend on barriers to its implementation, which might undermine expected benefits or even result in higher costs than direct regulations (e.g. P. Smith et al. 2007; Ancev 2011). In particular, the literature frequently mentions high TC, carbon leakage risks, distributional impacts on farmers as well as the strength of the agricultural lobby, as

Kerr, and Bruce-Brand 2020). In a "split-gas" system pricing is different for each GHG regulated according to, for instance, their GWP.

elaborated in more detail below. Some scholars also mention adverse economic effects on consumers in the form of increasing food prices and decreasing food security (e.g. Pérez Dominguez, Britz, and Holm-Müller 2009; Jiang and Koo 2014), however, due to the particularly strong influence of a powerful agricultural lobby of EU policy-making, this study focuses on the distributional impact on farmers.

3.3.1 Transaction costs

The most frequently mentioned barrier to an ETS for agriculture is high TCs both for regulated entities and the regulatory authority, which escalate the cost of implementing the policy and, therefore, diminish the anticipated efficiency gains from carbon pricing (e.g. Ancev 2011; P. Smith et al. 2007; Gerber et al. 2010; Pérez Domínguez and Fellmann 2015; Isermeyer, Heidecke, and Osterburg 2019). These high TCs are the result of various factors: First, measuring and controlling emissions and emissions reductions from agriculture is significantly more challenging and costly than fixed sources like CO_2 emissions from fossil fuels (Cooper, Boston, and Bright 2013), which increases TC in particular related to MRV (Ancev 2011; P. Smith et al. 2007). This is because of the complexity and diffuse nature of agriculture with emissions being highly dependent on local soil and climate conditions as well as management practices (such as the diet of individual animals, tillage intensity, and fertilizer application methods), also influencing the interaction between different emissions (Weishaupt et al. 2020). The majority of farms also capture CO_2 through sequestration in soils and vegetation, which is considered even harder to measure (Frank et al. 2015; Weishaupt et al. 2020). Second, the multitude of farms and agricultural holdings with different sizes and capacities complicates the implementation of MRV systems (Ancev 2011; Pérez Domínguez and Fellmann 2015; P. Smith et al. 2007; Gerber et al. 2010). In 2020, there were 9.1 million farms in the EU compared to some 10,000 installations covered under the current EU ETS (Eurostat 2023). Of these, two-thirds (63.8% in 2020) are small and medium-sized farms (< 5 ha) (ibid), which face relatively higher compliance costs since fixed MRV costs are not proportional to the size of the entity and third-party auditing fees are particularly burdensome to them (Bellassen et al. 2015; Gerber et al. 2010). This is even further complicated by the varied and evolving ownership structures across EU farms. Based on the latest available Eurostat data, in 2016, 45% of the EU's utilized agricultural area was rented out (17% of agricultural holdings) and 48% (78% of holdings) was farmed by the owner (Trinomics (2023) based on Eurostat (2016)).

In the absence of long-term experiences from existing emission pricing mechanisms in agriculture, empirical evidence for the actual magnitude of TCs is scarce and insights from the modeling literature for European agriculture are even more limited. For instance, contrary to the conceptual argument made by Ancev (2011) that TCs are usually underestimated in several developed countries and would offset the limited gains from emissions trading, Vermont and De Cara (2010) and Stéphane De Cara and Vermont (2011) present an opposing view for European agriculture. Moreover, Joas and Flachsland (2014) conclude that, despite concerns, the TC from non-agricultural emissions regulated under the current EU ETS has generally been low. Yet, applying TCs from sectors dominated by major industrial players to agriculture is clearly constrained. Looking at the very few studies modeling TC in agriculture elsewhere provides a quite contrasting picture and gives only limited further insights. For agricultural CDM projects in South America, for instance, TC was estimated to vary at a relatively low level between 0.19–0.71€ per ton (Michaelowa and Jotzo 2005). For international trading schemes of non-CO_2 emissions model assumptions are that TC amounts to 2–10% of the total transaction value (Pérez Dominguez and Holm-Muller 2007). By some, this value is reckoned to be much higher for carbon sequestration, as shown in an agricultural offset scheme in Western Canada, where TCs were assessed as 65–85% of the overall costs involved in generating offsets (Fulton, Cule, and Weersink 2005; van Kooten 2009). Yet, in a small-scale soil carbon storage scheme in Montana (USA), MRV costs are expected to be considerably lower at 3–10.6% of total credit (Mooney et al. 2002). In a regional nitrogen trading scheme in New Zealand, Duhon, McDonald, and Kerr (2014) find that most TC were up-front costs to set up the MRV system, ranging from 2,500–10,000 NZ$[23], while the recurring costs in the following years were comparably low. Finally, some studies assume that international trading schemes come at higher administrative costs compared to national markets (e.g. Pérez Dominguez, Britz, and Holm-Müller 2009), which Pérez Dominguez and Holm-Muller (2007) estimate at 10€ per ton CO_2eq and 5€ per ton CO_2eq, respectively. To conclude, despite theoretical assumptions of a high TC for carbon pricing in European agriculture, the actual magnitude of TC can only be derived to a limited extent from the existing literature and eventually needs to be defined empirically.

3.3.2 (Carbon) leakage risks

A second barrier that has raised concern in scholarship are potential (carbon) leakage risks (e.g Cooper, Boston, and Bright 2013; Gerber et al. 2010; Pérez Domínguez and Fellmann 2015; Van Doorslaer et al. 2015; González-Ramírez, Kling, and Valcu 2012; Arvanitopoulos, Garsous, and Agnolucci 2021; Isermeyer, Heidecke, and Osterburg 2019). That is, the risk that domestic consumption is replaced by imports from other countries with no or less stringent environmental regulation. This is due to the potential negative effects of a unilateral pricing scheme on the economic viability of EU farm enterprises and the related competitive disadvantage in international trade. This could not only harm the European economy but also jeopardize emission mitigation efforts from a global perspective, and in the worst case even result in a net increase in total global GHG emissions (Pérez Domínguez and Fellmann 2015).

[23] Equals approximately 1,400–6,700€ (according to exchange rate on 18/12/2023).

Again, due to the lack of real-world application of emissions pricing in agriculture, there is no ex-post study estimating the actual economic impacts and potential carbon leakage effect. However, ex-ante modeling studies suggest that leakage rates could be substantial due to the high exposure of EU agriculture to trade, yet findings vary widely. Leip (2010), for instance, estimate that covering agriculture under the EU ETS decreases emissions by 19.3% but increases livestock emissions elsewhere by 6%. Moreover, Van Doorslaer et al. (2015) found a significant rate of carbon displacement exceeding 100%, rendering an EU ETS for agriculture both economically and environmentally ineffective. However, it should be noted that studies comparing ex-ante modeling to ex-post evidence have typically indicated that carbon leakage in emission pricing schemes in other sectors is overestimated (e.g. Branger and Quirion 2014). For instance, in the case of the EU ETS, despite concerns about carbon leakage prior to its introduction, Martin et al. (2014) found no evidence that the introduction of the EU ETS resulted in the relocation of firms to non-European markets. Moreover, Branger, Quirion, and Chevallier (2016) concluded that the EU ETS has not increased EU net imports of products from regulated industries such as cement and steel.[24] Finally, it should also be acknowledged that European agriculture is a highly protected sector, for instance, through trade barriers such as tariffs for so-called "most-favored nations"[25] (varying between 18–28% in comparison to 3% for industrial products) (Matthews 2020) and non-trade barriers such as "technical, sanitary, and phytosanitary" restrictions, particularly for animal products (EC 2023c). To conclude, the literature suggests that the risk of carbon leakage from pricing European agricultural emissions could be significant, however, leaves the actual magnitude unclear.

[24] However, it should be noted that firms operating in sectors deemed at risk of carbon leakage were granted free allowances under the EU ETS to avoid precisely this issue (see **Section 6.1.1**).

[25] Following WTO rules a WTO member must treat all trading partners (that are part of the WTO) with the same rules as the "most-favoured nation", i.e. the trading partner with the most favourable trading conditions (WTO 1947).

3.3.3 Distributional impacts on farmers and the strength of the agricultural lobby

A final critical barrier is the potential negative distributional impacts on farmers (e.g. Cooper, Boston, and Bright 2013; González-Ramírez, Kling, and Valcu 2012; Pérez Domínguez and Fellmann 2015; Van Doorslaer et al. 2015). This is closely related to institutional barriers mentioned by the literature such as lack of political support and the strength of the agricultural lobby stemming from potential policy-induced financial impacts on farmers. For instance, prior to the potential introduction of an ETS for agricultural emissions in New Zealand, the political discourse was centered around concerns about social equity reduced agricultural production, and potential job losses in the industry (Cooper, Boston, and Bright 2013; Kerr and Sweet 2008; Cooper and Rosin 2014). Similarly, in Australia, an attempt to include agriculture into an ETS failed most importantly due to the strong political opposition having considerable influence (Verschuuren 2017). In Europe, the agricultural lobby is also known for being particularly influential and for enjoying substantial public support, primarily in the form of the lobby organization "Copa Cogeca," and from agriculture-intensive Member States such as France, Spain, Italy, Germany, and the Netherlands, (Keeler 1996; Patterson 1997). Similarly to New Zealand and Australia, this could potentially limit the feasibility of implementing ambitious climate policies within the sector.

However, the actual magnitude of the effect of tradable emission permits on agricultural income is controversially discussed in the literature, yet the majority of studies observe a negative effect. For instance, Bakam and Matthews (2009) conclude that farmers could face a 40–50% loss of income to achieve a 30% emissions reduction target under a cap-and-trade system in Scotland. Another study in the US calculates that mandating the fertilizer industry under a pricing scheme negatively affects the income of more than 70% of the farms (Jiang and Koo 2014). However, some studies also suggest that farmers could potentially profit pointing toward the cost-effectiveness of emissions trading compared to fixed standards

(Pérez Dominguez, Britz, and Holm-Müller 2009; Pérez Dominguez and Holm-Muller 2007). Regardless, it can be assumed that the impact on farmers' income will not be uniform across agricultural practices and geographic locations but depend on regional specifications. For instance, farms and regions specialized in the production of less emissions-intensive food will likely benefit from a higher demand as a result of carbon pricing compared to emission-intensive products, such as beef, which are more vulnerable (Van Doorslaer et al. 2015). Eventually, the actual impact on farmers' income will hinge on the possibility of passing on the policy costs to consumers (Grosjean et al. 2018). However, agriculture is characterized by homogeneous and degradable products, which limits farmers' ability to do so (Fulton, Cule, and Weersink 2005; Kerr and Sweet 2008). Finally, it should be taken into consideration that European agriculture is heavily supported through the CAP, a tool particularly designed to safeguard the revenues of farmers (as explained in **Section 2.1.4**), which could mitigate undesired distributional consequences. To conclude, the strong agricultural lobby will likely be a key obstacle to the inclusion of agriculture into the EU ETS due to concerns about distributional impacts, however, the actual magnitude of impacts on farmer's income remains unclear.

3.4 Design options to overcome barriers to an (EU) ETS for agriculture

As Grosjean et al. (2018) point out, the magnitude of the barriers to an ETS for agriculture depends on the policy design. However, only a few studies have thus far discussed respective policy options. Given more empirical evidence/existing (voluntary) schemes or more concrete political intentions regarding ETS inclusion, these mostly focus on the context of New Zealand (e.g. Cooper, Boston, and Bright 2013; Kerr and Sweet 2008; Kerr and Zhang 2009; Bullock 2012; Leining, Kerr, and Bruce-Brand 2020; Moyes 2008), Australia (e.g. Verschuuren 2017; Maraseni 2009), and the US (e.g. González-Ramírez, Kling, and Valcu

2012). Yet, apart from New Zealand, these mostly center around voluntary offset schemes rather than ETS inclusion[26].

In general, existing scholarship is limited to rather stylized and one-dimensional policy approaches looking mostly at full (EU) ETS inclusion from the outset (e.g. Ancev 2011; Stéphane De Cara and Vermont 2011; Pérez Dominguez and Holm-Muller 2007; Pérez Dominguez, Britz, and Holm-Müller 2009; Pérez Dominquez et al. 2012; Brandt and Svendsen 2011), the inclusion of voluntary offset schemes into the existing ETS (Verschuuren 2018) or at national ETS schemes in Germany (Isermeyer, Heidecke, and Osterburg 2019) and Scotland (Bakam and Matthews 2009). Moreover, a few studies explore in more detail particular design options such as MRV (Cowie et al. 2012), allowance distribution (Kerr and Zhang 2009). Others focus on specific emissions sources such as livestock herding (Weishaupt et al. 2020) or compare different points of obligation for an EU ETS along the agricultural value chain (Trinomics). Some studies also have derived lessons from other jurisdictions for the design of an agricultural ETS in the European context. For instance, Fleurke (2022) for MRV provisions and Verschuuren (2017) for voluntary carbon offsets.

To a limited extent, previous scholarship also looks into the development of the market in the first period of introducing a carbon trading policy, however, with a focus on the first few years of implementation. For instance, Bullock (2012) and Leining, Kerr, and Bruce-Brand (2020), promote an initial high share of free allocation which is phased out during the first years. Others suggest making use of price management measures during the transition period to protect participants against price volatility in the early years (Bakam and Matthews, 2009; Bullock 2012; Leining, Kerr, and Bruce-Brand 2020). Moreover, Grosjean et al. (2018)

[26] However, as Verschuuren (2017) notes, much can still be learned from voluntary offset schemes for the inclusion of agriculture onto a trading scheme.

suggest focusing on some emissions sources or types of farms to enhance the political feasibility and administrative operability. Finally, Verschuuren (2017) argues that voluntary mitigation projects, such as the Emissions Reduction Fund (ERF) in Australia, might promote the uptake of carbon pricing in the agricultural sector.

3.5 Summary of Literature Review and Gap

In summary, the European agricultural sector is a significant contributor to the EU’s GHG emissions, however, its mitigation potential remains untapped and dormant to a large extent. A flexible and cost-efficient market-based instrument such as an ETS could facilitate emissions reduction, but its implementation is difficult. Transaction costs jeopardize cost-effectiveness and leakage risks as well as distributional impacts undermine policy acceptance. Yet, the extent of such obstacles significantly depends on policy design. The literature identifies some policy design options to reduce these barriers, such as partial policy coverage of GHG emissions, shifting the point of obligation, free allocation of allowances, using proxy parameters, or price management measures. However, especially in the European context, the previous discussion focuses on rather one-dimensional and static policy design. Moreover, while some scholarship has discussed the importance of optimal timing of policy introduction, this focuses on the transition period of implementing an ETS. Studies applying a multi-dimensional and multi-temporal lens to overcome barriers through a gradual phase-in over multiple steps of policy reform are limited.

4 Theory and Conceptual Framework

This section presents the theories and conceptual framework utilized in this study. First, it provides a background on the theoretical background of the concept of "policy sequencing", in which this study is embedded **(Section 4.1)**. Next, it describes the analytical framework and its elements employed to guide this analysis **(Section 4.2)**. Finally, the limitations of the chosen theoretical approach are acknowledged **(Section 4.3)**.

4.1 Theoretical embedding and related work: Policy sequencing

4.1.1 Policy sequencing

Recent literature suggests that one way to address mechanisms that hinder stringent climate mitigation policies over time is *policy sequencing.* In addition to the well-established concept of policy mixes[27], policy sequencing adds a temporal dimension to sound policy design (Michael Howlett 2019). The central idea behind policy sequencing is that "policies at an early stage can be conducive to implementing more stringent policies at a later stage" (Leipprand, Flachsland, and Pahle 2020, 141). In that sense, policy sequencing is an approach to respond to policy problems over time by introducing less stringent policies at first to relax or remove barriers and thus enable more stringent policies later on covering additional sectors, issue areas, or jurisdictions (Meckling et al. 2015; Meckling, Sterner, and Wagner 2017; Pahle et al. 2018; Leipprand, Flachsland, and Pahle 2020). Policy options that can trigger such processes in relation to a specific barrier are referred to as *sequencing options* (ibid). The policy sequencing framework provides a lens for analyzing such mechanisms and processes that support ratcheting-up of climate policies taking into consideration "their context's political economy, affecting actors, institutions, and coalitions" (ibid). As Pahle et

[27] **Policy mixing** refers to the combination of different policy instruments, where each addresses a particular element of the policy problem (e.g. Edmondson, Kern, and Rogge 2019).

al. (2018) note, policy sequencing is a particularly helpful framework for analyzing policy process dynamics that facilitate ratcheting-up in the context of multiple barriers. As shown above, this is the case for introducing an EU ETS for agriculture.

The sequencing framework builds on mechanisms that have been discussed in the classical theoretical scholarship of *path dependency* and *policy feedback* theory (Pierson 1993; 2000; Mahoney 2000; M. Howlett 2009). The concept of *path dependency* refers to a situation where the present policy choice is constrained or shaped by institutional paths that result from policy choices made in the past. This may lead to a long-term reproduction of institutional patterns or a 'lock-in' of the prevailing conditions that hinder (or also foster) the adoption of more efficient policy alternatives (Mahoney 2000). In this context, sequencing options work in large parts through triggering *policy feedback*, which Béland (2010, 569) defines as "the impact of existing policies on politics and policy development". It is important to highlight, that feedback mechanisms do not directly affect policies, but they influence policymakers in their decision to reinforce or undermine policies (G. Jordan, Halpin, and Maloney 2004). Policy feedback can be both positive and negative. While positive policy feedback can help reduce or overcome barriers to higher stringency (Pierson 1993; 2000; Mahoney 2000; M. Howlett 2009), negative policy feedback can strengthen barriers to stringency and, thus, destabilize a (climate) policy regime (Jacobs and Weaver 2015; Weaver 2010). Building on that, while most of the policy sequencing scholarship assumes that all barriers relax over time (Meckling, Sterner, and Wagner 2017; Pahle et al. 2018), more recent work finds that ramping up climate policies can trigger opposition and resistance, therefore, tightening barriers or creating new ones (Leipprand, Flachsland, and Pahle 2020).

Although, the concept of policy sequencing is relatively new, it has found empirical relevance over the past years in case studies on policy ratcheting-up in individual sectors, such as energy (Meckling, Sterner, and Wagner 2017; Pahle et al. 2018), as well as in individual jurisdictions, such as the EU, Germany, and California (Pahle et al. 2018; Leipprand, Flachsland, and Pahle 2020). Most recently, Linsenmeier, Mohommad, and Schwerhoff (2022) provided international and cross-sectoral evidence on climate policy sequencing towards carbon pricing in G20 economies and 18 other large emitters. Lately, the concept also made its entrance into a recently published policy guidance on decarbonization by the World Bank strengthening its practical relevance (Hallegatte et al. 2023).

4.1.2 Barriers and sequencing options

Leipprand, Flachsland, and Pahle (2020) based on Pahle et al. (2018) identify four key types of economic, political, and legal barriers to higher policy stringency: 1) *economic cost* (technology cost, lack of policy cost-effectiveness), 2) *distributional dynamics* (interest group opposition, lack of supporting coalition), 3) *institutions and governance* (lack of expertise and capacity, veto power of opposing units in government), 4) *free riding* (free riding and heterogeneous preferences). As described below, the feedback literature provides insights into sequencing options that can relax or remove these barriers over time. Yet, as Pahle et al. (2018) note there might also be various routes (i.e. combination of sequencing options) which might break up a constellation of barriers.

Economic cost

Pahle et al. (2018) distinguish two types of economic costs: technology costs resulting from the deployment of mitigation technologies and policy costs resulting from a lack of cost-effectiveness of different policy design options (for instance, technology standards are usually less cost-effective than more flexible MBIs, such as an ETS). Green technology policies may reduce mitigation technology costs, thereby lowering or eliminating the cost barrier (Schmidt and Sewerin 2017), while at the same time avoiding a lock-in of innovation in dirty technologies (Acemoglu et al. 2012). A resulting higher competitiveness of low-carbon technologies, in turn, makes a strong case for policymakers to capitalize economic opportunities by implementing more ambitious policies, therefore, self-reinforcing further stringency (positive feedback) (Pahle et al. 2018). In contrast, increasing fiscal constraints or societal costs caused by (technology) policies could also reveal a lack of policy cost-effectiveness, therefore, reinforcing the cost barrier (Weaver 2010). This makes a strong case for phasing out technology policies once technologies are mature and expanding carbon pricing (negative feedback) (Pahle et al. 2018). If properly managed, technology policies can, therefore, improve the design and facilitate the adoption of carbon pricing (González 2007).

Distributional dynamics

Both the opposition of interest groups and the lack of a supporting coalition can be a barrier to increasing stringency (Pahle et al. 2018). A policy that creates significant and targeted costs for powerful actors likely causes resistance (A. Jordan and Matt 2014). On the contrary, if concentrated and well-organized groups receive policy benefits, they likely build a supporting coalition (Wilson 1980). One approach to address political resistance is to fragment a regulation (and thus the opposition) via sectoral policies with differentiated stringency (Bettzüge 2016). Other options are targeted exemptions and strategic transfers or compensation measures to soften the opposition of affected actors (Dorsch, Flachsland, and Kornek 2020; Carattini, Carvalho, and Fankhauser 2018). However, caution needs to be applied to avoid a situation where compensation costs persist (or even increase) over time without actually destructing the resistance of the opposing group, thus only temporarily circumventing a barrier without relaxing it or even creating a lock-in (Rogge, Kern, and Howlett 2017). The creation of a supporting coalition can be achieved through the provision of targeted benefits in the form of subsidies or other payments to form or grow interest groups (Dorsch, Flachsland, and Kornek 2020). Such “winning coalitions” can become advocates for higher stringency, thus stabilizing a policy (Meckling et al. 2015). Even more so, attempts to dismantle policies that favor such actors later on might encounter strong resistance (Béland 2010; Pierson 1993; A. Jordan and Matt 2014), therefore, self-reinforcing a policy sequence. Finally, policies addressing multiple issues might expand the support coalition through the creation of co-benefits. However, one needs to be cautious since it may also constrain zones of agreement, therefore, preventing further ratcheting-up (Rogge, Kern, and Howlett 2017).

