Analysis of the market demand mechanisms and the demand potential for land-based carbon credits

LIFE CarbonFarmingScheme

20/11/2020

Project Data
Project number: LIFE19 PRE FI/001 – SI2.828588
Project start date: 14/05/2020
Project end date: 13/05/2022
Total Project duration: 24 months
Project Website: https://www.st1.com/st1-life

Beneficiary Data
Beneficiary: North European Oil Trade Oy
Contact person: Aino Siirala
Postal address: PL 55, 00088 S Group
E-mail aino.siirala@neot.fi

CARBON FARMING SCHEME
LIFE Preparatory Project

Table of contents

Definitions

Carbon credit	A credit eligible to compensate one ton of CO_{2e}. The term is used for a credit granted from reducing, avoiding, or sequestering and storing emissions.
Carbon Farming	Nature-based practices performed in agriculture or forestry in order to sequester greenhouse gases from the atmosphere.
Compliance carbon market	System where a company can use carbon credits as mechanism that contributes to reaching legally binding climate targets
CRC	Carbon removal credit. A credit covering one ton of CO_{2e} removed from the atmosphere and stored.
$MtCO_{2e}$	Million tons of carbon dioxide equivalent
Voluntary carbon market	Market where parties such as companies and private persons can voluntarily offset their emissions by buying carbon credits. In a voluntary market carbon credits cannot be used to fulfil legally binding climate targets.

1 Introduction

This market analysis is produced as a part of LIFE preparatory project LIFE CarbonFarmingScheme “Expanding carbon sequestration activities by providing best practices and guidance for future carbon farming schemes" -project. The project aims to identify factors and incentives that can direct private sectors’ investments to carbon sequestration actions, where the project focuses on the demand from sectors mandated to GHG reductions. Also, the project conducts a pilot on actual carbon farming activities to gain understanding of onboarding of farmers and foresters and of incentives needed