Institutions and governance

On an institutional level, implementing ambitious climate policy may face significant barriers in the form of limitations to the effectiveness of and support for government institutions and processes (Pahle et al. 2018). An integral part of addressing a lack of technical (and enforcement) expertise or capacity within a governing body is learning from earlier policy experiments on related issues (Heikkila and Gerlak 2013; Daugbjerg 2009). Since policymakers tend to rely on 'proven' policies, this can reinforce sequencing later on, especially when implementing complementary policies (Yi and Feiock 2012). Policies may also facilitate such learning (themselves) if they include monitoring, review, and verification (MRV) systems that uncover areas of improvement (A. Jordan and Matt 2014). A way to overcome potential resistance from opposing units in governments might be to allocate regulatory competencies to units with progressive objectives and personnel while withholding them from units with differing climate-related policy objectives. Implementing this early on, will reinforce the political power of certain units of government later on, therefore, entrenching their progressive position (Brunner, Flachsland, and Marschinski 2012). Implementing policy options that do not require a supermajority initially is also an option to circumvent the veto power of opposing agencies (Pahle et al. 2018).

Free riding

Finally, free riding and heterogeneous climate policy ambition can undermine domestic actions to increase stringency (Pahle et al. 2018). One approach to overcome free riding, is to incrementally align or link climate policies across jurisdictions, for instance, in the form of international rules and norms (Bernstein and Cashore 2012). This may eventually lead to the establishment of climate clubs (Nordhaus 2015), which are able to protect themselves and are willing to impose sanctions on free riders, therefore, self-reinforcing climate stringency (Keohane, Petsonk, and Hanafi 2017). An alternative approach is to engage as a first mover in policy experimentation to create and disseminate knowledge to other jurisdictions (Bernstein and Cashore 2012). If this leads to increasing stringency elsewhere, such policy diffusion is also self-reinforcing (Pahle et al. 2018).

4.1.3 Types of policy sequencing

So far, the sequencing theory has mainly focused on successive progression <u>across</u> different policies. Pahle et al. (2018), for instance, found that green innovation and industrial policies facilitated the adoption of more stringent carbon pricing policies in Germany and California as they help decrease the technology costs of low-carbon alternatives to fossil fuels, therefore, looking into mechanisms that alter barriers through feedback effects caused by <u>other policies</u>. Recently, Leipprand et al. 2020 have expanded the relevance of the sequencing framework to processes within individual policies such as the EU ETS and the EU's Renewable Energy Directive identifying mechanisms that alter barriers to higher stringency through feedback effects of the <u>policy itself</u>. As explained in **Section 4.2** the latter approach is used in this study.

Moreover, policy sequencing can be both <u>unintentional</u> and <u>intentional</u> (Michael Howlett 2019). Much of the existing scholarship has investigated unintentional (or *reactive*) *sequencing*. That is, policy development is the result of responses to significant alterations in existing trajectories of policies and outcomes (ibid). However, existing policies can rarely be completely replaced but new policies are usually 'layered' onto existing ones, which can create antagonism between policies (Michael Howlett and Rayner 2013; van der Heijden

2011). Therefore, scholarly attention has shifted from policy sequencing as an unintentional process of institutional change to sequencing as an intentional policy design tool for smarter regulation (*strategic sequencing*) (Michael Howlett 2019). As a core policy design principle, this requires anticipating barriers to and potential feedback effects of policies as well as possibly channeling these feedback effects into the desired direction (Pahle et al. 2018). As explained in **Section 4.2**, the latter approach is used in this study.

4.2 Conceptual Framework

In this thesis, a policy sequencing framework adapted from Leipprand, Flachsland, and Pahle (2020) is used for analyzing lessons learned from the introduction of the existing EU ETS and subsequently the mechanism and processes that could support a step-wise introduction of an EU ETS for agriculture (**Figure 3**). The framework, therefore, simultaneously functions as the input and output of this research.

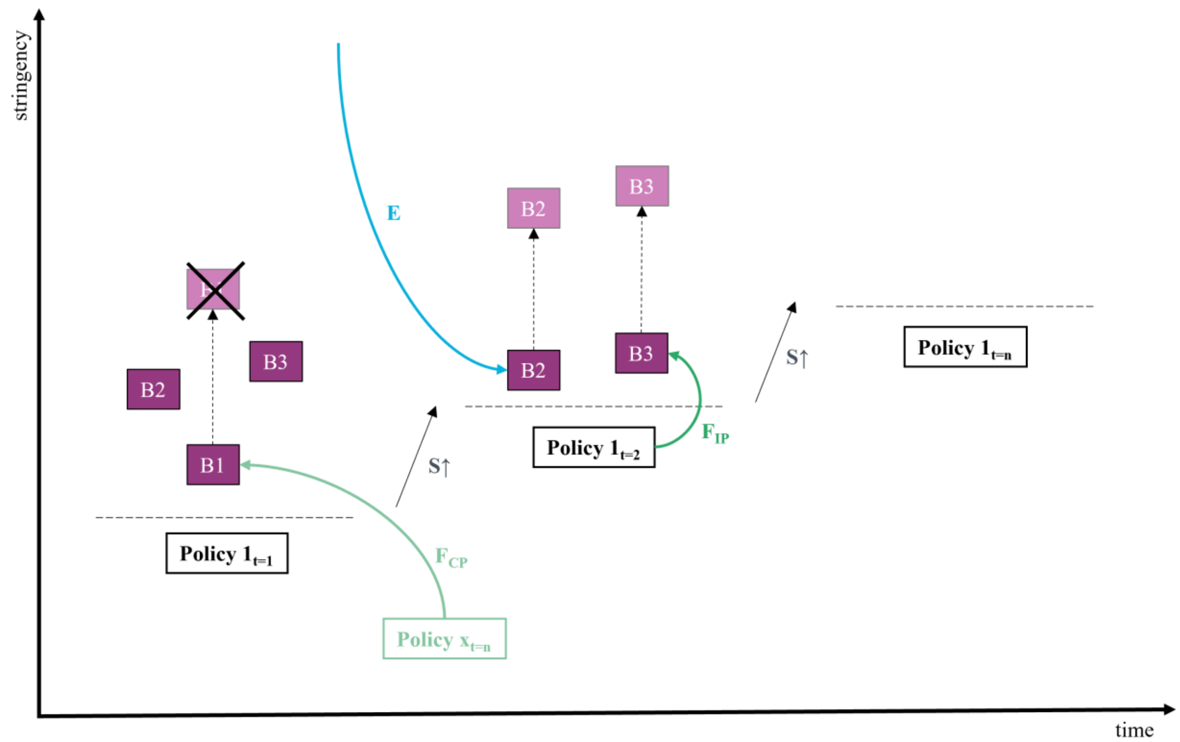

Figure 3 Analytical framework of policy sequencing to ratchet-up climate policy stringency: Barriers (B) to stringency increase (S↑) are relaxed or removed through internal policy feedback (F_{IP}), cross-policy feedback (F_{CP}), and external factors (E) (reproduced from Leipprand, Flachsland, and Pahle (2020)).

As Leipprand, Flachsland, and Pahle (2020) explain, the increase in *stringency (S)* of a policy is the key dependent variable in the framework. Drawing on Oberthür (2019) and Schaffrin, Sewerin, and Seubert (2014), they assess the (change in) policy stringency based on the following three indicators:

1. Policy *ambition*: Are the targets of the policy becoming increasingly ambitious? In the case of an ETS, this refers to the cap, the rate of decrease of the annual quantity of allowances, and the price level of allowances

2. Policy *scope*: Is the policy expanding in scope? This refers to the coverage of greenhouse gas emissions, sectors, and countries (defined as 'ratcheting out' by Pahle et al. (2018)).

3. Policy *design*: Is the design of the policy becoming increasingly suitable to ensure target achievement? This includes considerations of the level of bindingness, enforceability, and monitoring and review provisions. Stringency is restricted by *barriers (B)*, and it can increase (S↑) as barriers are relaxed or removed.

Following Leipprand, Flachsland, and Pahle (2020) and adapting Pahle et al. (2018) this study concentrates on barriers related to (economic) costs (B_C), to politics (B_P), and to institutions and governance (B_{IG}) (**Table 2**).

Table 2 Types of barriers to more stringent climate policy (based on Leipprand, Flachsland, and Pahle (2020) adapted from Pahle et al. (2018)).

Category	Specific barrier
(Economic) Cost (B_C)	High (technology) costs of low-carbon alternatives
	Free riding & international competitiveness
Politics (B_P)	Interest group opposition
	Lack of supporting coalition
Institutions and Governance (B_{IG})	Lack of expertise and capacity
	Veto power of opposing units in government

Further, *Ratcheting-up* of a policy occurs if stringency is increased over time. *Sequencing* refers to the adoption of intermediary policy design choices that – intentionally or not – enable ratcheting-up by relaxing or removing barriers via specific mechanisms over time (*sequencing options*). These mechanisms, or *feedback effects,* can be two-fold: 1) feedback effects from the policy itself (*internal feedback* F_{IP}) or 2) feedback caused by the effect of other policies (*cross-policy feedback* F_{CP}). As noted above, it is important to take into account, that barriers might not only be relaxed but can also be tightened. This study, therefore, recognizes that policy sequencing options include both the triggering of positive and the controlling of negative feedback mechanisms. While this study mainly focuses on policy internal feedback mechanisms, it does recognize that an EU ETS for agriculture would stand in stark interaction with other policies, predominately the CAP, and, therefore, also considers cross-policy feedback, when applicable. Finally, barriers can also be altered through *external effects* (E) that are not caused by the policy itself or other policies. External processes or conditions are, for instance, the availability of policy alternatives, pressures from internal environmental regimes, the role of policy entrepreneurs, the complexity and consistency of policies within policy mixes, and the degree of political polarization (Leipprand, Flachsland, and Pahle (2020) based on Edmondson, Kern, and Rogge (2019); Jacobs and Weaver (2015); A. Jordan and Matt (2014); Weaver (2010)). Following Mahoney (2000) this study recognizes that policy sequences are the result of an interaction between both policy feedback and external effects.

4.3 Limitations of Conceptual Framework

As Pahle et al. (2018) and Leipprand, Flachsland, and Pahle (2020) note, the policy sequencing framework is a simplification in several ways: First, barriers are looked at separately while, in fact, they might be intertwined. Second, while the framework does consider cross-policy feedback, it is not suited to study complex interactions in a broader policy mix. Third, similarly, the framework considers the effect of external circumstances, however, it remains limited in the possibility of analyzing the impact of (changing) societal and political discourse on policy ratcheting-up.

Moreover, it is important to note that the majority of the policy sequencing literature has focused on ratcheting-up policy stringency in renewable energy transitions (Meckling et al. 2015; Meckling, Sterner, and Wagner 2017; Pahle et al. 2018). Policy problems concerning land use are much more complex than designing and deploying renewable energy technologies. Although the utility of the sequencing framework has recently also been demonstrated for addressing multi-stakeholder and multi-agenda issues such as deforestation (Furumo and Lambin 2021) and sustainable water use (Pakizer et al. 2023), a direct application to agriculture is thus far missing. Despite, this should serve as validation for applying the concept to agriculture**.**

5 Research Design, Materials and Methods

This section presents the research methodology applied in this study. After giving an overview of the general research design (**Section 5.1**), it provides a detailed description of the methods used for data collection (**Section 5.2**) and data analysis **(Section 5.3)** and discusses ethical considerations (**Section 5.4**) taken as well as the limitations of this methodological approach (**Section 5.5**).

5.1 Research Design

This study takes a *qualitative research approach* to answer the posed research questions. As an approach to capture a "complex set of factors surrounding the central phenomenon" (Creswell & Creswell, 2018, p. 192) it was deemed well-suited for acquiring an in-depth understanding of the nuances, perspectives, and contextual intricacies of feasible pathways for introducing and EU ETS for agriculture. Also, Ritchie and Ormston (2014) highlight the insight that qualitative research can provide about historical, political, social, or cultural factors as well as the relationships and interactions between stakeholders, which aligns well with the importance of acquiring an in-depth understanding of the political, socio-cultural, and economic mechanisms enabling or hindering potential policy sequences. As is typical for a qualitative study, the research design was in many aspects *emergent* meaning that learning throughout the research process led to slight adaptions of the research plan (Creswell and Creswell, 2018).

Following the interrelated nature of the RQs (as introduced in **Section 1.3**), data was collected and analyzed in two steps. First, to derive lessons learned from the existing EU ETS in other sectors for how to overcome barriers through the step-wise introduction of an ETS (RQ1), desk research of written material was conducted. This included official documents of the EU ETS policy-making process as well as scientific studies and grey literature that analyze specific episodes or aspects of the EU ETS policy development (**Section 5.5.1**). Based on these lessons, feasible pathways for the stepwise introduction of an EU ETS for agriculture (RQ2) were explored. To this end, desk research of theoretical and empirical academic literature was leveraged. To enhance the analysis and empirically support or verify the factors observed in the literature, this was combined with empirical evidence from supplementary semi-structured interviews with experts and stakeholders along the EU agricultural value as well as a public stakeholder workshop with policy makers, experts and representatives of key stakeholder groups conducted by the European Commission (**Section 5.2.2**). The conceptual framework of *policy sequencing* derived from Leipprand, Flachsland, and Pahle (2020) in combination with the *barrier typology* introduced by Pahle et al. (2018), as described in the previous chapter, guided data collection and analysis. A schematic overview of the research flow including methods employed to collect data and materials collected as well as methods utilized to analyze the data can be found in **Figure 4**.

Research Aim	This master's thesis research aims to contribute to the development of a regulatory framework that allows to overcome the barriers to an Emission Trading System (ETS) for agricultural GHG emissions at the EU level through a step-wise approach.				

Research Questions	**RQ1:** What can be learned from the existing EU ETS for overcoming barriers through the gradual phase-in of an effective Emission Trading System (ETS)? *RQ1.1:* What were the barriers to the introduction of the existing EU ETS? *RQ1.2:* What policy design pathways were chosen to overcome these barriers?		**RQ2:** Based on these lessons learned (and other evidence), what are feasible pathways to overcome barriers through the step-wise introduction of an Emission Trading System (ETS) for agricultural GHG emissions in the EU (and their trade-offs)? *RQ2.1:* What are the barriers to the introduction of an EU ETS for agricultural GHG emissions? *RQ2.2***:** What policy design pathways could be used to overcome these barriers?		
Data Types & Data Collection Methods **(see Section 5.2)**	Qualitative Data Desk research of 29 official documents of EU policy-making to establish the EU ETS (secondary data)	Qualitative Data Integrative literature review (ILR) (Torraco 2005) of 18 scientific studies and grey literature that analyze specific episodes or aspects of the EU ETS policy development (secondary and tertiary data)	Qualitative Data Integrative literature review (ILR) (Torraco 2005) of 28 theoretical and empirical academic literature on potential design options for the introduction of an ETS for agriculture (secondary and tertiary data)	Qualitative Data 18 semi-structured interviews with experts and stakeholders along the agricultural value chain in the EU (primary data)	Qualitative Data 3 ½ hour public stakeholder workshop with policy makers, experts and representatives from stakeholder groups along the agricultural value chain in the EU (primary data)
	<u>Purpose:</u> Identify policy sequencing options that helped to overcome barriers to stringency	<u>Purpose:</u> Understand internal and cross-policy feedback mechanisms and external effects that were conducive to increasing policy stringency	<u>Purpose:</u> Derive theoretical insights as well as empirical validation from other jurisdictions (e.g. NZ, Australia)	<u>Purpose:</u> Complement and empirically validate information from desk research	

Data Analysis **(see Section 5.3)**	Thematic content analysis (TCA) (Braun et al. 2019; Mackieson et al., 2019)	Thematic content analysis (TCA) (Braun et al. 2019; Mackieson et al., 2019)
	<u>Coding approach:</u> abductive, i.e. combination of • *deductive* coding approach based on the barrier typology adapted from Pahle et al. (2018) and the policy sequencing framework adapted from Leipprand, Flachsland, and Pahle (2020) (overarching themes) • *inductive* coding approach (sub-themes) (Tavory & Timmermans, 2014)	<u>Coding approach:</u> abductive, i.e. combination of • *deductive* coding approach ○ based on the barrier typology adapted from Pahle et al. (2018) and the policy sequencing framework adapted from Leipprand, Flachsland, and Pahle (2020) (overarching themes) and on RQ1 (sub-themes) • *inductive* coding approach (new sub-themes) (Tavory & Timmermans, 2014)

Figure 4 Schematic overview of the research flow and interrelated nature of the research questions including methods employed for data collection and data analysis as well as the links to the analytical framework (own illustration).

5.2 Methods used to collect data and materials collected

5.2.1 Methods used to collect data and material collected in support of RQ1

In support of RQ1, two types of qualitative data sources were leveraged. First, official (policy) documents of the EU ETS policy-making process were consulted. This included the initial legal act establishing the EU ETS in November 2003 and subsequent amendments of the EU ETS Directive up until its latest amendment in June 2023 as well as other legal acts relevant to the EU ETS (25 in total). In light of the research aim, only legal acts that influenced the policy stringency of the EU ETS and could provide learnings for the agricultural sector were included, while such with no or limited discernable impact were disregarded. Moreover, the European Commission's "Green Paper on Greenhouse Gas Emissions Trading within the European Union" and three official reports of the European Commission to the European Parliament and the European Council on the "state of the European carbon market" [28] were reviewed allowing to follow the considerations taken by the European Commission informing the introduction and each reform of the EU ETS. All consulted (policy) documents are publicly available on "EUR-Lex", an official website of the EU publishing EU law and other public documents of the EU.[29] A full list of examined policy documents in chronological order and stating the respective policy reform, as well as consulted carbon market reports, can be found in **Annex I**.

Second, to improve the understanding of the underlying processes and external effects that were conducive to policy sequencing, scientific studies and grey literature that analyze

[28] As stipulated in Articles 10(5) and 29 of Directive 2003/87/EC, the carbon market reports analyze the functioning of the carbon market and propose corrective regulatory actions if needed. They have been published every year since 2012. Three major EU ETS reviews — before Phase 3, before Phase 4, and in the context of increasing the EU 2030 climate target — have been conducted to date.

[29] https://eur-lex.europa.eu/advanced-search-form.html?action=update&qid=1716970792536 (Accessed: 29 May, 2024).

specific episodes or aspects of the EU ETS policy process were leveraged. With the aim to distill information on certain themes derived from the conceptual framework this approach can be best classified as an *integrative literature review (IRL),* which is a method used to "review and synthesize literature [from different disciplines] on a topic in an integrated way such that new […] perspectives on the topic are generated" (Torraco 2005, p. 356). Moreover, recognizing that scientific literature is an essential source of information for this study and with the aim to ensure a coherent data analysis, following Bandara et al. (2015) the literature review process is seen as part of the qualitative study and the extracted literature as a qualitative data set. To find appropriate studies, the databases Google Scholar (due to the high coverage of literature from an array of publishing formats and disciplines), Scopus (due to the wide array of sorting and filtering options, especially regarding scientific disciplines), and Google (as a key tool to identify grey literature) were leveraged. Various combinations of the search terms 1) 'emission trading', 'emission trading system', 'ETS', 'carbon pricing', and "market-based instruments', 2) 'EU', 'European Union', and 'Europe', and 3) 'sequencing', 'transition', 'introduction', 'gradual' were employed. After filtering and reading the titles and abstracts, a total of eight academic articles along with one key report were deemed most suitable for the review. Reviewing the literature of these sources, also known as *snowballing* (Wohlin et al. 2022), led to an additional nine relevant papers. No cut-off date was applied since it was of interest to understand the development leading up to the introduction of the EU ETS from the start.

5.2.2 Methods used to collect data and material collected in support of RQ2

As introduced above, three different qualitative data sets were analyzed to answer RQ2. First, given a lack of empirical evidence on the application of carbon pricing instruments to the agricultural sector in the EU context, theoretical and empirical peer-reviewed as well as grey literature on potential design options for the introduction of an ETS for agriculture was an important source of information. Following the same rationale as for RG1 an *integrative* approach to this *literature review* (ILR) (Torraco 2005) was chosen and the extracted literature was treated as a qualitative data set (Bandara et al. 2015). Analogous to RQ1, the databases Google Scholar, Scopus, and Google were employed to find relevant studies. Various combinations of the following search terms groups were utilized: 1) 'agriculture' and 'farming', 2) 'emission trading', 'emission trading system', 'ETS', 'carbon pricing', and "market-based instruments', and 3) 'EU', 'European Union', and 'Europe'. Since the literature specifically focusing on the EU context was limited and exclusively of a theoretical nature, empirical studies from jurisdictions outside of the EU that have empirical experience with market-based instruments in the agricultural sector were included in the analysis. Including the application of the snowballing method, 28 studies were deemed as most relevant. Since the literature on an ETS for agricultural emissions is relatively small and it was deemed important to cover a broad range of thinking, it was decided not to apply a cut-off date.

Second, recognizing the limitations of solely relying on empirical evidence from jurisdictions outside of the EU and to empirically support the findings from the literature, interviews were conducted. To select relevant interview partners, a *non-random judgment approach (purposive sampling)*, was employed, selecting the most productive sample to answer the research question (Marshall 1996). Besides EU policy-makers and experts from research institutes and think tanks, the following stakeholders were deemed most relevant for this study: stakeholders along the agricultural supply chain that would potentially be impacted by an EU ETS for agriculture (i.e. farmers represented through farmers associations as well as up- and down-stream industry actors), environmental NGO's (to incorporate a civil society perspective), and media representatives (to provide a more objective view on the political economy of introducing an EU ETS for agriculture).

To recruit relevant interview partners, the professional network of the researcher within and surrounding the European Commission was leveraged (mainly acquired during a traineeship conducted from October 2022 to February 2023), along with tools such as the Transparency Register of the EU[30], LinkedIn, Twitter, and Google. The attended public stakeholder workshop organized by the European Commission (see below) provided further leads for relevant interview partners. The interviewees were recruited mainly via e-mail and, in cases where e-mail addresses were not publicly available, via LinkedIn or phone calls. To confirm whether potential interviewees had the relevant and required expertise, participants were sent an outline of the research aim along with the interview guide detailing the interview questions prior to the interview. In addition, as the interviews proceeded the interviewees suggested or recruited additional samples for the research, otherwise referred to as the *snowballing method* (Kirchherr & Charles, 2018). In total, 75 potential participants (14 researchers, 16 policymakers, 22 representatives of farmers' associations, 13 industry representatives, five environmental NGOs, and four media representatives) were contacted. In the end, 17 interviews were performed with 18 participants in total (one joint interview was held with two participants at the same time. The participants included six researchers and five EU policymakers; three interviewees represented farmers' associations, two industry, one an environmental NGO, and one media. It must be noted that two of the EU policymakers (P1 and P2) were no longer working for the European Commission at the time of the interview but could provide a policymaker perspective due to their long service at the European Commission, inter alia in their role as co-developer of the EU ETS. **Annex II** represents the full list of those interviewed alongside a description of their position and organization as well as the identifier they are referred to in the following.

[30] Link to the Transparency Register: https://ec.europa.eu/transparencyregister/public/consultation/listlobbyists.do?locale=en&reset= (Date: February 3rd, 2024)

Interviews were held between September 1st and October 26th and lasted between 23 min and 84 min. They were conducted online via the "Zoom Video Communications" (Zoom) videoconferencing tool due to the geographical spread of informants and to reduce the burden for stakeholders to participate in the research (Howlett, 2021). Interviews were conducted following a *semi-structured interview guide* with *open-ended and non-directional questions* that was prepared beforehand based on lessons learned identified in RQ1 and themes emerging from the theoretical and empirical literature analyzed for RQ2 (**Appendix III**). This semi-structured approach ensured comparability among and allowed for the synthesis of stakeholder views. At the same time, there was flexibility to diverge from the script, permitting an in-depth study of certain themes and an openness toward emerging ideas (Adams 2015; Horton 2004). In that notion, the interview guide was slightly adapted depending on the stakeholder group and the interviewee's expertise, for instance, by adding or removing certain questions. To eliminate potential misinterpretation due to language variations and, therefore, ensure comparability of data sets, all interviews were conducted in English. Finally, the interviews were audio-recorded and handwritten notes were taken simultaneously in case the recording equipment failed.

A final data source to enhance empirical validation was a public stakeholder workshop conducted by the Directorate-General for Climate Action (DG CLIMA) of the European Commission in conjunction with several think tanks, including Trinomics, Institute for European Environmental Policy (IEEP), ecologic, Umweltbundesamt, and Carbon Counts. The 3 ½ hour-long panel discussion was held on June 14th, 2023, and invited several policymakers, experts, and representatives from various stakeholder groups along the agricultural value chain to discuss a study commissioned by DG CLIMA on "Pricing agricultural emissions and rewarding climate action in the agri-food value chain". The workshop was attended in-person in Brussels, Belgium. The statements of participants who specifically made comments on a gradual phase-in of an EU ETS for agriculture were included in this analysis: one researcher, three EU policymakers, one representative from a farmer's association, one from industry, and one from an environmental NGO. **Annex IV** represents the full list of included panelists and participants alongside a description of their position and organization as well as the identifier they are referred to in the following. During the workshop, hand-written notes were taken to complement the publicly available videorecording[31].

5.3 Methods used to analyze data

As a first step of the data analysis, all primary data was prepared for analysis. The interview data together with the publicly available video-recording of the workshop was auto-transcribed using the speech-to-text transcription software "Otter.ai"[32]. Recognizing the inherent limitations of such software, each interview transcription as well as the workshop transcription also underwent manual cross-verification against the respective recordings to ensure accuracy to the original spoken word.

Next, together with the data collected from policy documents and academic literature, the empirical data was systemically analyzed based on the approach of *thematic content analysis* (TCA). As one of the most heavily relied upon analytical tools in social sciences, a TCA seeks to identify "patterns ('themes') across qualitative datasets" to construct thematic networks (Braun et al., 2019, p. 844) going beyond simply describing data to interpreting it and in the process of doing so pooling similar arguments (Mackieson et al., 2019). Since qualitative data is often very dense, an inherent characteristic of this approach, is also the so-called "*winnowing* of data", which is a process of focusing on some of the data while

[31] https://webcast.ec.europa.eu/workshop-in-the-context-of-the-study-on-applying-the-polluter-pays-principle-to-agricultural-emissions-23-06-14 (Accessed: February 17th, 2024)

[32] https://otter.ai/

disregarding others (Guest, MacQueen, & Namey, 2012). In general, a TCA follows five stages, namely 1) getting familiar with and creating a general understanding of the collected and generated data, 2) developing codes and coding the data, 3) identifying themes based on the coding, 4) constructing thematic networks, and 5) interpretation (Creswell and Creswell 2018).

For this TCA, an *abductive* coding approach was pursued (Tavory & Timmermans, 2014), which is a combination of *deductive* and *inductive* coding. While for *deductive* coding themes and codes are developed and defined at the beginning of the research process, and the data is categorized into those predetermined codes (Willig & Rogers, 2017) for *inductive* coding themes and codes are conceptualized and developed while engaging with the material, and the coding process is emerging and iterative (Braun et al., 2019). This combined setup of the coding framework, much like the semi-structured interviews, allowed a determined yet flexible coding procedure, enabling the identification of patterns while also showing differences between the information identified in the data (Creswell & Creswell, 2018).

For RQ1, the overarching themes of the coding framework were deducted from the barrier typology adopted from Pahle et al. (2018) as well as the policy sequencing framework adopted from Leipprand, Flachsland, and Pahle (2020) as introduced in **Section 4.2**. Respective sub-themes, i.e. specific barriers as well as concrete policy sequences and underlying feedback mechanisms, were created inductively emerging from the data throughout the research process. Analogously, the overarching themes for RQ2 were deducted from the conceptual framework. Given the interrelated nature of the research questions, the sub-themes for RQ2 were deducted from RQ1, i.e. evidence for the applicability of policy sequences and underlying mechanisms identified in RQ2 to the agricultural sector was explored in the datasets, while still allowing new sub-themes, i.e. other feasible pathways to introduce an EU ETS in agriculture, to emerge inductively. Due to the density of the interview data, the transcripts were analyzed in two steps, first extracting key information on the interview questions before coding the extracted information. The final coding framework for both RQ1 and RQ2 can be found in **Appendix VI**.

The coding process was conducted with the support of NVivo (Version 1.7.1), a computer-assisted qualitative data analysis software. The utilization of such improves the efficiency, rigor, and reliability of analyzing large qualitative data sets (Creswell and Creswell 2018).

5.4 Ethical Considerations

There were no threats to compromising the honesty or personal integrity of this research since it was not supported or funded by any external organization that could influence the nature of this research or the conclusions. Also, no one else was in a position to unduly influence this analysis and conclusions.

All interviewees received an information sheet prior to the interview (**Annex V**) and confirmed their written consent to participate in the research to increase trust in the research purpose. Although a purposive sampling approach was used to seek out specific interview partners that sought to have the relevant expertise and experience to find answers to the research questions, the participation in interviews was entirely voluntary and participants were able to withdraw from the research at any time before the end of the study without consequences (Creswell and Creswell 2018). Moreover, an effort was made to avert any disadvantages, damages, or potential harm to the reputation, dignity, or privacy of the study subjects. To this end, it was made sure that the purpose of this research was made explicit and transparent. Moreover, all interview partners were asked for their written consent to record the interviews for transcribing purposes. Also, interview partners were given to possibility to deny the permission to record but to take written notes instead. To ensure data protection, all interview partners were anonymized (to a self-chosen degree) (e.g. civil servant at European

Commission) and referred to by an abstract description (e.g. R1, E1, etc.) (Creswell and Creswell 2018). Since the workshop was held publicly and the recording is still available online, the panelists and workshop participants included in this study were not anonymized but still referred to by an abstract descriptor for simplicity reasons (e.g. Pa, Fa).

Lastly, the raw data, which can be labeled as sensible, e.g. non-anonymized interview recordings as well as a list with interviewees and respective encrypted identifiers, were stored on a password-protected hard drive. As Creswell & Creswell (2018) suggest and in accordance with CEU's Data Protection Policy, the data will be stored for five to ten years and will then be discarded safely.

5.5 Limitations of the Methodology

Several limitations of the methodology must be acknowledged. In a qualitative study like this one, the researcher takes on a central role in the research process, and thus data collection, analysis, and interpretation might be influenced by the researcher's worldview, previous knowledge, and values (Creswell and Creswell 2018). To increase both the validity and reliability of the results data analysis was conducted through a Thematic Content Analysis (TCA) utilizing a computer-assisted data analysis software. This reduces bias and increases transparency, allowing for a methodological review by others. However, a TCA can also be influenced by the researcher determining the conceptual framework according to which the analysis is conducted (ibid). Moreover, while computer-assisted data analysis software is useful for qualitative researchers in managing large data sets its limitations need to be recognized. Is not intended to substitute the analyst's capacities and rational capabilities, therefore, the researcher remains the main generator of insights and analysis (Heracleous and J. Fernandes 2019). To further increase reliability, the use of "thick descriptions" was, therefore, leveraged. Byproviding detailed accounts of the contexts and participants involved, enabling a deeper understanding and allowing others to assess the transferability of the findings (Creswell and Creswell 2018).

Moreover, the use of secondary data, such as published articles, presents certain limitations for validity and reliability. The consulted papers looking into jurisdictions outside of the EU may not be perfectly aligned with the specific context of the EU agricultural sector, potentially leading to issues of applicability and relevance. Furthermore, the original studies might have been conducted with different objectives, methodologies, and biases, which can have influenced the derived lessons. Relying on secondary sources also limits the researcher's control over data quality and comprehensiveness, thereby affecting the overall robustness of the findings (Creswell and Creswell 2018).

To further enhance the validity and reliability of the research, a triangulation strategy was, therefore, employed. Triangulation, defined as "the combination of methodologies and data sources in the study of the same phenomenon" (Denzin 1970, 271), aims to seek convergence and corroboration through different data sources and methods to counterbalance the inherent biases in any single method (Creswell and Creswell 2018). To this end, this study incorporates multiple data sources: In addition to the document analysis, interviews and participation in a publicly accessible stakeholder workshop were leveraged.

However, several limitations must also be noted for the interviews. Although an effort was made to recruit an even number of informants from each stakeholder group to ensure equal representation, this could not be ensured for all stakeholder groups due to varied response rates. Positive response rates were significantly higher among researchers and policymakers, while they were comparably lower among farmers, industry representatives, environmental NGOs, and media. Interview invitations from these stakeholder groups were mainly declined due to the novelty of the topic and a respective limited previous engagement in the discussion or a missing official position from the represented organization. Due to the diversity of stakeholders interviewed and time restrictions, the number of participants from each stakeholder group is limited. Despite this, responses between interviewees showed patterns and similarities, indicating that a certain degree of theoretical saturation (i.e., when gathering fresh data no longer leads to new insights) has been reached (Charmaz 2006). Also, interviews only provide indirect information filtered through the view of interviewees, and potentially these views do not reflect those of the broader actor group. In particular, there could be a self-selection bias in the sample, as people concerned about sustainability in agriculture (e.g., sustainability managers in the industry or organic farmers) might be more likely to participate in research aimed at identifying tools to reduce GHG emissions from the sector (Collier and Mahoney, 1996). Moreover, the interviews did not take place in a natural setting but were conducted via Zoom and thus provided information only in a designated place and time. The interviewee's responses could also be biased by the researcher's presence (Creswell and Creswell 2018). A final limitation of the interviews is the variety of possible understandings of "emissions trading" in the context of agriculture. While participants were informed of the researcher's understanding of carbon trading and the scope of the research, it is possible that interviewees' answers were informed by a different conception of the term, for example, focusing on carbon sequestration rather than reducing emissions.

Finally, using a stakeholder workshop as a source of information presents specific limitations. One major concern is the potential for a skewed representation of views. Stakeholder workshops might attract participants who are more engaged or have stronger opinions about the subject matter, leading to an overrepresentation of certain perspectives. Especially representation from farmers was missing. Additionally, the dynamics of group discussions can sometimes lead to conformity or dominance by particular individuals, which may influence the overall outcomes of the workshop (Creswell and Creswell 2018).

6 Findings and Discussion

This section presents and analyzes/discusses the results of the study. First, it elaborates on lessons learned from the gradual phase-in of the existing EU ETS. To this end, it gives an overview of the historical development of the EU ETS (**Section 6.1.1**) building the groundwork for the analysis of the barriers to the introduction and further strengthening of its policy design (**Section 6.1.2**, RQ1.1) as well as policy design choices made to overcome these in a step-wise manner (**Section 6.1.3**, RQ1.2). Second, based on these lessons, it lays down considerations for the gradual introduction of an EU ETS for agricultural emissions. To this end, it discusses the barriers to its introduction in the context of European agriculture (**Section 6.2.1**, RQ2.1) and discusses transitional policy design choices to overcome these (**Section 6.2.2**, RQ2.2).

6.1 Lessons learned from the introduction of the EU ETS

6.1.1 Development of the EU ETS

The EU ETS[33] operates in "trading phases", which are each marked by significant modifications to the legislation (**Figure 5**): Phase-1 (2005–2007) was a pilot phase since all institutional infrastructure needed to be created in the first place. Phase-2 (2008–201) was the first full implementation phase and corresponded with the first commitment period under the Kyoto Protocol, while Phase-3 (2013–2020) corresponds to Kyoto's second commitment period. Finally, Phase-4 (2021–2030) is currently running and corresponds to the EU's first commitment under the Paris Agreement (Delbeke and Vis 2019).

[33] Aligning with the official language used by the European Commission, the term "EU ETS" refers to the original ETS scheme introduced in 2005. The new and separate ETS scheme established to enter into full operation in 2027 is referred to as "ETS2".

6.1.1.1 Phase-1 (2005 – 2007) & Phase-2 (2008 – 2012)

The EU ETS was put into place with the primary objective of meeting the EU's international climate commitment, specifically those under the 1997 Kyoto Protocol[34] in a cost-effective way[35]. This was laid out in the European Commission's "Green Paper on Greenhouse Gas Emissions Trading within the European Union" published in 2000 (Commission of the European Communities 2000). It also puts into practice the "polluter pays principle", which is enshrined in the Treaty governing the EU (EC 2016). The EU ETS Directive was adopted in 2003 and the EU ETS was officially launched in 2005 *(Directive 2003/87/EC)* (EC) 2003). In Phase-1 (2005 – 2007), the EU ETS was essentially "a system of linked national trading schemes" where each Member State (MS) decided on its respective caps and rules for the distribution of allowances as set out in their national allocation plans (NAPs) (Leipprand, Flachsland, and Pahle 2020, 144; Ellerman, Marcantonini, and Zaklan 2016). Moreover, the coverage of sectors and greenhouse gases was rather narrow, covering only CO_2 emissions from power generators and energy-intensive industries (i.e. stationary installations), such as iron, steel, aluminum, cement, glass, cardboard, and paper. Other sectors such as transport and buildings as well as agriculture and land-use were excluded. It was argued that the marginal abatement costs for these sectors would exceed the estimated carbon price of 33€ per ton CO_2eq and that the large number of small emitters is not administratively feasible (Commission of the European Communities 2000). To avoid carbon leakage (i.e. that businesses transfer their production to other countries with laxer environmental constraints due to costs related to the EU ETS) the 2003 ETS Directive had foreseen that the majority of

[34] The 1997 Kyoto Protocol set for the first time legally binding emissions reduction targets, or caps, for 37 industrialized countries, including the EU (UNFCCC 1998).

[35] As already mentioned before, the European Commission had experimented with market-based instruments to address carbon emissions before, proposing a carbon/energy tax in 1992 (EC 1992). However, tax policies require unanimity in the EU, which was too difficult to reach despite the EU only having 12 MS at that time and the proposal was eventually withdrawn (EC 2001).

allowances (at least 95% in Phase-1 and at least 90% in Phase-2) were initially allocated for free, mostly through grandparenting (EC 2003). In 2004, the ETS Directive was amended by the Linking Directive, which allowed regulated entities to use emission reduction units generated under the Kyoto Protocol's Clean Development Mechanism (CDM) and Joint Implementation (JI)[36] to fulfill their obligation under the EU ETS *(Directive 2004/101/EC)* (EC 2004).

In Phase-2 (2008 – 2012), the EU ETS policy scope expanded with several MS including NOx emissions from the production of nitric acid as well as Iceland, Liechtenstein, and Norway joining the system[37]. Also, from 2012 onwards domestic aviation was included in the EU ETS under a separate cap (however, not flights outside of the European Economic Area as initially planned). Also, the 'banking' of allowances was introduced in 2008 (and has been allowed ever since) with the aim to incentivize early emissions reductions and provide market stability while also ensuring a smooth transition between trading periods *(Directive 2008/101/EC)* (EC 2008). However, the first two trading phases experienced an oversupply of allowances (overallocation), leading to low carbon prices reaching almost 0€ per ton in 2007 (icap 2023). Moreover, the free allocation of allowances led to significant windfall profits for corporations, and the different MS rules for allocation created a competitive distortion (Ellerman, Marcantonini, and Zaklan 2016).

[36] The Clean Development Mechanism (CDM) , as well as the Joint Implementation (JI), are two project-based flexibility mechanisms to help countries with an emission-reduction or emission-limitation commitment under the Kyoto Protocol to fulfill their reduction targets by implementing emission-reduction projects in developing countries or other developed countries, respectively (UNFCCC 1998).

[37] The linkage of the EU emissions trading system with Norway, Iceland, and Liechtenstein was conducted through the incorporation of the EU ETS Directive (Directive 2003/87/EC as amended) into the European Economic Area agreement.

6.1.1.2 *Phase-3 (2013 – 2020)*

For the reasons mentioned above and true to the intent of an initial trial period, the EU ETS, underwent a major reform in 2009 resulting in the adoption of considerable revisions for Phase-3 (2013 – 2020) *(Directive 2009/29/EC)* (EC 2009). Most importantly, it led to a centralization of the system by introducing a single, EU-wide cap replacing the previous systems of aggregated national caps. Moreover, the EU ETS saw a considerable strengthening of ambition. A linear reduction factor (LRF) of 1.74% per year was introduced for the cap (only stationary installations) to achieve the 21% emissions reduction target by 2020 compared to 2005 levels. Also, auctioning was adopted as the basic allocation principle (covering up to 57% of allowances), to be fully applied to the power sector as of 2013, and to be gradually phased in for the remaining industrial sectors more slowly. However, optional derogations applied to energy installations in ten low-income and coal-dependent MS in Eastern Europe[38] giving them more time to phase in auctioning and, thus, supporting sectoral modernization and diversification. The remaining allowances were allocated for free to stationary installations who were deemed to be especially exposed to a significant risk of carbon leakage[39] ("carbon leakage list") according to 54 centrally determined and harmonized technological benchmarks[40] *(2010/2/; 2014/746/EU)* (EC 2009; 2014). For aviation, 15% of allowances were auctioned and 82% were allocated for free. Also, the regulations for importing third-country credits were tightened excluding certain countries and sectors *(Commission Regulation (EU) No 550/2011)* (EC 2011). The revenues from auctioning allowances went predominantly to MS, which had to use at least 50% of revenues from

[38] Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, and Slovakia

[39] According to the EU ETS Directive, a sector is exposed to significant leakage risks if (1) the direct and indirect additional costs from EU ETS represent at least 5% of its gross added value, and (2) it is exposed to high trade intensity defined by a ratio 'between the total value of exports to third countries plus the value of imports from third countries and the total market size for the Community' larger than 10% (EC 2009).

[40] Benchmarks are set at the average of the 10% most efficient installations in the (sub-)sector.

stationary installations and 100% of revenues from aviation to fund climate- and energy-related projects. Moreover, 5% of the cap (300 million allowances) was allocated to the newly established New Entrants' Reserve (NER300) to fund the deployment of new innovative renewable energy technologies and carbon capture and storage (CCS) *(2010/670/EU)* (EC 2010). Finally, the EU ETS also saw an expansion in coverage including CCS installations as well as emissions from several industrial sectors. Moreover, the ten new MS who had joined the EU in 2004 (Czech Republic, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Slovakia, and Slovenia) were included. As of 1 January 2020, the EU ETS is also linked with the Swiss ETS, including aviation *(Decision No 2/2019)* (EC 2019c).

However, a growing surplus of allowances as a result of a low demand following the 2008 economic crisis in combination with the transfer of surplus allowances from Phase-2, the forward selling of Phase-3 allowances to generate funds for the NER300 program as well as the extensive use of external CDM and JI credits contributed to the carbon price remaining at a low level and giving rise to new ETS reform debates *(COM(2012) 652 final)* (Delbeke and Vis 2019; EC 2012). As an immediate response, the auctioning of 900 million allowances was deffered until 2019 ("backloading"). To address the supply and demand imbalances as well as the low carbon prices in the long-term, a Market Stability Reserve (MSR) was put into force in 2019 *(Decision (EU) 2015/1814)* (EC 2015). Allowances are to be transferred from the auction volume to the reserve at a rate of 12% whenever the total number of allowances is higher than 833 million. Additional allowances are to be released from the reserve whenever the total number in circulation falls below 400 million.

6.1.1.3 Phase-4 (2021 – 2030)

In 2018, the EU ETS underwent another reform to strengthen its ambition in Phase-4 (2021-2030) *(Directive (EU) 2018/410)* (EC 2018) in line with the EU's 2030 climate and energy framework. Between 2021 and 2030 the overall number of allowances is to decline at an annual LRF of 2.2.% (also applicable to the aviation cap) to align the cap with the EU target of cutting emissions by at least 43% by 2030 compared with 2005 levels. The updated EU ETS continues free allocation for industries at high risk of carbon leakage (with a reduced number of sectors covered in the carbon leakage list and according to strengthened benchmarks[41] *(Commission Delegated Decision (EU) 2019/708)* (EC 2019a) and optional derogations for low-income Eastern European MS[42]. The 2018 ETS Directive also temporarily doubled the MSR's absorption rate of surplus allowances to 24% for the period between 2019 and 2023. The use of offsets through CDM and JI credits is no longer possible *(Commission Regulation (EU) No 1123/2013)* (EC 2013). All auctioning revenues allocated to MS have to be used for climate-and energy-related projects as of 2021. Moreover, a share of allowances is auctioned to fund the newly established Innovation (450 million allowances) and Modernization Funds (310 million allowances). As a successor of the NER300, which ended in 2020, the Innovation Fund, catalyzes the commercial demonstration of innovative low-carbon technologies and industrial solutions aimed at decarbonizing energy-intensive industries. It also promotes the development of renewable energy, energy storage, and CCS (as specified in *Delegated Regulation (EU) 2019/856)* (EC 2019b). As a solidarity mechanism, the Modernization Fund provides support to ten lower-income Member States[43] to modernize energy systems, improve energy efficiency, and support a socially just transition to climate neutrality for the 2021 to 2030 period (as specified in Implementing *Regulation (EC) 2020/1001*) (EC 2020).

[41] To reflect the technological progress in different sectors, benchmark values are updated twice in Phase-4: for 2021-2025 and for 2026-2030.

[42] Out of ten eligible MS only three decided to continue using the derogation in Phase-4.

[43] Bulgaria, Czechia, Estonia, Greece, Croatia, Latvia, Lithuania, Hungary, Poland, Portugal, Romania, Slovenia and Slovakia

In 2023, the EU ETS underwent its latest reform through the Fit for 55 package to strengthen its ambition in line with the European Green Deal objectives, especially the more ambitious 2030 climate target of decreasing net emissions by at least 55% compared to 1990 levels (European Climate Law) *(Directive (EU) 2023/959)* (EC 2023d). Sectors covered under the EU ETS are now required to reduce emissions by at least 62% by the end of Phase-4 (2030) compared to 2005 levels. To this end, allowance reductions follow a strengthened LRF of 4.3% per year between 2024 and 2027 and 4.4% per year between 2028 and 2030. Moreover, to eliminate the persistent discrepancy between the cap and de-facto emissions, the cap will be reduced twice ('re-basing') – by 90 million allowances in 2024 and an additional 27 million in 2026. The MSR will also be strengthened by maintaining the annual allowance intake rate at 24% of total allowances until 2030, instead of reducing it to 12% from 2023 onwards as initially scheduled, and restricting the number of allowances in the reserve to 400 million, with any surplus being permanently canceled *(Decision (EU) 2023/852)* (EC 2023b). Free allocation for stationary installations will be phased out gradually between 2026 and 2034 (EC 2023d) while phasing in the EU's Carbon Border Adjustment Mechanism (CBAM)[44] obligations for third-country imports from energy-intensive products to protect against carbon leakage *(Regulation (EU) 2023/956)* (EC 2023e). Between 2024 and 2026 free allowances will also be phased out for aviation *(Directive (EU) 2023/958)* (EC 2023d). Moreover, 100% of auctioning revenues from both stationary installations and aviation allocated to MS have to be used for climate- and energy-related projects. The additional revenues from gradually eliminating free allowances for sectors covered under the CBAM will be used to expand the Innovation Fund's budget from 450 to 575 million allowances in the period 2020-2030. The

[44] Under the **CBAM** countries importing energy-intensive goods such as cement, iron, steel, aluminium, fertilizers, electricity, or hydrogen into the EU will be subject to a carbon price depending on the GHG emissions embedded in these imported goods to equalize the price of carbon between domestic products and imports (EC 2023d).

budget of the Modernization Fund will be also expanded by 110 million allowances while simultaneously adding Greece, Portugal, and Slovenia as beneficiaries.

In addition, a considerable expansion of sectoral coverage was agreed upon. Maritime transport above 5,000 gross tonnages will be gradually introduced into the existing EU ETS between 2024 and 2026[45] (i.e. applicable to 40% (2024) → 70% (2025) → 100% (2026) of emissions subject to surrender requirements). Meanwhile, MRV requirements, that is, that is, the obligation of regulated entities to hold a permit and report emissions, for 100% of covered emissions will already be put in place as of 2023.[46] Initially, it will only concern CO_2 emissions but also CH_4 and N_2O emissions from 2026 *(Regulation (EU) 2023/957)* (EC 2023f). As of 2021, the aviation cap will include flights to the UK and as of 2024 flights to and from the EU's, the UK's, and Switzerland's outermost regions (EC 2023d). Also, between 2022 and 2027 the International Civil Aviation Organization's (ICAO) Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)[47] is to be implemented through the EU ETS for flights to and from countries outside of the European Economic Area *(Decision (EU) 2023/136)* (EC 2023b). Moreover, in 2027[48] a new self-standing emission trading system (ETS 2) will be put into force covering fuel combustion in buildings, road transport, and additional sectors (mainly small industries not currently covered by the existing ETS) *(Directive (EU) 2023/959)* (EC 2023e). The cap is set to achieve -42%

[45] To this end, the 2024 cap is increased by 78.4 million allowances based on the sector's average emissions reported for 2018 and 2019 (EC 2023).

[46] The European Commission had already adopted a strategy for progressively integrating maritime transport emissions into the Union's policy for reducing greenhouse gas emissions in 2013. As a first step in this approach, the Union had already established a system to monitor, report, and verify emissions from maritime transport in Regulation (EU) 2015/757 of the European Parliament and of the Council (EC 2015b).

[47] Established in 2016, **ICAO's CORSIA** is a global offsetting scheme that requires airlines and other aircraft operators (which are by default not included into international climate regime administered by the UNFCCC) to offset any growth in CO_2 emissions above 2020 levels from 2027 onwards (ICAO 2023).

[48] In light of the current energy crisis and to safeguard vulnerable household, the start of the ETS2 will be delayed to 2028 if oil or gas prices are exceptionally high.

emissions reductions in 2030 compared to 2005 levels, therefore, decreasing annually by an LRF of 5.1% between 2024-2027 and 5.38% from 2028 onwards. Due to concerns about technical feasibility and administrative efficiency given the very large number of small emitters in the covered sectors, it is designed as an upstream system regulating distributors of fuels in the respective sectors and not households or other end-consumers. To ensure a smooth start, MRV requirements will already start in 2025. Moreover, several safeguards were put in place to mitigate the potential risk of excessive price surges and, thus, ensure a socially fair introduction: In the first year of operation, an additional 30% of allowances will be auctioned ("front-loading").[49] Also, a new dedicated MSR was agreed upon. During the first three years it will release an additional 20 million allowances if the allowance price exceeds 45€ over a period of two consecutive months, with the possibility of releasing additional allowances from the reserve should the allowances prices increase dramatically over a period of three consecutive months[50]. As an additional social safeguard, the revenues from the ETS 2 will be channeled toward the newly established Social Climate Fund (SCF) mobilizing around 86.7 billion € to cushion the impact of the carbon price on vulnerable citizens and businesses most affected by the new system. The remaining ETS2 revenues have to be used for climate and social measures by the MS *(Regulation (EU) 2023/955)* (EC 2023d). Given the limited exposure of building and road transport sectors to competition from outside the EU and related low carbon leakage risks, allowances will be allocated solely via auctioning. Finally, as of 2028, municipal waste incineration might also be included in the EU ETS, which will be assessed by the end of 2026 based on an MRV period, which will be put in place in 2025 *(Directive (EU) 2023/959)* (EC 2023e). With this, the EU ETS will regulate

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[49] The additional volume will be deducted from the auction volumes over a three-year period beginning two years later.

[50] In view of the aim of this mechanism to ensure stability in the initial years of the new emissions trading system, the European Commission will assess its functioning and whether it should be continued after 2029.

all major sectors of the economy, apart from agriculture and land-use, covering around 75% of the EU's total GHG emissions (EC 2022c).

Following the multiple reforms in Phase-3 and Phase-4 market prices have been steadily increasing since 2018 reaching an average secondary market price of 80€ per ton in 2023 (icap 2023). With this, the carbon price is now in the range advocated by economists such as Stern and Stiglitz (High-level Commission on Carbon Prices 2017).

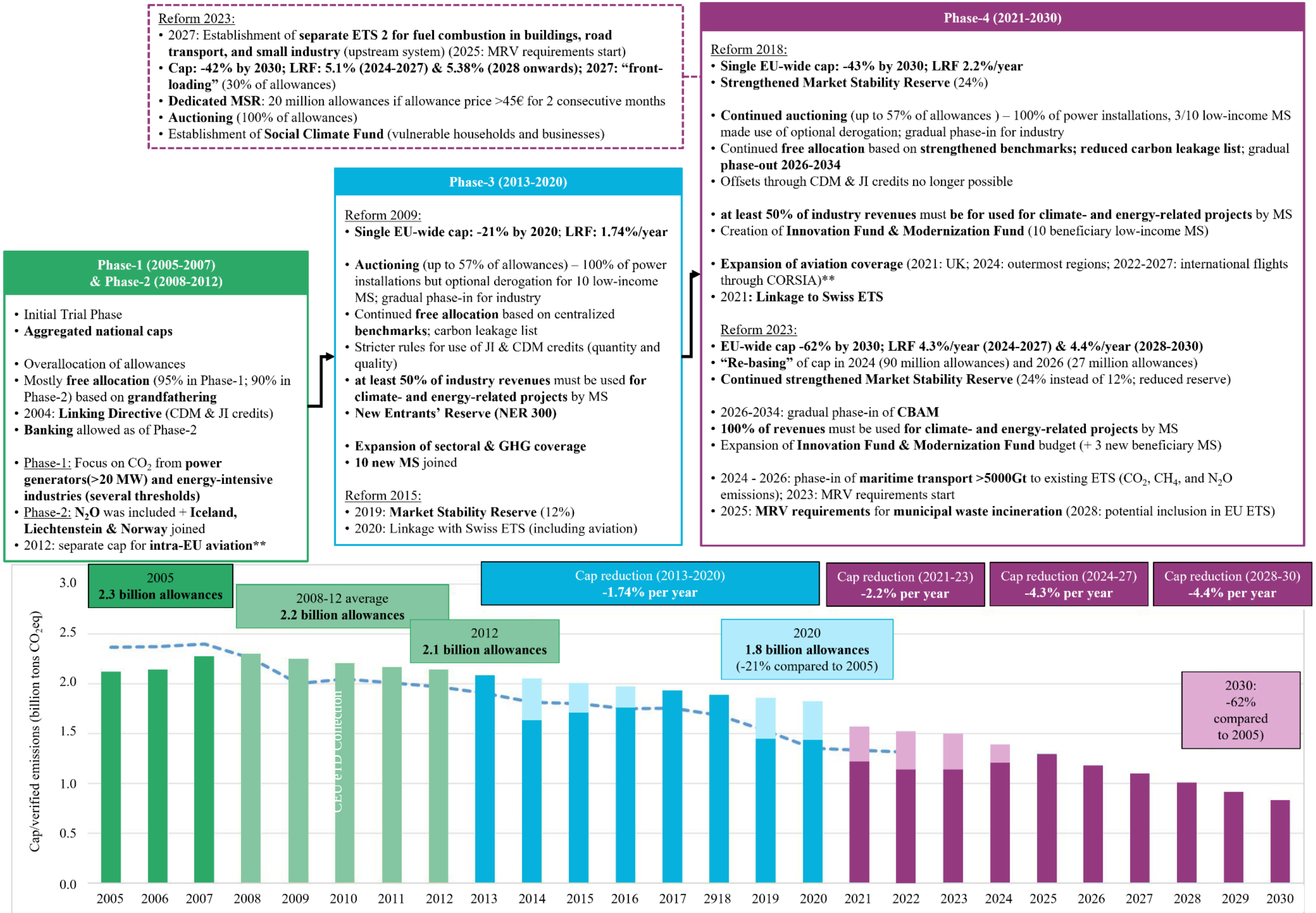

Figure 5 Policy development of the EU ETS (top; own illustration) and development of the emission cap (bottom; modified after EC (2023n) between 2005 and 2030 (based on the 2023 revision of the EU ETS, i.e. re-basing in 2024 and 2026, including the maritime transport sector in 2024; from 2021, the EU ETS no longer covers instal-lations in the UK, only electricity gene-rators in Northern Ireland). Legend: bars (cap), light shaded bars in 2014-2016 allowances backloaded from auctions), light shaded bars from 2019 onwards (feeds of allowances to the Market Stability Re-serve), dashed line (verified emissions). ***For simplicity rea-sons, policy and cap developments for avi-ation are excluded.*

6.1.2 Barriers to the introduction of the EU ETS

The introduction and further strengthening of the EU ETS has been facing multiple barriers. Although the advocates of an EU ETS put forward its cost-effectiveness compared to national climate policy instruments without a market mechanism to trade emissions (Commission of the European Communities 2000), a central barrier were concerns about economic costs for regulated industries (B_C) (Leipprand and Flachsland 2018). Closely related were concerns about negative impacts on their competitiveness with international entities not being subject to comparable regulation (free-riding) (B_C) (Commission of the European Communities 2000). This opposition from industry stakeholders has been a strong and persistent barrier to the introduction of the EU ETS as well as to increasing stringency over time (B_P). Due to the comparatively higher exposure to international competition and a weaker ability to pass on costs to consumers, the non-power industry has been the most vocal group in its opposition (Leipprand and Flachsland 2018; Skjærseth and Wettestad 2010). Moreover, when the EU ETS was introduced, there was little support from the initial 15 European MS at that time as a result of concerns about sovereignty and disproportionate effects on national economies (B_P) (Skjærseth and Wettestad 2010). Later on, it was primarily Central and Eastern European Countries (CEECs) that were resistant to increasing stringency due to their stronger reliance on fossil fuels as well as concerns about electricity prices. Initially, there was also a lack of support from green groups (i.e. environmental NGOs, Green Parties, and renewable energy industry associations) due to concerns about environmental effectiveness (B_P) (Fitch-Roy, Fairbrass, and Benson 2020; Leipprand, Flachsland, and Pahle 2020). For the ETS2, the impacts of the carbon price on low-income households and businesses highly dependent on fossil fuels for heating and transport were a major concern (B_C)) *(Directive (EU) 2023/959)* (EC 2023e). Finally, a major obstacle was the limited expertise and capacity in operating an ETS (B_{IG}). This was especially related to a lack of data on firm-level emissions as well as no prior experience with emissions registries and the distribution of responsibilities for implementation and monitoring in the MS (Leipprand and Flachsland 2018; Convery 2009; Skjærseth and Wettestad 2010). For the ETS2, a significant barrier was the very large number of small emitters in the building and transport sectors raising concerns about technical feasibility and administrative efficiency (B_{IG}) *(Directive (EU) 2023/959)* (EC 2023e). In the early stages of the ETS, there was also opposition from individuals in MS and EU administrations who favored holding on to traditional command-and-control instruments (B_{IG}) (Leipprand, Flachsland, and Pahle 2020).

6.1.1 Sequencing options and policy feedback mechanisms to overcome barriers to the EU ETS

The development of the EU ETS shows a clear indication of an increase in stringency over several successive steps of policy evolution (policy sequencing): First, the *ambition* of the policy's target, that is, the cap, the rate of decrease of the annual quantity of allowances, and the price level of allowances were made more stringent throughout each policy reform. Moreover, the *policy scope* was broadened to include additional greenhouse gases, sectors, and countries. Finally, the *policy design* was also progressively strengthened to improve the instrument's environmental effectiveness (that is, compliance with the cap) as well as its cost-effectiveness (that is, achieving the long-term cumulative cap at minimal expense) (Leipprand and Flachsland 2018). As Leipprand, Flachsland, and Pahle (2020) note, this was the result of a combination of **internal policy feedback (F_{IP})**, **cross-policy feedback (F_{CP})**, as well as **external processes and conditions (E)** that helped to overcome **barriers** to higher stringency.

Underlying feedback mechanisms that played a crucial role were: (1) The availability *of price management measures to* avoid sudden and extreme price fluctations (+ on B_C); (2) *Constituency-building effects* among different actor groups, that is, the emergence of expert communities in the EU institutions, national governments, and government agencies but also in the regulated firms, business associations, research, think tanks, and NGOs that were interested in improving the functioning of the scheme (+ on B_P); (3) *Learning effects*, that is, the experiences made with earlier versions of the scheme by a community of experts and stakeholders that were engaged in the ETS policy-making informed positive reform processes; (4) The opportunity for *strategic compensation of reluctant actors* (Leipprand, Flachsland, and Pahle 2020).

The concrete sequencing options and respective (triggered) feedback mechanisms are discussed in more detail in the forthcoming. A schematic overview is provided in **Figure 6**.

6.1.1.1 Internal Policy Feedback

As Leipprand, Flachsland, and Pahle (2020) show, an initially less stringent but politically feasible policy design related to ***policy ambition, scope, and design*** led to **internal policy feedback effects (F_{IP})** that helped to gradually relax barriers to a more stringent ETS by triggering positive feedback and controlling negative feedback.

Policy ambition

Decentralized cap setting by the EU MS in the first two phases of the EU ETS led to an overallocation of allowances, and therefore, largely lacked the ambition to reduce emissions *(initial low policy ambition)*. However, the decentralized NAP system was needed to get political buy-in from MS (+ on B_P). Moreover, the resulting low allowance prices were key to easing cost concerns from regulated industries and MS (+ on B_C) (Delbeke 2024; Leipprand, Flachsland, and Pahle 2020). Allowing the banking of allowances, and thus, providing a tool to reduce the risk of price volatility as of Phase-2 served a similar purpose (Ellerman, Valero, and Zaklan 2015). At the same time, the low environmental effectiveness of the low allowance prices resulting from a surplus of allowances in Phase-1 and Phase-2 also motivated reforms (positive F_{IP}) (Leipprand, Flachsland, and Pahle 2020). Progressively, the cap was tightened to guarantee emissions reductions, achieved by an ever-decreasing supply of allowances through the introduction and then a gradual increase of a yearly LRF as of Phase-3. Moreover, as a tool to structurally address the insufficient or excessive supply of allowances, and thus, inter alia mitigate price volatility, the MSR was put in place in 2019 and gradually strengthened, thereafter *(increasing policy ambition)* (Perino and Willner 2017; Leipprand, Flachsland, and Pahle 2020). Deliberately, it was decided against a price floor, which was initially also considered *(Carbon market report COM/2012/652)* (EC 2012b). Although this decision has been much criticized (Edenhofer and Flachsland 2018; Ellerman, Marcantonini, and Zaklan 2016), it has been argued that this is to prevent the risk of potentially imposing excessive costs on ETS participants and society while ensuring flexibility.

Learning from the development of the EU ETS, the introduction of the ETS2 will be accompanied by a front-loading of allowances to provide market liquidity and smoothen the transition *(low initial policy ambition)* while already setting a clear reduction trajectory in the form of a decreasing cap and an increasing LRF from the start (increasing policy ambition). Particularly insightful is the design of MRS for the ETS2. By creating a price-based system in the first three years it serves as both a tool to keep prices in a range that incentivizes emissions reductions but also ensures that vulnerable households and businesses are not disproportionately affected (+ on B_C) (Delbeke 2024).

<ins>Learning:</ins> The use of price management measures for the introduction (e.g. higher trading ratios/front-loading, banking) and further development of an ETS (e.g. MSR) can mitigate concerns about cost and avoid sudden and extreme price developments (+B_C). However, a clear roadmap to long-term policy objectives (decreasing cap and increasing LRF) is crucial to achieve effective emission reductions.

Policy scope

Coverage

The initially narrow policy scope of the EU ETS, covering only CO_2 emissions from power generators and energy-intensive industries, was mainly the result of concerns about economic costs (B_C) as well as technical and administrative feasibility (B_{IG}) (Commission of the European Communities 2000; Leipprand, Flachsland, and Pahle 2020). It was argued that for sectors such as transport, buildings, agriculture, and land-use marginal abatement costs would exceed the estimated carbon price of 33€ per ton CO_2eq. Moreover, including a large number of "small mobile emitters" (p. 10) was simply deemed too complex (Commission of the European Communities 2000). The European Commission, therefore, deliberately opted for a "step-by-step" (p. 10) approach initially confining the policy scope to a small number of large fixed-point sources of carbon dioxide, which significantly contributed to total emissions but could reduce emissions at a reasonable cost (small initial policy scope) (Commission of the European Communities 2000). Over time, learning processes built up administrative capacities, especially with regards to MRV (positive feedback F_{IP}), allowing a significant expansion of policy scope adding more countries (15 new MS; Iceland, Liechtenstein and Norway; linking with Swiss ETS), sectors (i.e. aviation and maritime as well as fuels from transport and buildings under the ETS2), and GHG gases (HFCs, N_2O, PFCs, and SF_6) *(increasing policy scope)*. A prime example of this "step-by-step" approach is also the introduction of maritime transport into the existing EU ETS, gradually expanding in percentage and types of GHG emissions covered to ensure a smooth start *(Regulation (EU) 2023/957)* (EC 2023f).

Moreover, to ease distributional impacts (+ on B_P) and administrative burden (+ on B_{IG}), several thresholds were applied to exclude small installations/actors and, therefore, reduce the number of regulated entities to a manageable size *(small initial policy scope).* For instance, for power generators, limiting the scope to installations >20W thermal output resembles approximately 11,000 entities with current compliance obligations *(Directive 2003/87/EC)* (EC) 2003, Annex I). Similar thresholds exist for stationary installations (> 25,000 CO_2eq resembling approximately 15,000 entities) *(Directive (EU) 2018/410)* (EC 2018, Article 27), aviation (>10,000 tons of CO_2 per year for commercial flights and >1,000 tons of CO_2 per year for non-commercial flights resembling approximately 1,500 aircraft operators) *(Directive 2008/101/EC)* (EC 2008, Annex I), and maritime (large ships of ≥5,000 gross tonnage, therefore, applying to 50% of maritime emissions). In 2026, the feasibility of including more entities from certain sectors by lowering the respective thresholds will be discussed (e.g. to power generators <20W thermal output and ships <5,000 gross tonnage) *(Directive (EU) 2023/959)* (EC 2023d, Annex I) *(increasing policy scope).*

Learning: A transitional partial coverage of emissions sources, GHGs, and actors as well as continued targeted exemptions via thresholds depending on mitigation potential, transaction costs, economic circumstances, and carbon leakage risks can reduce political barriers (+ on B_P) and facilitate learning processes to reduce administrative burden (+ on B_{IG}).

Point of Obligation

Another approach to reducing complexity is demonstrated by the intended policy scope of the ETS2. Designed as an upstream system, it moves the point of obligation, i.e. the entities that are required to report their emissions and surrender allowances, from households and other end-consumers to fuel distributors. This significantly reduces the number of regulated entities, thus, increasing technical and administrative feasibility (+ on B_{IG}). Moreover, by removing the burden from vulnerable small stakeholders it reduces negative social impacts and, thus, political barriers (+ on B_P) *(Directive (EU) 2023/959)* (EC 2023e).

Learning: (Initially) putting the point of obligation on up- or down-stream actors can significantly reduce political barriers (+ on B_P) and administrative burden while facilitating learning processes (+ on B_{IG}).

Policy design

Monitoring, Reporting and Verification (MRV)

Acknowledging that a functioning ETS requires an efficient monitoring, reporting, and verification (MRV) system, the first trading phase of the EU ETS was practically set up as a trial period (Commission of the European Communities 2000). This allowed both regulators and regulated entities to build the necessary infrastructure for a robust emissions trading system as well as to develop and refine MRV processes as needed. As such, learning processes enabled the swift enhancement of technical and administrative capacity (positive feedback F_{IP}) (+ on B_{IG}) (Leipprand, Flachsland, and Pahle 2020). Learning from that, the introduction of maritime transport into the existing EU ETS as well as the establishment of the ETS2 will have a transitional period, in which regulated entities have monitoring and reporting but no compliance obligations *(initially less stringent policy design)*. As a "data collection phase" it is set up to gather the required information to ensure the establishment of a reliable and accurate MRV system (positive feedback F_{IP}) (+ on B_{IG}) before moving on to a compliance scheme *(more stringent policy design) (Directive (EU) 2023/959)* (EC 2023f; Delbeke 2024).

Another transitional measure introduced in Phase-3 *(Commission Regulation (EU) No 601/2012)* (EC) 2012a) (and continuously improved since) is the "tiered" approach to MRV *(Commission Implementing Regulation (EU) 2018/2066 and 2023/2122)* (EC 2018a; 2023b). This approach involves different levels (tiers) of accuracy for measuring and reporting GHG emissions, with lower tiers depending mostly on default values or simplified calculations, while higher tiers require more precise but also more costly site-specific data and measurements. As such, small emitters are allowed to use lower tiers (Tier 1 or 2) due to their lower volume of emissions and to reduce the administrative burden *(less stringent policy design)*. Large emitters, such as large industrial plants, power stations, and aircraft operators, on the other hand, are required to use higher tiers (Tier 3 or 4) to ensure the accuracy and reliability of emissions data. Regulated entities are also encouraged (in some cases required) to move to higher tiers as they develop the capacity for more accurate monitoring and reporting (positive Feedback F_{IP}) *(more stringent policy design)* (+ on B_{IG}).

<u>Learning:</u> An initial trial phase with MRV but no compliance obligations as well as a tiered approach to MRV accuracy could trigger learning processes, which will likely reduce transaction costs (+ B_{IG}).

Use of Offsets Credits

Allowing the use of international offset credits generated through the CDM and JI made it possible for regulated entities to comply with their obligations under the EU ETS at a lower cost *(less stringent policy design)*, thus, easing cost concerns and creating buy-in for the introduction of the EU ETS (+ on B_C and B_P) *(Carbon market report COM/2012/652)* (EC 2012b; Delbeke 2024; Ellerman, Marcantonini, and Zaklan 2016). However, an excessive influx of offset credits in Phase-2 and resulting low allowance prices motivated reforms to set a quantitative limit on credits able to enter the EU ETS in Phase-3 *(Carbon market report COM/2012/652)* (EC 2012b). Moreover, concerns about environmental integrity led to the introduction of qualitative restrictions, excluding certain types of projects (e.g. nuclear energy, afforestation, and reforestation) in Phase-3 *(Commission Regulation (EU) No*

550/2011) (EC 2011) and discontinuation of the scheme entirely as of Phase-4[51] (positive Feedback F_{IP}) *(more stringent policy design) (Commission Regulation (EU) No 1123/2013)* (EC 2013).

<u>Learning:</u> Allowing the use of offset credits could create buy-in by reducing compliance costs (+ on B_C and B_P), however, a quantitative limit and qualitative standards are crucial to avoid negative feedback effects.

Distribution mechanism and strategic compensation measures

The development of the EU ETS showed that continued strategic transfers and compensation of resistant actors as part of the policy design was instrumental in overcoming the political resistance barrier at the introduction as well as each major reform of the scheme (+ B_P) (Dorsch, Flachsland, and Kornek 2020; Leipprand and Flachsland 2018). In this context, Dorsch, Flachsland, and Kornek (2020) observe two types of distributional decisions: Mitigating the resistance of veto-players through *"brown cushioning"* and fostering the creation of a supporting coalition through a *"green push"*.

On one end of the spectrum, by moderating the distributional impacts of the ETS, *"brown cushioning"* helped to keep potential negative feedback from industry stakeholders and reluctant (low-income) MS under control giving them more time until, for instance, the costs of technological or ideological change are lower (Dorsch, Flachsland, and Kornek 2020). (+ on B_P). A key role in this context played the free allocation of allowances to industry stakeholders as well as strategic revenue spending to reluctant MS (Jevnaker and Wettestad 2017; Leipprand, Flachsland, and Pahle 2020). Decentralized free allocation of allowances via grandparenting in the first two trading phases *(less stringent policy design)* significantly eased

[51] However, it has to be noted that this was not due to a lack of trust in the overall credibility and cost-effectiveness of the system, but was a result of the EU's decision to define its 2030 climate target only in terms of a domestic reduction commitment and without relying on the use of international credits

concerns about economic costs and international competition as well as carbon leakage (+ on B_C) and, thus, was central for gaining buy-in from both industry stakeholders and reluctant MS (+ on B_P) (Convery 2009). However, significant windfall profits of power generators and competitive distortion between MS also necessitated reforms to increase policy stringency (positive feedback mechanism). Subsequent reforms in Phase-3 and Phase-4 led to a significant decrease, and gradual phase-out, of free allocation and respective increase in auctioning allowances *(more stringent policy design)*. This was made possible through a continued and strategic use of transfers by further differentiating allocation mode and revenue spending increasing the level of focus and conditionality (Dorsch, Flachsland, and Kornek 2020). This includes the continued free allocation of allowances to industries deemed particularly at risk of carbon leakage (carbon leakage list), albeit, based on continuously strengthened benchmarks (benchmarking) as well as continued concessions made to reluctant MS, such as highly flexible legislation for the spending of MS's increasing share of revenues. Low-income and coal-dependent CEECs benefitted particularly from several compensation measures, including a delayed phase-out of free allocation in industrial sectors, and multiple funds financed through auctioning revenues dedicated to the modernization of respective MS (e.g. NER300 (Phase-3), Modernization Fund (Phase-4)). Also, the CBAM can be seen as a compensation measure for industries protecting them from international competition CBAM and gradually replacing free allocation. As the revenue spending design of the ETS2 in the form of the Social Climate Fund shows, compensation measures can also be used *preventative* to hinder the build-up of (future) resistance (Dorsch, Flachsland, and Kornek 2020) Also, the Innovation Fund (Phase-4) included options to fund CCS and CUU, likely to prevent backlash from industries.

Overall, these continued compensations created trust among industry stakeholders and MS, reassuring them that policymakers would remain attentive to their concerns. Moreover, they channeled lobbying toward securing higher compensation instead of opposing the scheme altogether (Jevnaker and Wettestad 2017; Leipprand, Flachsland, and Pahle 2020). However, as Leipprand, Flachsland, and Pahle (2020) observe, while strategic transfers and compensation measures alleviated resistance to each reform, they did not, themselves, create dynamic feedback mechanisms. Instead, they helped to prevent negative political feedback, thereby, enabling other self-reinforcing feedback mechanisms to emerge over time. Thus, caution is needed to avoid the persistence (or even increase) of compensation costs over time without actually destructing the resistance of the opposing group, thus only temporarily circumventing a barrier without relaxing it or even creating a lock-in (Rogge, Kern, and Howlett 2017).

<u>Learning:</u> Continued strategic compensation measures (e.g. free allocation of allowances, recycling of revenues, border tariffs, etc.) as well as targeted exemptions (carbon leakage list, benchmarking) at the introduction and each major reform of an ETS scheme ("brown cushioning") can ease political barriers (+ on B_P) and help strengthen compliance (i.e. grandfathering → benchmarking → full auctioning) over time. However, caution is needed to avoid negative lock-in effects.

On the other end of the spectrum, the revenue spending design of the EU ETS demonstrates an increasing commitment to spurring innovation at each reform, which created a **"green push"** establishing and strengthening a green constituency (+ on B_P) (Leipprand and Flachsland 2018; Dorsch, Flachsland, and Kornek 2020). In fact, Dorsch, Flachsland, and Kornek (2020) observe a gradual shift from substantial "brown cushioning" in Phase-1 and Phase-2 to more green push elements in Phase-3 and Phase-4. This includes the obligation to use an increasing share of MS's auctioning revenues for climate- and energy-related purposes (over Phase-3 and Phase-4) as well as the establishment and continued expansion of the Innovation Fund established in Phase-4. As a result positive feedback effects (F_{IP}) helped to transform a wide range of heterogeneous actors with diverse interests into increasingly supportive green constituencies for an ambitious ETS design (+ on B_P) (Dorsch, Flachsland, and Kornek 2020). This included a growing number of actors from policy, i.e. national governments and government agencies as well as business, i.e. regulated firms and business associations, esp. from the power industry, which increasingly benefitted from the revenues, but also research associations, think tanks, and NGOs, which saw increasing environmental effectiveness in the instrument (Fitch-Roy, Fairbrass, and Benson 2020). Among those stakeholders, an ETS expert community emerged, which took responsibility for the instrument and was invested in improving the instrument's functioning – albeit with different specific interests (Voß and Simons 2014; Leipprand and Flachsland 2018).

Learning: Targeted and increasing revenue spending to spur innovation ("green push") can be used to form and grow a supporting coalition/green constituency interested in improving the instrument's functioning (+ on B_P).

6.1.1.2 Cross-Policy Feedback

Besides internal policy feedback (F_{IP}), **cross-policy feedback (F_{CP})**, especially from the development of the EU Renewable Energy Directive (RED), played an important role in increasing the stringency of the EU ETS (Leipprand and Flachsland 2018). Established in 2018, the EU RED promotes the use of renewable energy sources by setting binding national targets for MS, including measures to encourage renewable energy in electricity, heating and cooling, and transport sectors (with a current target of 42.5% share of renewable energies in 2030) (EC 2023e). As such it caused positive cross-policy feedback (F_{CP}) on the EU ETS, lowering the costs of renewable energy technologies (+ on B_C) and facilitating the creation of business models for renewable energy. This led to synergetic effects between the EU RED (pull) and the EU ETS (push) enlarging a supporting coalition of both new and incumbent power producers in favor of decarbonization and stringent carbon pricing (+ on B_P)

(Leipprand and Flachsland 2018; Meckling et al. 2015). However, as Leipprand and Flachsland (2018) note, the uptake of the EU ETS was also threatened by negative cross-policy feedback (F_{CP}). The surplus of allowances and resulting low carbon prices led to a strong skepticism of the renewable energy community, especially from environmental NGOs. They criticized that the EU ETS would fail to make renewable technologies competitive with conventional ones, and thus not incentivize the investments needed to ensure long-term decarbonization (- on B_P) (Edenhofer and Flachsland 2018; Leipprand and Flachsland 2018). Yet, this conflictual relationship between EU RED and EU ETS proponents has been slowly relaxed over recent years by an increasing stringency of the EU ETS (Leipprand and Flachsland 2018).

Also important to mention, and as already mentioned in the previous sections, is that the introduction of further sectors (such as maritime transport) into the existing EU ETS, as well as the establishment of the ETS2, have also substantially been informed by learnings from the initial establishment of the EU ETS (Delbeke 2024).

Learning: Green (technology) policies can support the uptake of an ETS through reduced technology costs (+ on B_C) and constituency-building effects (+ on B_P), however, antagony between green technology stakeholders about environmental effectiveness might also pose a threat (- on B_P).

6.1.1.3 External Effects

External effects (E) also shaped the ETS policy development. A major role in promoting ambitious EU climate targets more generally and the EU ETS specifically played strong leadership from individuals and institutions (Skjærseth and Wettestad 2010), in particular, the European Commission as a "policy entrepreneur" (Skjærseth 2017; Skjærseth and Wettestad 2010; Fitch-Roy, Fairbrass, and Benson 2020). Progressive units inside the European

Commission (especially DG ENV at that time[52]), with the support of a growing "green constituency" of actors across institutions and governance levels ("entrepreneurial network"), built up required technical expertise and mobilized the necessary support from state and non-state actors at various levels of decision-making to navigate this territory of high scientific uncertainty and social complexity (+ on B_{IG} and B_P). Moreover, it was crucial to overcome the opposition from more conservative units inside the European Commission and national governments (+ on B_{IG}) (Skjærseth and Wettestad 2010; Convery 2009).

Learning: Strong leadership from progressive individuals and institutions ("entrepreneurial networks"), esp. from the European Commission as a policy entrepreneur, is crucial (+ on B_{IG}).

Moreover, the development of international climate negotiations (in particular the Kyoto Protocol) was a key factor (Commission of the European Communities 2000). This is especially true since the EU's emissions cap and LRF are a direct translation of the EU's international reduction commitments (as discussed in **Section 6.1.1**) (Leipprand and Flachsland 2018). Also, the US's decision to withdraw from the Kyoto Protocol opened the stage for the EU as the world's leader in ambitious climate policy in general, and regarding emissions trading in particular (Convery 2009).

Finally, the public perception of the importance of climate change for European citizens and policymakers had a strong influence on the introduction as well as subsequent reforms of the EU ETS. For instance, as Convery (2009) observes, the 2002 European floods convinced many Europeans, especially the German public, of the realities of climate change, which led to increased support for the Green parties in subsequent elections, which in turn led to more government support for the EU ETS from both Member States and the European Parliament.

[52] In 2010 "relevant climate change activities in DG Environment" were moved to the new DG Climate Action (DG CLIMA), including the oversight of the EU ETS:

Learning: Development in and pressure from international climate and environmental regimes as well as the public and political perception of the importance of climate change can create crucial momentum (+ on B_P).

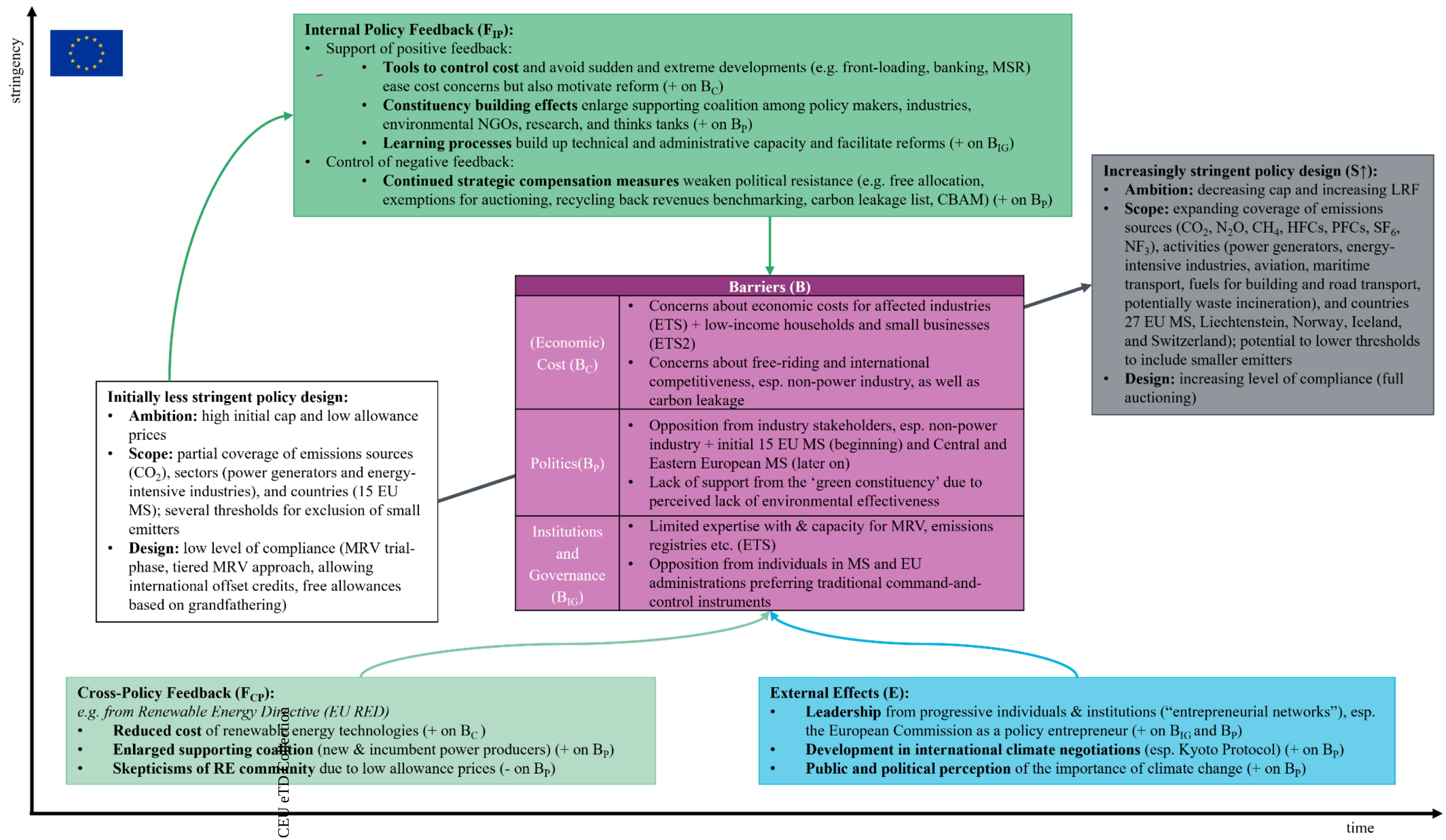

Figure 6 Schematic overview of **barriers (B)** to the EU ETS in other sectors as well as observed policy sequencing options and feedback mechanisms (**internal (F_{IP})** and **cross-policy (F_{CP})**) that helped to overcome barriers and increase policy stringency over time. **External effects (E)** are also displayed (own illustration).

6.2 Considerations for the introduction of an EU ETS for agricultural GHG emissions

6.2.1 Barriers to an EU ETS for agricultural GHG emissions

Similarly to the EU ETS, the introduction of an EU ETS for agriculture is facing a plethora of barriers. Central barriers are concerns about economic costs for regulated farms and the risk of price volatility (B_C) (15 interviews). Closely related is the fear of negative impacts on farmers' international competitiveness due to (carbon) leakage (B_C) (ten interviews). These concerns directly translate into strong opposition from the European agricultural lobby (B_P) (12 interviews), which was perceived as the most challenging barrier by many interview participants (R1, Ra, R6, P2, P5, M1). Similarly to the EU ETS, there is also skepticism about the environmental effectiveness of a trading scheme from the green groups, including environmental NGOs (E1, Ea), members of the Green parties (P5), and organic farmers (F1, F2, F3, Fa). For instance, a representative from an organic farmers association (F3) stated that "a risk that I see with an ETS system […] is that we are relying on techno-fixes […] but we are not changing the system." (B_P). Moreover, analogous to the introduction of the ETS2 there are concerns about the negative impacts of rising food prices on low-income households as well as food insecurity, given that a carbon price is likely to trickle down to the consumer (B_P) (four interviews). A further major obstacle is the technical and administrative feasibility of operating an EU ETS for agricultural emissions, in particular with regard to a reliable MRV system. This is especially a result of the multitude of small emitters (similar to the ETS2) as well as the complexity and diffuse nature of agricultural GHG emissions in the EU (12 interviews) (B_{IG}). Finally, three interviewees noted that there is also opposition from more traditional individuals in the EU administration, in particular in DG AGRI (M1, P1, Pb), who prefer (the reform of) existing command-and-control measures, such as increasing penalties under the CAP (R4, Pb) and a comparative weakness in terms of budget and number of personnel in more progressive units, especially DG CLIMA (P1) (three interviews).

6.2.2 Sequencing options and policy feedback mechanisms to overcome barriers to an EU ETS for agricultural GHG emissions

The findings from the policy evolution of the existing EU ETS in other sectors suggest that a gradual phase-in of an EU ETS for agricultural emissions could reflect the heterogeneity of actors and emissions sources and reduce barriers related to (economic) costs (B_C), politics (B_P), as well as institutions and governance (B_{IG}) over time. While some interview partners raised concerns about the environmental effectiveness of such an approach stating that "[…] we could again lose another decade or more to make the system fit for purpose. It's what happened with the existing ETS, it took a while for it to become just a bit effective." (E1), many of the other interviewees supported this notion (P1, P2, R4, R5).

The concrete possibilities and trade-offs of sequencing options and respective (triggered) feedback mechanisms to overcome **barriers** in the context of the European agriculture sector are discussed in more detail in the forthcoming taking into account **internal policy feedback (F_{IP})**, **cross-policy feedback (F_{CP})**, as well as **external processes and conditions (E)**. A schematic overview is provided in **Figure 7**.

6.2.2.1 Internal Policy Feedback

As the policy development of the EU ETS suggests, an initially less stringent but politically feasible policy design related to ***policy ambition, scope, and design*** could lead to **internal policy feedback effects (F_{IP})** that help to gradually relax barriers to a more stringent Agri-ETS by triggering positive feedback and controlling negative feedback.

Policy ambition

Learning from the example of the EU ETS, the use of price management measures during the introduction of an Agri-ETS *(low initial policy ambition)* could significantly reduce cost concerns of farmers (+ on B_C) and ensure a smooth roll-out. For instance, temporarily increasing the trading ratios of allowances (front-loading), as planned under the ETS2, would allow regulated entities to hedge by purchasing allowances in advance to mitigate price fluctuations (Bullock 2012; Leining, Kerr, and Bruce-Brand 2020 and R2, P1, P2). Moreover, allowing farmers to bank allowances, that is to carry over unsold credits from one period to the next, like it is possible under the EU ETS and also the planned NZ ETS (Bakam and Matthews 2009), would help to encourage early emission reductions when it is most cost-effective and smooth the effects of potential shocks (Bullock 2012). However, as interviewee R2 noted, the diverse nature of agricultural holdings across the EU, their varying planning horizons, and differing capacities to hasten emissions reductions in order to benefit from allowance banking are likely to influence practices in this area and affect the permit market. Additionally, the complexity of GHG data necessary for establishing an appropriate allocation level in an agricultural ETS could increase the likelihood of errors during the initial phases (Trinomics 2023).

Therefore, with both front-loading and banking, the risk of transferring potential negative impacts to subsequent trading phases will need to be taken into account. Learning from the stark price fluctuations of the EU ETS in the first two trading phases, continued use of price management measures beyond the initial trading period can, therefore, protect regulated entities against price volatility, which is of particular concern for vulnerable farmers (+ on B_C) (Trinomics 2023). A system similar to the EU ETS MSR established in 2019 could be explored to allow for course corrections and price regulation (Trinomics 2023). Introducing floor and ceiling prices, like in the planned NZ ETS and similar to the MSR of the ETS2, could be an alternative approach. That is, if the carbon price falls below a defined minimum price (floor), the government will sell permits at an auction instead of distributing them for free. Instead, if the carbon price rises above the ceiling price, the release of reserve units is triggered which increases the availability of credits and lowers the price (Leining, Kerr, and Bruce-Brand 2020).

However, while such price management measures enhance liquidity and protect against sudden and extreme price developments, as the example of the EU ETS shows, they also distort the market mechanism exerting a suppressive effect on the carbon price and delaying emissions reductions and, thus, lower the environmental effectiveness of the scheme (Trinomics 2023). As interviewee R3 noted, this might lead to a situation where "it is simply more profitable for the farms to buy [allowances] and not to reduce [their emissions], and then the instrument is not so effective anymore". Therefore, a clear roadmap to a long-term policy target that starts reducing the number of allowances within a few years of the schemes' introduction (with a clear cap and LRF trajectory) is pivotal to ensuring environmental integrity and providing a planning horizon for regulated entities *(increasing policy ambition)* (P1, P2, E1, Ea). As interviewee P2 suggested this trajectory should be oriented toward the EU's 2050 climate neutrality target or even on the 2035 neutrality target for the LULUCF sector.

<u>Feasible Agri-ETS Pathway:</u> Combining an initial low policy ambition (e.g. through front-loading and banking) with a clear long-term reduction roadmap to climate neutrality in 2050 supported through price management measures (e.g. MSR, floor/ceiling prices) is essential to mitigate price volatility (+ on B_C) but also ensure environmental integrity.

Policy scope

Sectoral coverage

Following the example of the EU ETS, initial partial coverage of agricultural GHG emissions focusing on some emission sources, GHG emissions, and actors with a comparatively high mitigation potential and economic capacity as well as low transaction costs and leakage risks *(small initial policy scope)* could significantly reduce the political barrier (+ on B_P) as well as reduce the technical and administrative complexity (+ on B_{IG}) (Grosjean et al. 2018; Trinomics 2023 and R1, R2, R4, R5, R6, Ra, P1, P2, P4, I1, E1). Over time, learning processes could lower the administrative burden for both regulators and regulated entities (positive feedback F_{IP}), which would allow for expansion of the policy scope over time, ultimately, towards (almost) full sectoral coverage (R3, I2) *(increasing policy scope)*. Similarly to the EU ETS continued but targeted exemptions could ease this transition.

Different avenues for such initial partial coverage could be followed in the European agricultural sector. With regards to emissions sources and GHG emissions partial coverage could focus on CH_4 and N_2O emissions related to enteric fermentation and manure management from animal products, such as beef, dairy, and pork as well as N_2O emissions from mineral fertilizers (German Zero 2022 and R1, R4, R5, R6, Ra P1, P2, P4, E1, Ea). These have substantial mitigation potential (as introduced in **Section 2.1.1**) but low marginal abatement costs (as introduced in **Section 2.1.3**), low leakage risks, and limited TC (Grosjean et al. 2018; Trinomics 2023) and, therefore, are "the low-hanging fruits" CO_2 emissions, on the other hand, would play a marginal role, apart from emissions from peatlands, of which interviewee R4 describes the rewetting as highly politically feasible due to the perceived benefits for farmers. However, partial coverage of emission sources bears the risk of internal carbon leakage as farmers could change activities to escape compliance. This could even result in adverse environmental impacts if the regulated activity produces less emissions than the non-regulated one (Grosjean et al. 2018 and F3, E1). Moreover, the interviews revealed that many farmers would actually prefer an encompassing approach to GHG emission coverage looking at the "climate balance of a farm" from the outset since this would allow them to counterbalance their emissions sources and sinks (R1, Ra, F3, Fa, I2, Ia).

Another option related to emissions sources could be to introduce a split-gas approach, that is a separate carbon price for N_2O, CH_4, and CO_2 (R4). New Zealand, for instance, plans to penalize CH_4 less than N_2O relative to their global warming potential (Leining, Kerr, and Bruce-Brand 2020). In the case of Germany, Isermeyer, Heidecke, and Osterburg (2019) suggest, similarly to the proposal in New Zealand, a split-gas approach pricing CH_4, N_2O, and CO_2 differently. However, as Verschuuren (2017) notes based on experience with Australia's Carbon Farming Initiative, dividing activities on-farm into different measures and methodologies could also increase administrative costs for farmers.

With regards to actors, a de minimis threshold could be used, like in the EU ETS, to exempt small farms with relatively low emissions, and that do not (yet) have the financial and human capacity to manage ETS compliance as well as cushion price volatility (Ancev 2011; Stéphane De Cara and Vermont 2011; Grosjean et al. 2018; Trinomics 2023; Kerr and Sweet 2008 and R1, R2, R3, R4, R5, Ra, P1, P2, I1, E1). Otherwise, more than 10 million farms could potentially be included in an EU Agri-ETS (Trinomics 2023). As interviewee P2 put it, an Agri-ETS should focus on large farms, "like intensive livestock installations, not a farmer in Romania or Bulgaria who has a cow or two". Grosjean et al. (2018), for instance, establish a Lorenz Curve based on the Farm Accountancy Data Network (FADN) and observe that the top 10% of agricultural emitters in the EU are responsible for approximately 38% of emissions and the top 20% for even 58% of emissions. Such an approach could, therefore, reduce compliance costs and impacts on livelihoods for smaller entities as well as lower the administrative cost of operating the ETS while still covering a significant share of emissions.

A threshold could, for instance, be defined based on total emissions (R5), farm size in hectares (P1, R5), or livestock numbers (R2) (Trinomics 2023). For instance, in New Zealand, the current proposal for an ETS in agriculture sets a size threshold of about 200 tons of CO_2eq per year, covering approximately 23,000 farmers (Leining, Kerr, and Bruce-Brand 2020). Interviewee R5 noted that the revenues of a farm could also be taken into consideration since there is a difference between "a highly profitable flower farm in the Netherlands, which gives you 60,000 € per hectare, and a rain-fed cereal [farm] in southern Spain which [generates] 200 € [per hectare]". However, applying thresholds also entails risks (Grosjean et al. 2018): For instance, utilizing a size threshold for livestock could incentivize farm intensification with more livestock units per hectare, which would be problematic for biodiversity and animal rights, among others (R4, P4, F3). Therefore, and since the majority of farms are mixed farms, it is advisable to employ a combined approach to threshold types (Trinomics 2023 and R4). Moreover, in a sector characterized by family ownership (94.8% of EU farms were family farms[53] in 2020 (Eurostat 2023)), thresholds could lead to gaming among participants, where farmers break up installations into separate entities under the ownership of various family members to avoid compliance (Weishaupt et al. 2020 and P2, R4). For similar reasons, farms below the threshold may curb their growth. However, as Kerr and Sweet (2008) note, this issue could be resolved by setting a threshold that determines the obligation to participate, however, then gradually increasing the level of emissions that must be covered with farm size for those above the threshold. Alternatively, interviewee P2 also suggests that this could be avoided by setting a trajectory for reducing the de minimis threshold over time from the outset. Moreover, defining a threshold is a politically sensitive topic and raises concerns about fairness for farms just above or below the threshold (E1, Ea). Finally, contrary to the

[53] Defined as being farms on which 50% or more of the agricultural labour force is provided by family members (Eurostat 2023).

assumptions above, the exemption of small farms might lead to a low GHG coverage since subsistence farms tend to have a higher GHG emission intensity due to the use of outdated agricultural practices (Trinomics 2023 and R4, E1, Ea). In the end, as Trinomics (2023) note, defining a suitable threshold requires finding a balance between emissions coverage, administrative costs, and impacts on the competitiveness of the agricultural sector.

Feasible Agri-ETS Pathway: A focus on emissions sources and GHG emissions with a high mitigation potential, such as CH_4 and N_2O emissions from animal husbandry and mineral fertilizer ("the low-hanging fruits") and large farms above a certain threshold with comparatively high economic capacity as well as low transaction costs and leakage risks could create political buy-in (+ on B_P) and could enhance the technical and administrative capacity of both regulators and regulated entities (+ on B_{IG}) which would allow expanding the policy scope over time. This expansion should follow a clear trajectory from the start to avoid perverse incentives such as farm-splitting.

Point of Obligation

As exemplified by the ETS2, another option is to shift the point of obligation in the supply chain. Instead of targeting farm operators directly, an ETS could (temporarily) apply to up- (e.g. feed or fertilizer manufacturers and importers or distributors/vendors) or down-stream actors (e.g. meat and dairy processors or retailers) (Ancev 2011; Trinomics 2023; Isermeyer, Heidecke, and Osterburg 2019; Weishaupt et al. 2020; Maraseni 2009 and R1, R3, R5, R6, Ra, P1, P2, P4, I1, I2, E1, Pc). Up-stream actors would be encouraged to produce or import feed and fertilizer that cause less GHG emissions during use or increase the price of emission-intensive feed and fertilizer. This could incentivize more efficient on-farm use of products, a switch to less emission-intensive products, or different agricultural practices (Kerr and Sweet 2008; Cooper, Boston, and Bright 2013; Leining, Kerr, and Bruce-Brand 2020; Trinomics 2023; Isermeyer, Heidecke, and Osterburg 2019). Down-stream actors would need to surrender allowances for the emissions of products purchased from farmers, therefore, incentivizing changes in on-farm management practices (Trinomics 2023; German Zero 2022; Weishaupt et al. 2020).

Shifting obligations away from farmers would reduce the economic burden on farmers, which in turn could increase political support (Ancev 2011 and R1, Ra, P2). In contrast to farms, thes einstallations are typically owned by large multinational corporations and as interviewee R1 observes "there is much less support politically for the meat industry compared to […] farmers" (+ on B_P). In addition, a down-stream system could also cover imported agricultural products, therefore, reducing carbon leakage (P2, Pa) (+ B_C). Moreover, TC could be decreased significantly (+ on B_{IG}). Besides having higher financial and human capacity to manage an ETS (R1), up- and down-stream actors might already have experience with surrendering allowances under an existing ETS scheme, as is the case for the EU ETS where fertilizer and feed producers are already regulated for the GHG emissions occurring from manufacturing process (Trinomics 2023 and E1, R4). Most importantly, however, regulating up- and down-stream obligations would cut the number of liable participants significantly (Ancev 2011; Weishaupt et al. 2020). For instance, in New Zealand, the initial attempt to cover agriculture under the NZ ETS in 2008 was targeted at fertilizer manufacturers and importers as well as meat and dairy processors reducing the number of regulated entities to 75 (Kerr and Sweet 2008). For the EU, Trinomics (2023) estimates that an up-stream system would reduce the number of regulated entities to about 5,300 manufacturers and importers (feed: ~3,800; fertilizer: ~1,500) or 53,000 distributors and vendors (feed: ~27,000; fertilizer: ~26,000), and a downstream system to about 1,600 processors[54]. They mention that numbers could be further reduced by setting a de minimis threshold based on company size (i.e.

[54] Directly at farm-gate and excluding small and medium-sized enterprises (i.e. with 50 or more employees).

number of employees) or production capacity to exempt small companies with a limited contribution to agricultural GHG emissions (also supported from P1 and I1). This is also important to avoid negative distributional impacts, as interviewee I1 highlights since “99% of food and drink companies are SMEs[55] in the EU”. For instance, a down-stream ETS that covers processors with 50 or more employees would put a price on around 82% of emissions related to meat production and 91% of emissions associated with dairy production (Trinomics 2023). However, similar to a threshold at farm-level, they advise caution to avoid companies circumventing the ETS and to minimize unfair competition for companies just above or below the threshold. Based on a survey of 91 stakeholders along the agricultural supply chain, they found a strong preference for the down-stream option over a farm-level approach, and a slight preference for the up-stream option, respectively.

However, despite the perceived benefits, a common criticism of switching the point of obligation throughout the agricultural supply chain, especially on an up-stream level (I2, Ia), is that it fails to put in place an adequate incentive structure to achieve a change in farmer’s behavior in relation to their GHG emissions (Ancev 2011 and R2, R3, I2). Moreover, emissions estimates are not as accurate as if measured directly on-farm level and farmers have fewer options for how they respond to the price signal (Kerr and Sweet 2008 and R2, R3, I1). Finally, such an approach could only cover parts of the emissions from agriculture since the activities that can be regulated, and therefore, encouraged at the farm-level are a wider set than those at processor-level (e.g. a crucial mitigation measure for nitrous oxide, the application of nitrification inhibitors, can only be monitored on-farm; pricing nitrogen fertilizers changes behaviour related to the level of fertilizer used, however, does not support low- or no-tillage practices) (Kerr and Sweet 2008; Moyes 2008 and R2, R3, R5). For these

[55] SMEs = small and medium-sized enterprises

reasons, the up- and down-stream approach in New Zealand was undermined by farmer's own wishes to have the individual farm as the point of obligation, which also informed the final decision for a farm-level approach entering into force in 2024/25 (Leining, Kerr, and Bruce-Brand 2020; New Zealand Government 2023).

As such it could be feasible to treat the stage of up- or down-stream compliance as a transition period *(small initial policy scope)* and then gradually move to farm-level compliance obligations expanding the scope and accuracy of regulated emissions *(increasing policy scope)* (Leining, Kerr, and Bruce-Brand 2020 and E1). Such an approach could buy time for regulators to establish a robust compliance framework and support system before moving onto the technical and administratively more complex farm level (+ on B_{IP}). Moreover, it could ensure that farmers are adequately prepared and supported when direct obligations are eventually introduced (+ on B_P) (I1, I2, Ia). Especially for down-stream actors this could be encouraged through close cooperation with farmers to support their transition. As the interviewed industry representatives (I1, I2, Ia) note, such structures are already in place with food processors, such as Arla and Nestle, already supporting their contracted farmers with the transition to regenerative agriculture and MRV of emissions in light of their Tier 3 emissions to be reported in their corporate sustainability reports. To smoothen the transition the shift to farm operators could also be conducted at different speeds for different emission sources, GHG emissions, and actors groups requiring some farmers to report at the farm level while others are covered through up- or down-stream actors. However, such a hybrid approach would raise different issues such as equity concerns about which farmers are regulated at what level and potential perverse behavior to avoid regulation. For instance, two separate methodologies for reporting could lead to farmers moving dairy animals from farms already covered at the farm scale to those still covered at the processor level during non-milking periods to reduce monitored farm emissions (Kerr and Sweet 2008).

An alternative approach mentioned by some scholars is (temporarily) consolidating farmer's allowances and participation in an ETS through intermediate actors, such as industry associations, to decrease administrative costs and financial burden for smallholder farmers (especially regarding MRV) *(small initial policy scope)* (+ on B_{IG}) (Ancev 2011; Stéphane De Cara and Vermont 2011; Trinomics 2023 and R1, F1). As Ancev (2011) notes, agriculture has the advantage over other sectors (such as transport or buildings) to already have such structures in place. For instance, the approach gained relevance in Australia's Carbon Farming Initiative, where so-called "carbon agents" (e.g. specialized consultants, individuals, or high-level stakeholders such as producer organizations) coordinate the administration between the legal authority and the farmers (Verschuuren 2017). The proposed framework in New Zealand also allows farmers to form collectives to aggregate administrative tasks (Leining, Kerr, and Bruce-Brand 2020). Eventually, this could prepare regulators and regulated entities for a transition to an on-farm ETS allowing for more direct participation of farmers in emissions trading. This gradual transition could facilitate the establishment of robust MRV systems at the farm level, enhance the accuracy of emissions data (+ B_{IG}), and ultimately lead to more effective and comprehensive emissions reductions across the agricultural sector *(increasing policy scope)*.

Feasible Agri-ETS Pathway: (Initially) putting the point of obligation on up-stream (e.g. feed or fertilizer manufacturers and importers or distributors/vendors) or down-stream actors (e.g. meat and dairy processors or retailers) could significantly reduce the political barrier (+ on B_P) and decrease administrative complexity (+ on B_{IG}). By buying time to build up technical and administrative capacity this could also facilitate a gradual transition to a more encompassing farm-level compliance scheme. Alternatively, intermediate actors, such as industry associations, could be targeted for similar reasons.

Policy design

Monitoring, reporting, and verification (MRV)

The initial trial period of the EU ETS as well as the introduction of maritime transport and the ETS2 exemplify the importance of gathering data to set up a reliable and robust MRV system. Since agricultural emissions are even less well-understood (Trinomics 2023), an Agri-ETS introduction could be based on an MRV pilot phase *(initially less stringent policy design)* to collect more accurate data (+ on B_{IG} for regulators) as well as to give regulated entities the time to adapt to the new reporting requirements (+ in B_{IG} for farmers) (positive feedback F_{IP}) (Trinomics 2023 and R2, P1, P2, R4). Such an approach was also utilized for the planned introduction of the NZ ETS for agriculture starting with a mandatory reporting period from Q4 2024 and moving onto mandatory pricing from Q4 2025 under the "Know Your Numbers" initiative (New Zealand Government 2023). As of now, 80% of farmers are aware of their total annual emissions, and 40% have implemented plans monitor and manage them (Trinomics 2023).

Different approaches could be considered: While mandatory reporting requirements would enhance the quantity of data collection, there would be a high risk of farms under-reporting their recorded emissions to avoid the future pricing scheme. Even if intentional under-reporting was not a major problem, farms might find it challenging to accurately identify the correct input variables due to a lack of time and interest. Voluntary reporting of farms genuinely interested in identifying their climate impact could yield a higher data quality of data, however, compromising on quantity (Trinomics 2023). Similar to the NZ ETS example, it would be necessary to provide farmers with different tools to help them navigate this period. Such are already available, for instance, the EU-wide farm-level carbon footprint calculator from the European Commission Joint Research Center.

Another dimension to significantly influences TC is the accuracy of MRV as exemplified by the "tiered" approach to MRV under the EU ETS. Such an approach could also be feasible for an Agri-ETS (Fleurke 2022 and R1, R3, R4, R4, R5, Ra, P1, P2, P3, P4). Due to the complexity and volatility of agricultural GHG emissions as well as the large number of external influences outside of the farmer's control (e.g. weather and local soil conditions), directly measuring emissions is currently unfeasible at reasonable costs (Grosjean et al. 2018). Moreover, TC for direct measurement of certain activities is much higher than the cost of actually reducing the related emissions. For instance, while regular soil testing provides a far higher accuracy about CO_2 emissions, it is much costlier than regulating management practices such as tillage (Grosjean et al. 2018). The majority of studies, therefore, suggest (first) focusing on an MRV modeling emissions based on proxy parameters *(less stringent policy design)*, which can significantly reduce TC (+ on B_{IG}) (Fleurke 2022; Gerber et al. 2010; Moyes 2008). Proxies can include inputs (e.g. fertilizer purchases or feed imports), activities (e.g. type and number of livestock animals, type of stables) (R1, Ra), management practices (e.g. animal diet, tillage, manure management techniques), outputs (e.g. milk or meat produced), or measurements (e.g. tests of soil carbon level) (Grosjean et al. 2018; Gerber et al. 2010). However, a main limitation of this approach is the poor validation of weather- and seasonality-induced variability, especially for CO_2 emissions. Moreover, there is a trade-off between the accuracy of covering emissions through these proxies and TC connected to measuring and monitoring them (Grosjean et al. 2018 and F3, E1, Ea). While reducing the emissions from fertilizers has comparably relatively low TC because it involves well-established practices, cost-effective technologies, and efficiency gains, using proxies provides a weak mitigation incentive since N_2O emissions depend on many more factors than the amount of fertilizer application (e.g. management practices) (Grosjean et al. 2018; Gerber et al. 2010). Moreover, the choice of proxies is highly relevant to the policy outcome and determines which incentives it provides. For instance, while simple proxies based on input or output will likely promote a shift toward lower emission-intensive products, they do not encourage producers to reduce their per-unit emissions by adopting innovative practices (Gerber et al. 2010).

For these reasons, the accuracy of the MRV could be gradually increased. Learning processes, for instance through an MRV trial phase and sample on-farm monitoring on both the regulator and farm side could eventually allow a transition to more accurate proxies or measurements for MRV (positive feedback F_{IP}) *(more stringent policy design)* (Weishaupt et al. 2020; Trinomics 2023 and R4). While for large farms, this could become mandatory, smaller farms could have the voluntary opportunity for a self-reporting system incentivized by the possibility of correcting potential overestimation of emissions through proxy calculation imposed by the regulator (R2, R3).

> <u>Feasible Agri-ETS:</u> An initial trial phase with MRV but no compliance obligations as well as a tiered approach to MRV accuracy (coarse proxy values → more exact proxies or measurements) could trigger learning processes, which will likely reduce transaction costs for both the regulator and farmers (+ on B_{IG}).

Voluntary Offset Scheme

Another option that could increase the uptake of an Agri-ETS, is a voluntary offset scheme (Grosjean et al. 2018; Verschuuren 2017; Trinomics 2023 and R1, R3, Ra, R4) *(initial less stringent policy design)*. That is, farms implement voluntary mitigation projects and for each ton of CO_2eq they mitigate below a certain baseline, they can sell an offset either on a compliance market or a voluntary market (Grosjean et al. 2018). The use of international CDM and JI credits under the EU ETS is a precedent for this. By revealing information on abatement costs as well as transaction costs they could trigger learning effects for MRV requirements (+ on B_{IG}) (Bellassen et al. 2015). Moreover, since they provide an additional income, they foster a smooth transition for a highly subsidized agricultural sector. As interviewee R1 noted “otherwise, you have a big break, in regulating the sector”. Therefore, with the potential to contribute to the development of a new constituency supporting carbon pricing, it can be viewed as a first step in tackling the political barrier (+ on B_P) (Kollmuss 2009; Verschuuren 2018 and R3, M1, R4). As Verschuuren (2017) argues voluntary mitigation projects might, therefore, be a great opportunity to prepare the farming sector for a more compelling whole-sector scheme (positive feedback F_{IP}) *(more stringent policy design)*. This strategy was successful for the voluntary mitigation projects under the Emission Reduction Fund in Australia (Verschuuren 2017) and is also the basis for the planned on-farm carbon levy for agricultural emissions in New Zealand, which incorporates payments or credits for carbon sequestration (Leining, Kerr, and Bruce-Brand 2020). While some studies assume that carbon offsets would be sold outside of the agricultural sector (e.g. to regulated entities under the EU ETS or to non-agricultural enterprises on a voluntary market (Grosjean et al. 2018), interviewees highlight the importance of keeping the offset credits within the sector, either for carbon neutrality at farm-level (F3, Fa, I2, Ia) or within the food chain (“in-setting”), which could lead to joint business-farm reduction efforts (I1, I2, Ia). This is in the notion of the constituency-building effects. It is also important to note that in practice, a gradual phase-in would also mean covering some actors or emissions sources under a voluntary policy while targeting others with compliance policies (Grosjean et al. 2018).

However, some caution is advisable with the use of carbon offsets. Transaction costs tend to be high due to the complexity of defining a baseline and measuring additionality and permanence for heterogeneous on-farm missions as well as the small-scale nature of projects. The voluntary nature, therefore, might lead to a “patchy” uptake (R2) but at the same time ensures that these high transaction costs are not disproportionately impacting vulnerable actors (Bellassen et al. 2015). As the experience with international CDM and JI credits under the EU ETS shows, strict rules should apply to the quantity of allowances to avoid market distortion and to the quality of allowances, especially regarding permanence, additionality, and certainty of emission reductions (Murray, Sohngen, and Ross 2007; Trinomics 2023 + R2, P1, P2, P3, R5, R4). Concerns about the latter were particularly high among the interviewed "green group" (F1, F2, F3, Fa, P5, E1) (P5: "Should we compensate farmers for not destroying? […] Do you pay your neighbor for not destroying your car […]?"). An offset scheme might also lead to perverse incentives. For instance, interviewee R4 noted that it could lead to offsetting instead of reducing on-farm emissions, especially by emission-intensive entities, such as livestock farms. Interviewee P1 gave the insight that prior to the introduction of such a scheme in New Zealand "[farmers] cut down trees because they did not want them to be counted after [the scheme] started". As interviewee P2 suggested, one way to circumvent these risks is the introduction of a "carbon central bank" as an intermediary.

Feasible Agri-ETS Pathway: Voluntary offset schemes have great potential for preparing the uptake of mitigation measures (+ on B_{IG}) and changing the attitude of farmers towards climate-smart agriculture (+ on B_P). As such, they might be a first step of the farming sector toward a more compelling whole-sector scheme. Yet, issues such as reversibility, additionality, and uncertainty about the reduction potential as well as perverse incentives need to be taken into serious consideration for a robust scheme and call for strong regulation.

Distribution mechanisms and strategic compensation measures

As the policy development of the EU ETS shows strategic transfers and compensation of resistant actors in the form of (initial) free allocation, recycling of revenues, and border tariffs as part of the policy design could be instrumental in overcoming the political resistance barrier at the introduction of an Agri-ETS. Continued targeted exemptions of particularly resistant or vulnerable actor groups could allow for further strengthening of policy design later on (Grosjean et al. 2018, Trinomics 2034)

An initial high share of free allocation would ease the transition for farmers, reducing resistance and allowing time for adaptation (+ on B_P) *(less stringent policy design)* (Bullock 2012; Leining et al. 2020; Kerr and Zhang 2009; Trinomics 2023 and R2, R3, R4, R5, P1, P2, P3). There are different potential options for allocating free allowances in the agricultural sector. The example of the EU ETS demonstrates that the chosen approach can significantly influence the distribution of costs among individual emitters, the incentives for emitters to reduce their emissions, and the support provided to emitters during the transition (Trinomics 2023). The most frequently mentioned approach for agriculture is grandfathering (e.g. Pérez Domínquez et al. 2020; Grosjean et al. 2018; Cooper, Boston, and Bright 2013; Bullock 2012; Kerr and Zhang 2009; Kerr and Sweet 2008; Bakam and Matthews 2009; Trinomics 2023), followed by output-based allocation (e.g. Bullock 2012; Leining, Kerr, and Bruce-Brand 2020; Trinomics 2023; Kerr and Zhang 2009). For instance, in New Zealand, after initially considering grandfathering allowances, the government moved forward with an output-based approach planning to allocate 90% (and later 95%) of allowances for free based on yearly average output within the industry (Bullock 2012). Area-based and proportional allocation as well as benchmarking are discussed only to a very limited extent for agriculture (Grosjean et al. 2018; Trinomics 2023) and have so far found no relevance in actual policy discussions. Both grandfathering and output-based allocation can be considered highly effective in reducing the risks of carbon leakage, loss of competitiveness, and adverse economic impacts, while the latter is perceived as particularly fair and preventative of leakage (Grosjean et al. 2018). However, in the case of grandfathering, entities are essentially compensated for technologically locked-in emissions. Yet, it will incentivize a drop in both emission intensity and the production of GHG-intensive goods since regulated entities forfeit the opportunity to be able to sell their allowances if they do not or even need to buy allowances if their share of free allowances is insufficient for a potential expansion of production (ibid). Output-based allocation, on the other hand, favors installations with initially high GHG emissions and even compensates participants for increasing emissions (Bullock 2012), while grandfathering, therefore, only tends to support the former (Grosjean et al. 2018). Moreover, Bullock (2012) argues that output-based allocation may even further increase emissions through internal carbon leakage by creating a favorable regulatory environment for emitters from other countries. Overall, several studies agree that output-based allocation weakens the market mechanism to a degree at which almost no emission reduction incentives are created (Bullock 2012; Leining, Kerr, and Bruce-Brand 2020). As exemplified by the EU ETS, an alternative approach could, therefore, be benchmarking. By rewarding farmers who have already taken steps to reduce emissions through benchmarks based on “best available practices”, this can drive overall improvements in the sector (Grosjean et al. 2018, P3, R2, R5).

However, due to their downsides, free allowances should decrease gradually, transitioning to auctioning to ensure the environmental effectiveness of the scheme *(increasing stringency of policy design)* (Bullock 2012, Leining et al. 2020 and R2, R3, R4, R5, P1, P2, P3, E1). Nonetheless, due to the particularly high vulnerability of many actors in the agricultural sector, a transition to full auctioning might not be feasible for the entire sector or require more time. In fact, auctioning allowances for an ETS in agriculture only plays a minor role in existing schemes, and the literature (e.g. Grosjean et al. 2018 are one of the very few that discuss the possibility of auctioning). A multi-speed approach based on targeted exemptions for different emission sources, GHGs, or actors aligned with the increasing capabilities of farmers to adopt low-emission technologies could ease the transition (Bullock 2012; Kerr and Zhang 2009).

In addition, auctioning allowances would generate <u>revenues</u> that can also be used to address the distributional impacts and ensure continued support from stakeholders, especially since European agriculture has traditionally been a subsidy sector (+ on B_P) (Trinomics 2023 and

R1, R2, R3, R4, R5, R6, P1, P2, I1, I2, F3, Fa, E1). Following the example of the Innovation Fund of the EU ETS revenues should be re-invested in the sector to support the adoption of low-emission technologies and practices (Leining et al. 2020; Kerr and Zhang 2009 and R1, R2, R3, R4, R5, R6, P1, P2, I1, I2, F3, FA, E1), as interviewee R6 put it, in the form of a "rural transition package". Moreover, interviewee I2 highlighted that part of the revenues should be channeled back into research and development to further drive innovation for climate-smart agricultural practices and technologies (e.g. carbon farming techniques or precision agriculture). However, as interviewee F3, noted, particularly important would also be to fund advisory services and knowledge transfer since farmers not only lack the necessary equipment but even more so the knowledge to transform their agricultural practices. As the example of the EU ETS suggests, this could lead to constituency-building effects and a gradually growing green supporting coalition for sustainable farming (positive feedback F_{IP}). Moreover, ensuring fair burden-sharing by using a share of the revenues to support low-income farmers in the transition and avoid disproportionate economic hardship is critical as exemplified by the Modernization Fund (Pérez Dominquez et al. 2012 and R5, P1, P2). In addition, similarly to the Social Climate Fund, some of the interviewees suggested recycling a share of the revenues to consumers, especially to low- and medium-income households, to mitigate higher food prices since carbon prices will likely be passed down the supply chain (R4, P2, E1, Ea). Finally to address the risk of carbon leakage, implementing border tariffs for agricultural products can ensure a level playing field and protect the competitiveness of EU farmers (Grosjean et al. 2018 and R1, R3, Ra I2) To that regard the EU's CBAM could simply be extended to agricultural goods (R3, E1). However, although European agriculture is a subsidy sector, caution is needed with any form of compensation measures to eventually ensure a self-sustaining sustainable transition and avoid negative lock-in effects.

Feasile Agri-ETS Pathway: An initial free allocation of allowances could ease the transition for farmers and significantly reduce the political barrier (+ on B_P). Over time, these free allowances should be phased out, potentially in a multi-speed approach across emission sources, GHGs, and actors, transitioning to auctioning. The generated revenues should be reinvested in the agricultural sector to drive innovation and support vulnerable farmers. To prevent carbon leakage the EU's CBAM could be extended to agricultural products. However, caution is needed to avoid negative lock-in effects and ensure a self-sustaining transition towards sustainable farming practices in the long-term.

6.2.2.2 Cross-Policy Feedback

As the policy evolution of the EU ETS suggests, besides internal policy feedback (F_{IP}), **cross-policy feedback (F_{CP})** could also be conducive to or hinder the uptake of a more stringent ETS design.

On the one hand, multiple existing schemes (partly) regulating the EU agricultural sector could play an important role in increasing the policy stringency of the EU ETS. For instance, greening measures under the CAP could, similarly to the EU RED, support the uptake of an Agri-ETS through reduced costs of sustainable farming practices (+ on B_C) and constituency building effects (+ on B_P) (Grosjean et al. 2018; Trinomics 2023 + R4). Moreover, lessons can be learned and capacity leveraged from the existing MRV schemes of the CAP (e.g. the Land Parcel Identification System (LPIS), the Industrial Emissions Directive (IED), the Soil Monitoring Law and the Nitrate Directive (Trinomics 2023 + R1, R2, Ra, P2, R4) (+ on B_{IG}). The year-long experience with the EU ETS in other sectors is of course also conducive. Finally, the proposed Carbon Removal Certification Framework (CRCF) can basically be seen as a transitional voluntary offset scheme preparing the sector for a more comprehensive (compliance) scheme (I1, R4).

On the other hand, the CAP could also hinder the introduction of an Agri-ETS. Since the European agricultural sector has traditionally been a subsidy sector stakeholders across administrations, farms, and industries might be reluctant to a pricing scheme and would rather prefer further subsidies for the transition to sustainable agricultural practices through a reformed CAP (P1, P3, P4, R5, M1, P1, Pb).

Feasible Agri-ETS Pathway: While green CAP payments could reduce the cost of sustainable farming and enlarge a supporting coalition (+ on B_C), the CAP community could also prevent an Agri-ETS uptake preferring subsidies for a green transition under the CAP (- on B_P). Moreover, synergies through various existing MRV tools under the CAP, the Nitrate Directive, the Soil Monitoring Law, and the Industrial Emissions Directive could be leveraged (+ on B_{IG}). Finally, the planned Carbon Removal Framework Certification (CRFC) could promote the Agri-ETS uptake through a voluntary offset scheme (+ on B_{IG}).

6.2.2.3 External Effects

As the development of the EU ETS shows also **external effects (E)** could be conducive to a gradual phase-in of an Agri-ETS. Strong "entrepreneurial leadership" from progressive individuals and institutions, especially from inside DG CLIMA of the European Commission, could attract the support of a growing "green constituency" across the European Parliament, national governments, think tanks, and environmental NGOs and create an "entrepreneurial network" (+ on B_P). This, in turn, could be conducive to building up the needed expertise and momentum to overcome the opposition from more conservative units within the European Commission, such as DG AGRI (+ on B) (P1, R4).

Feasible Agri-ETS Pathway: Strong leadership from the European Commission as a "policy entrepreneur" could gravitate toward the development of a "green entrepreneurial network" building up the necessary expertise and momentum.

Moreover, the development of international climate and environmental regimes, such as the Paris Agreement can provide momentum. The "UNFCCC COP28 UAE Declaration on Sustainable Agriculture, resilient Food Systems, and Climate Action",[56] undersigned by an overwhelming majority of Parties, among them the European Union, was a first step in this direction (M2).

Traction can also be created by the public and political perception of the importance of sustainable food production as well as the importance of the agricultural sector for GHG emission reductions (P2, M2). However, while the political level has shown some intention for progressive movements recently (for instance as part of the 2023 "State of the Union Address" by European Commission President Ursula von der Leyen[57], the farmer's protests across Europe provide strong political backlash[58]. Yet, as interviewee P2 commented, there is a growing number of farmers that realize "how [much] climate change is impacting their own farm". In the end, the outcome of the 2024 European elections[59] will be a yardstick for the future political climate around progressive agricultural policy.

Feasible Agri-ETS Pathway: The "UNFCCC COP28 UAE Declaration on Sustainable Agriculture, resilient Food Systems, and Climate Action" could provide much-needed political momentum, however, a tense public and political climate around the transition toward progressive agricultural policy in the EU might create a backlash.

[56] See: https://www.cop28.com/en/food-and-agriculture (Accessed 1 June 2024).

[57] See: https://ec.europa.eu/commission/presscorner/detail/en/speech_23_4426 (Accessed: 1 June 2024).

[58] See, for instance: https://www.politico.eu/article/farmer-protest-europe-map-france-siege-paris-germany-poland/ (Accessed: 1 June 2024).

[59] See: https://elections.europa.eu/en/ (1 June 2024).

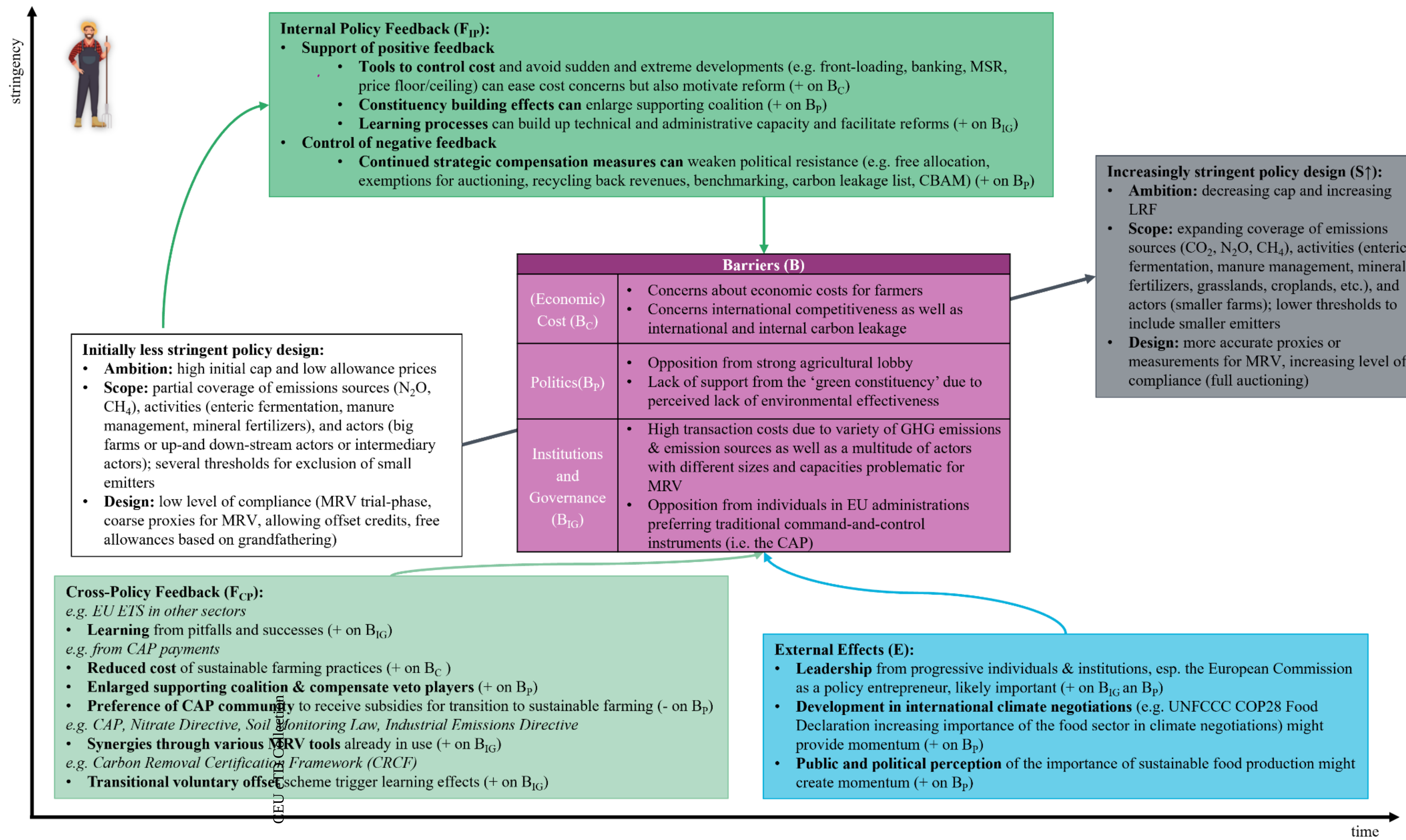

Figure 7 Schematic overview of **barriers (B)** to an EU ETS for agricultural GHG emissions as well as feasible policy sequencing options and feedback mechanisms (**internal (F_{IP})** and **cross-policy (F_{CP})**) that could help to overcome barriers and increase policy stringency over time. **External effects (E)** are also displayed (own illustration).

7 Conclusion and Recommendations

7.1 Summary

This master's thesis research aimed at contributing to the development of a regulatory framework that allows to overcome the barriers to an Emission Trading System (ETS) for agricultural GHG emissions at the EU level through a step-wise approach. The findings from the policy evolution of the existing EU ETS in other sectors suggest that a gradual phase-in of an EU ETS for agricultural emissions through *policy sequencing*, that is an increase in policy ambition, scope, and design could reflect the heterogeneity of actors and emissions sources and be conducive to reducing economic, political, and administrative barriers over time. For this, a combination of internal policy feedback and cross-policy feedback, as well as external processes and conditions can be leveraged by building on feedback mechanisms such as learning effects, tools to control costs, strategic compensation measures, and constituency-building effects.

However, while an incremental approach allows for gradual adaptation and learning, it can also lead to complacency and insufficiently ambitious policies. There is a risk that policymakers might settle for small gains without making the necessary substantial changes required for significant climate mitigation. Moreover, policy sequencing requires great care since differentiating policies could result in unintended consequences, such as internal leakage, leading to an increase in overall emissions. Therefore, early action is essential to achieve comprehensive coverage within a reasonable timeframe. Moreover, a clear roadmap to long-term policy objectives and clear indications that policymakers are committed to achieving uniform emissions pricing in the medium- to long-term is pivotal.

7.2 Practical Implications and Policy Recommendations

Internal Policy Feedback:

Policy Ambition:

- Combining an initial low policy ambition (e.g. through front-loading and banking) with a clear long-term reduction roadmap to climate neutrality in 2050 supported through price management measures (e.g. MSR, floor/ceiling prices) is essential to mitigate price volatility but also ensure environmental integrity.

Policy Scope:

- An initial particular coverage should focus on emissions sources and GHG emissions with a high mitigation potential, such as CH_4 and N_2O emissions from animal husbandry and mineral fertilizer ("the low-hanging fruits") as well as large farms above a certain threshold with comparatively high economic capacity as well as low transaction costs. This could create political buy-in and enhance the technical and administrative capacity of both regulators and farmers. As such, it would allow the expansion of the policy scope over time, which should follow a clear trajectory from the start to avoid perverse incentives.

Policy Design:

- (Initially) putting the point of obligation on up-stream (e.g. feed or fertilizer manufacturers and importers or distributors/vendors) or down-stream actors (e.g. meat and dairy processors or retailers) could significantly reduce the political barrier and decrease administrative complexity. By buying time to build up technical capacity this could also facilitate a gradual transition to a more encompassing farm-level compliance scheme. Alternatively, intermediate actors, such as industry associations, could be targeted for similar reasons.

- An initial MRV trial phase with reporting but no compliance obligations as well as a tiered approach to MRV accuracy (coarse proxy values → more exact proxies, measurements) could trigger learning processes, which will likely reduce transaction costs for both the regulator and farmers.
- Voluntary offset schemes have great potential for promoting the uptake of mitigation measures and changing the attitude of farmers towards climate-smart agriculture. As such, they might be the first step of the farming sector toward a more compelling whole-sector scheme. Yet, issues such as reversibility, additionality, and uncertainty about the reduction potential as well as perverse incentives need to be taken into serious consideration for a robust scheme and call for strong regulation.
- An initial free allocation of allowances could ease the transition for farmers and significantly reduce the political barrier. Over time, these free allowances should be phased out, potentially in a multi-speed approach across emission sources, GHGs, and actors, transitioning to auctioning. The generated revenues should be reinvested in the agricultural sector to drive innovation and support vulnerable farmers. To prevent carbon leakage the EU's CBAM could be extended to agricultural products. However, caution is needed to avoid negative lock-in effects and ensure a self-sustaining transition towards sustainable farming practices in the long-term.

Cross-Policy Feedback:

- While green CAP payments could reduce the cost of sustainable farming and enlarge a supporting coalition, the CAP community could also prevent an Agri-ETS uptake preferring subsidies for a green transition under the CAP.
- Moreover, synergies through various existing MRV tools under the CAP, the Nitrate Directive, the Soil Monitoring Law, and the Industrial Emissions Directive could be leveraged.
- Finally, the planned Carbon Removal Framework Certification (CRFC) could promote the Agri-ETS uptake through a voluntary offset scheme.

External Effects:

- Strong leadership from the European Commission as a "policy entrepreneur" could gravitate toward the development of a "green entrepreneurial network" building up the necessary expertise and momentum.
- The "UNFCCC COP28 UAE Declaration on Sustainable Agriculture, resilient Food Systems, and Climate Action" could provide much-needed political momentum, however, a tense public and political climate around the transition toward progressive agricultural policy in the EU might create a backlash.

7.3 Limitations and Recommendations for Future Research

Several limitations of this study must be acknowledged. One major limitation is the challenge of deriving lessons from the EU ETS to the European sector since it was the first of its kind and established under different temporal and sectoral conditions. Moreover, the agriculture sector differs significantly from the power sector in terms of the number of actors, economic vulnerability, and the need to integrate other sustainability issues such as biodiversity, water, and land management. Furthermore, other important issues for agriculture such as access to land, investments, and knowledge for the long-term sustainability of farming practices, are often beyond the scope of emissions trading schemes.

Future research is needed to define politically feasible thresholds that capture the largest farms while ensuring a high level of emissions coverage. Moreover, a key limitation of existing research is the lack of understanding of farmers' reactions to market-based climate policy instruments, as current models often assume profit-maximizing behavior, which may not be entirely accurate. Additional research is needed to understand how farmers adopt emission-reduction measures and to gather more data on mitigation potential and marginal abatement. The interaction of existing policy measures, such as direct payments and border tariffs, with emissions mitigation policies also warrants further investigation.

Finally, pricing alone is unlikely to be sufficient for driving the necessary changes, and a broader policy mix, including demand-side instruments to reduce consumption of animal products, should be considered. Embedding these strategies within a comprehensive policy approach can help farmers transition to sustainable agriculture. Future studies should also consider challenges related to individual behavior and response to economic incentives under uncertain conditions. Given the limitations of this research, it serves as a foundational basis for expanded studies on introducing an ETS for agricultural emissions, which can address the identified gaps and refine the proposed models and strategies.

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Appendix

Appendix I – List of (a) examined policy documents and (b) carbon market reports

a) List of examined policy documents

Time	Document	Author	Content
13 October 2003	Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 Establishing a Scheme for Greenhouse Gas Emission Allowance Trading within the Community and Amending Council Directive 96/61/EC	European Commission	Directive **establishing a scheme for greenhouse gas emission allowance trading within the Community (EU ETS)**
27 October 2004	Directive 2004/101/EC of the European Parliament and of the Council of 27 October 2004 Amending Directive 2003/87/EC Establishing a Scheme for Greenhouse Gas Emission Allowance Trading within the Community, in Respect of the Kyoto Protocol's Project mechanisms	European Commission	Linking Directive **allowing regulated entities to use emissions reduction credits generated under the Kyoto Procotol's CDM and JI to fulfill their obligation under the EU ETS**
19 November 2008	Directive 2008/101/EC of the European Parliament and of the Council of 19 November 2008 Amending Directive 2003/87/EC so as to Include Aviation Activities in the Scheme for Greenhouse Gas Emission Allowance Trading within the Community	European Commission	Directive **including domestic aviation into the EU ETS**
23 April 2009	Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009 Amending Directive 2003/87/EC so as to Improve and Extend the Greenhouse Gas Emission Allowance Trading Scheme of the Community	European Commission	Directive **to revise the EU ETS Directive for Phase-3**
24 December 2009	2010/2/: Commission Decision of 24 December 2009 determining, pursuant to Directive 2003/87/EC of the European Parliament and of the Council, a list of sectors and subsectors which are deemed to be exposed to a significant risk of carbon leakage (notified under document C(2009) 10251)	European Commission	Commission Decision **to establish a "carbon leakage list"**
3 November 2010	2010/670/EU: Commission Decision of 3 November 2010 Laying down Criteria and Measures for the Financing of Commercial Demonstration Projects That Aim at the Environmentally Safe Capture and Geological Storage of CO 2 as Well as Demonstration Projects of Innovative Renewable Energy Technologies under the Scheme for Greenhouse Gas Emission Allowance Trading within the Community Established by Directive 2003/87/EC of the European Parliament and of the Council	European Commission	Commission Decision **to establish the New Entrant's Reserve (NER300)**

7 June 2011	Commission Regulation (EU) No 550/2011 of 7 June 2011 on determining, pursuant to Directive 2003/87/EC of the European Parliament and of the Council, certain restrictions applicable to the use of international credits from projects involving industrial gases Text with EEA relevance	European Commission	Commission Regulation **introducing restrictions for the use of CDM and JI credits**
21 June 2012	Commission Regulation (EU) No 601/2012 of 21 June 2012 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council (Text with EEA relevance)	European Commission	Commission Regulation **to specify MRV rules**
8 November 2013	Commission Regulation (EU) No 1123/2013 of 8 November 2013 on determining international credit entitlements pursuant to Directive 2003/87/EC of the European Parliament and of the Council Text with EEA relevance	European Commission	Commission Regulation **phasing-out the use of CDM and JI credits by 2020**
27 October 2014	2014/746/EU: Commission Decision of 27 October 2014 Determining, Pursuant to Directive 2003/87/EC of the European Parliament and of the Council, a List of Sectors and Subsectors Which Are Deemed to Be Exposed to a Significant Risk of Carbon Leakage, for the Period 2015 to 2019	European Commission	Commission Decision **to update the "carbon leakage list" for the period 2015 to 2019**
29 April 2025	Regulation (EU) 2015/757 of the European Parliament and of the Council of 29 April 2015 on the monitoring, reporting and verification of carbon dioxide emissions from maritime transport, and amending Directive 2009/16/EC (Text with EEA relevance)	European Commission	Regulation **to establish a system to monitor, report and verify emissions from maritime transport**
6 October 2015	Decision (EU) 2015/1814 of the European Parliament and of the Council of 6 October 2015 Concerning the Establishment and Operation of a Market Stability Reserve for the Union Greenhouse Gas Emission Trading Scheme and Amending Directive 2003/87/EC	European Commission	Decision **to introduce the Market Stability Reserve (MSR) and postpone the auctioning of 900 million allowances until 2019 ("backloading")**
14 March 2018	Directive (EU) 2018/410 of the European Parliament and of the Council of 14 March 2018 amending Directive 2003/87/EC to enhance cost-effective emission reductions and low-carbon investments, and Decision (EU) 2015/1814	European Commission	Directive **to revise the EU ETS Directive for Phase-4 in line with the EU's 2030 climate and energy framework**
19 December 2019	Commission Implementing Regulation (EU) 2018/2066 of 19 December 2018 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council and amending Commission Regulation (EU) No 601/2012 (Text with EEA relevance)	European Commission	Commission Regulation **to update MRV rules**
15 February 2019	Commission Delegated Decision (EU) 2019/708 of 15 February 2019 supplementing Directive 2003/87/EC of the European Parliament and of the Council concerning the determination of sectors and subsectors deemed at risk of carbon leakage for the period 2021 to 2030	European Commission	Commission Delegated Decision **to update the "carbon leakage list" for the period 2021-2030**

26 February 2019	Commission Delegated Regulation (EU) 2019/856 of 26 February 2019 supplementing Directive 2003/87/EC of the European Parliament and of the Council with regard to the operation of the Innovation Fund	European Commission	Commission Delegated Regulation **to specify the functioning of the Innovation Fund**
5 December 2019	Decision No 2/2019 of the Joint Committee established by the Agreement between the European Union and the Swiss Confederation on the linking of their greenhouse gas emissions trading systems of 5 December 2019 amending Annexes I and II to the Agreement between the European Union and the Swiss Confederation on the linking of their greenhouse gas emissions trading systems [2020/1359]	European Commission	Decision **to link the EU ETS with Swiss ETS**
9 July 2020	Commission Implementing Regulation (EU) 2020/1001 of 9 July 2020 laying down detailed rules for the application of Directive 2003/87/EC of the European Parliament and of the Council as regards the operation of the Modernisation Fund supporting investments to modernise the energy systems and to improve energy efficiency of certain Member States	European Commission	Commission Implementing Regulation **to specify the functioning of the Modernisation Fund**
19 April 2023	Decision (EU) 2023/852 of the European Parliament and of the Council of 19 April 2023 amending Decision (EU) 2015/1814 as regards the number of allowances to be placed in the market stability reserve for the Union greenhouse gas emission trading system until 2030	European Commission	Decision (EU) **to strengthen the Market Stability Reserve as part of the "Fit for 55" package**
10 May 2023	Directive (EU) 2023/959 of the European Parliament and of the Council of 10 May 2023 amending Directive 2003/87/EC establishing a system for greenhouse gas emission allowance trading within the Union and Decision (EU) 2015/1814 concerning the establishment and operation of a market stability reserve for the Union greenhouse gas emission trading system	European Commission	Directive to revise the existing EU ETS and **establish the ETS2 as part of the "Fit for 55" package and in line with the European Green Deal and the European Climate Law**
10 May 2023	Directive (EU) 2023/958 of the European Parliament and of the Council of 10 May 2023 amending Directive 2003/87/EC as regards aviation's contribution to the Union's economy-wide emission reduction target and the appropriate implementation of a global market-based measure	European Commission	Directive **to revise the EU ETS in the aviation sector as part of the "Fit for 55" package**
10 May 2023	Regulation (EU) 2023/957 of the European Parliament and of the Council of 10 May 2023 amending Regulation (EU) 2015/757 in order to provide for the inclusion of maritime transport activities in the EU Emissions Trading System and for the monitoring, reporting and verification of emissions of additional greenhouse gases and emissions from additional ship types	European Commission	Regulation **to include maritime transport activities in the EU ETS**
10 May 2023	Regulation (EU) 2023/955 of the European Parliament and of the Council of 10 May 2023 Establishing a Social Climate Fund and Amending Regulation (EU) 2021/1060	European Commission	Regulation **to establish a Social Climate Fund**

10 May 2023	Regulation (EU) 2023/956 of the European Parliament and of the Council of 10 May 2023 Establishing a Carbon Border Adjustment Mechanism	European Commission	Regulation **to establish a Carbon Border Adjustment Mechanism**
12 October 2023	Commission Implementing Regulation (EU) 2023/2122 of 17 October 2023 amending Implementing Regulation (EU) 2018/2066 as regards updating the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council	European Commission	Commission Implementing Regulation **to update MRV rules**

Legend: Legislative acts are color-coded respective to the EU ETS trading phase they adhere to (**Phase-1 & Phase-2**; **Phase-3**; **Phase-4**)

Note: In the EU, there are different types of legal acts: A "**regulation**" is a binding legislative act, which must be applied in its entirety across the EU and does need not be transposed into national legislation. A "**directive**" is a legislative act that sets out a goal that EU countries must achieve, however, it is up to the individual countries to devise their own laws on how to reach these goals. A "**decision**" is binding on those to whom it is addressed (e.g. an EU country or an individual company) and is directly applicable. (Source: https://european-union.europa.eu/institutions-law-budget/law/types-legislation_en).

b) List of examined carbon market reports

Time	Document	Author	Content
8 March 2000	Green Paper on Greenhouse Gas Emissions Trading within the European Union	Commission of the European Communities	Green Paper to stimulate discussions on greenhouse gas emissions trading within the European Union, and on the relationship between emissions trading and other policies and measures to address climate change
14 November 2012	REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL. The state of the European carbon market in 2012 (COM/2012/652 final)	European Commission	Report on the functioning of the European carbon market in 2012
17 December 2018	REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL Report on the functioning of the European carbon market (COM/2018/842 final)	European Commission	Report on the functioning of the European carbon market in 2017
31 October 2023	REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL on the functioning of the European carbon market in 2022 pursuant to Articles 10(5) and 21(2) of Directive 2003/87/EC (COM/2023/654 final)	European Commission	Report on the functioning of the European carbon market in 2022

Legend: Carbon market reports acts are color-coded respective to the EU ETS trading phase they adhere to (**Phase-1 & Phase-2**; **Phase-3**; **Phase-4**).

Appendix II – List of interviewees

Stakeholder	Identifier	Description	Date	Duration
Research	R1	Professor, Tilburg University	Friday, 1 September 2023	48 min
	R2	University Professor	Wednesday, 6 September 2023	58 min
	R3	Executive Scientific Collaborator, ETH Zürich	Friday, 8 September 2023	36 min
	R4	Senior fellow at think tank	Thursday, 14 September 2023	84 min
	R5	Researcher, Joint Research Center, European Commission	Friday, 15 September 2023	50 min
	R6	Head; Partnerships Director World Research Institute, UK; Food and Land Use Coalition (FOLU)	Monday, 18 September 2023	23 min
EU Policymaker	P1	Former civil servant, European Commission Associate Researcher, School of Transnational Governance of the European University Institute	Thursday, 7 September 2023	64 min
	P2	Former senior civil servant, European Commission (co-developed EU ETS)	Tuesday, 12 September 2023	58 min
	P3*	Civil servant, European Commission	Tuesday, 12 September 2023	51 min
	P4*	Civil servant, European Commission		
	P5	Member of Parliament, Greens/EFA, Committee on Agriculture and Rural Development, European Parliament	Tuesday, 12 September 2023	51 min
Farmers' association	F1	Board member of Dutch farmers' association	Thursday, 7 September 2023	36 min
	F2	Coordinator, Boerenforum (Belgian farmers' association)	Thursday, 26 October 2023	48 min
	F3	Policy Officer on Climate Change and Biodiversity at European organic farmers' association	Friday, 22 September 2023	29 min
Industry	I1	Manager, Economic Affairs FoodDrinkEurope	Tuesday, 12 September 2023	33 min
	I2	Vice-President for Sustainability, Danish Crown	Friday, 15 September 2023	30 min
Environmental NGOs	E1	Policy Manager, European Environmental Bureau (EBB)	Thursday, 14 September 2023	39 min
Media	M1	Journalist, Euractiv	Friday, 15 September 2023	29 min

*interview was held jointly with both participants at the same time

Appendix III – Interview Guide

As described in **Section 5.2**, the interview guide was derived from the sequencing options and feedback mechanisms identified from the step-wise introduction of the EU ETS (RQ1) and further themes emerging from the theoretical and empirical literature analyzed for RQ2. The interview guide served as a guideline and was adapted depending on the stakeholder interviewed.

Introduction:

- Could you begin by describing your background and previous exposure to an ETS for agricultural emissions?
- Teaser: The development of the EU ETS shows that an initially less stringent policy design was able to decrease barriers to its implementation over time, and was, thus, conducive to a further ratcheting-up of policy stringency over several steps of policy evolution later on (policy sequencing). This suggests that a step-wise introduction of agriculture into an EU ETS could be a feasible pathway to overcoming seemingly unsurmountable barriers – Would you generally agree with this?

Interview Questions:

- **Barriers:** Do you think an EU ETS for agricultural emissions is a good idea?
  Where do you see key challenges for the introduction of an EU ETS for agricultural GHG emissions? Why has the sector been excluded so far?
  - Research/Think Tanks: challenges in general
  - Policymakers: political challenges
  - Farmers/farmer associations: challenges for farmers (on-farm level)
  - Industry: challenges for the industry (i.e. upstream and downstream)
- **Internal Policy Feedback:**
  - Policy Ambition:
    - *Cap:* What needs to be taken into consideration for the establishment of a cap? What time frame would be feasible for the introduction of a cap?
    - *Price management measures:* What role do price management measures, such as front-loading, banking, and a MSR, play?

<u>Policy Scope:</u>

- *<u>GHG coverage:</u>* What GHG emissions should be covered by an EU ETS for agriculture (CO_2, CH_4, N_2O)?
- What *<u>activities</u>* should be covered under an EU ETS for agricultural emissions? (i.e. enteric fermentation, manure management, fertilizer application, drainage of peatlands, burning crop residues, on-farm energy use, urea and liming application, rice farming)
  - *<u>Threshold</u>*: What could be a threshold for including/excluding farmers/actors into ETS coverage, i.e. size of land, size of revenues, etc.?
- *<u>Point of obligation</u>*:
  - Which *<u>actors</u>* should be covered under an EU ETS for agricultural emissions (e.g. farm-level, i.e. farmers, upstream, i.e. fertilizer and feed producers, downstream, i.e. food processors, other actors (e.g. retailers, consumers)?

- <u>Policy Design:</u>
  - *<u>MRV:</u>* What are key considerations for Measurement, Reporting and Verification (MRV), i.e. exact measurement vs. use of estimations or other measurement technology vs. hybrid (default proxy values with options to set up more accurate MRV to prove GHG emissions are lower?
  - *<u>Carbon removals:</u>*
    - Can mechanisms for rewarding good on-farm practices be integrated into an ETS? If so, how?
    - Should entities covered under an ETS be allowed to use carbon removals to meet their compliance obligations? If so, only on-farm, from other farms/other entities
  - *<u>Allowances:</u>* What needs to be taken into consideration for the allocation of allowances (auctioning vs. free allocation (grandparenting, proportional, output-based, land-based, or hybrid land- and output-based))?
  - *<u>Revenues:</u>* How should revenues raised from selling emission units be used?
- <u>Policy sequencing:</u> What do you see as a feasible sequence of ETS for agricultural emissions along the afore-mentioned ETS design features?
  - *<u>Economic costs:</u>* How could that mitigate negative impacts such as economic impacts on farmer's income?

  - *Economic costs:* How could that mitigate negative impacts such as carbon leakage (global competitiveness and trade balance)?
  - *Acceptability:* How could that increase the acceptance ("buy-in) of an EU ETS for agricultural GHG emissions (by farmers, the green constituency, and opposing government units)?
  - *Technical and administrative feasibility:* How could that make an EU ETS for agriculture more feasible from a technical and administrative perspective?
- **Cross-Policy Feedback:** How do you see the role of an ETS compared to existing legislation such as the LULUCF, the ESR regulation or the CAP (& now also the Carbon Farming Initiative? (Also taking into consideration the long time it will take to set up an ETS.) How can they be aligned?
- **External Effects**: What role do the following factors play in your opinion: leadership from the European Commission, development of international climate regimes, as well as public and political perception of the importance of sustainable food production

Conclusion:

- Is there anything else that should be taken into consideration when designing a step-wise introduction of an ETS for agricultural emissions in the EU? Or is there anything else you would like to add?

Appendix IV – List of relevant workshop participants

Stakeholder	Identifier	Description	Time spoken*
Research	Ra	Jonathan Verschuuren, Professor for European and international environmental law, Tilburg University	14:10.00
EU Policymaker	Pa	Alexandre Paquot, Director, Innovation for Low Carbon, Resilient Economy (DG CLIMA.C), European Commission	13:30:00
	Pb	Michal Pielke, Head of Unit, Economic Sustainability (DG AGRI.B.1), European Commission	13:50:00
	Pc	Christian Holzleitner, Head of Unit, Low Carbon Solutions (III): Land Economy & Carbon Removals (DG CLIMA.C.3)	16:55:00
Farmer's Association	Fa	Marion Picot, European Council of Young Farmers (CEJA)	14:31:00
Industry	Ia	Pierre-Marie Brizou, Danone (in charge of the company's activities on regenerative agriculture in Europe)	14:36:00
Environmental NGOs	Ea	Cécilia Nyssens-James, Senior Policy Officer for Agriculture and Food Systems, European Environmental Bureau (EEB)	16:05:00

*hour:minute:seconds

Appendix V – Consent Form

This form was sent to every participant prior to the interview and collected afterwards.

MESPOM Masters in Environmental Sciences, Policy and Management

CEU CENTRAL EUROPEAN UNIVERSITY

Exploring feasible pathways for the introduction of an ETS for agricultural GHG emissions in the EU

Sophie Röhrl

Department of Environmental Sciences and Policy, Central European University

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Information for participants

Thank you for considering participating in this study on exploring feasible pathways for the introduction of an Emission Trading System (ETS) for agricultural GHG emissions in the EU. The study takes place from June to October 2023. This document outlines the purpose of the study and provides a description of your involvement and rights as a participant.

1. What is this research about?

This research aims to explore feasible pathways for the introduction of an Emission Trading System (ETS) for agricultural GHG emissions in the EU. More specifically, learning from the existing EU ETS and accounting for the unique challenges and features of the agricultural sector, it examines key policy design criteria to be taken into consideration for a successful ETS in the agricultural sector.

2. What will my involvement be?

You are invited to take part in an interview discussing feasible pathways for the introduction of an Emission Trading System (ETS) for agricultural GHG emissions in the EU. The interview will last approximately 30-45 minutes and will be conducted online through Zoom.

3. What will my information be used for?

The collected information will be used for a dissertation to obtain a degree of MSc in Environmental Sciences, Policy, and Management jointly operated by Central European University, Lund University, the University of Manchester, and the University of the Aegean. The information may also be used for a publication in an academic journal or a policy brief.

4. Do I have to take part?

Your participation is voluntary. There are no negative consequences for you if you decide not to take part in this study. As an interviewee, you do not have to answer all the questions that are asked. You reserve the right to refuse or cease participation in the interview process without stating your reason at any stage of the research and may request to keep certain materials confidential (until September 30th, 2023).

5. Will my taking part and my data be kept confidential? Will it be anonymized?

The records from this study will be kept as confidential as possible. Only Sophie Röhrl and her supervisor, Prof. Aleh Cherp, will have access to the files and any recordings. Your data will be anonymized – your name will not be used in any reports or publications resulting from this study. All digital files transcripts, and summaries will be given codes and stored separately from any names or other direct identification of participants. Any hard copies of research information will be kept in locked files at all times. You have a right as a research participant to gain access to your own personal data, request its correction or deletion or limitation to processing of data as well as file a complaint about how your personal data is used at any stage of the research (until October 31st, 2023). All personal data will be deleted after a maximum of 10 years.

Limits to confidentiality: Confidentiality will be maintained as far as possible unless you tell something that implies that you or someone you mention might be in significant danger of harm and unable to act for themselves. In this case, relevant agencies may have to be informed of this, however, this would be discussed with you first.

6. Who has reviewed this study?

This study has undergone an ethics review in accordance with the CEU Ethical Research Policy: https://documents.ceu.edu/documents/p-1012-1v2201.

7. Data Protection Privacy Notice

The CEU Data Protection Policy can be found at: https://documents.ceu.edu/documents/p-1611-2v1705.

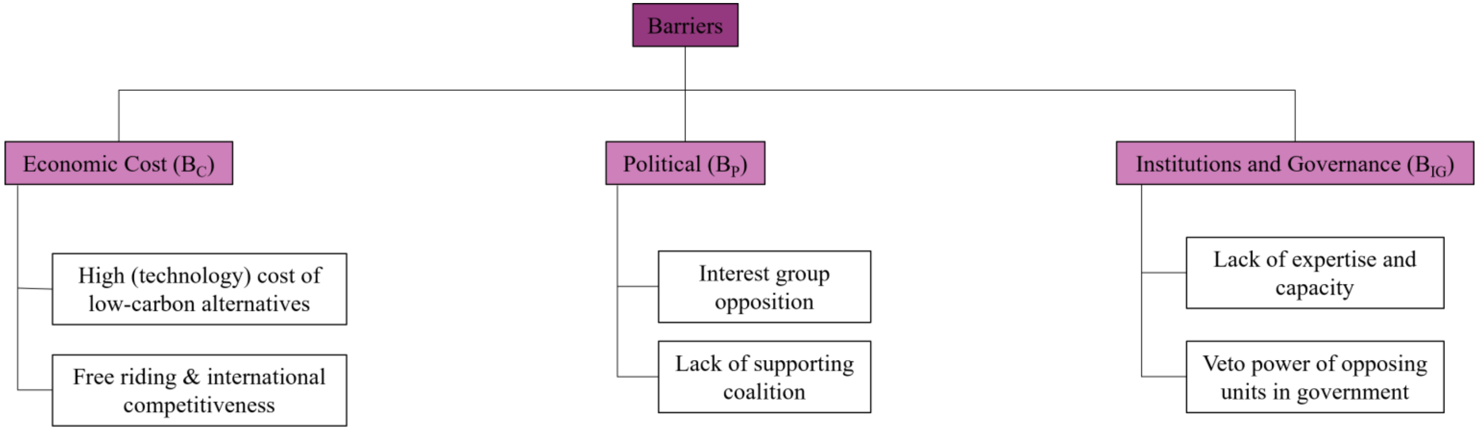
8. What if I have a question or complaint?

For any inquiries regarding this research, please contact the researcher:

Sophie Röhrl
MSc Candidate, Erasmus Mundus Joint Master's Degree in Environmental Sciences, Policy and Management (MESPOM)
Department of Environmental Sciences and Policy, Central European University
E-mail: sophie.roehrl@mespom.eu
Tel.: +49 177 4200245
Supervisor: Aleh Cherp (Cherpa@ceu.edu; aleh.cherp@iiiee.lu.se), Professor, Central European University

Appendix VI – Coding Framework for (a) barriers and (b) sequencing options and feedback mechansisms

(a) Barriers



(b) Sequencing options and feedback mechanisms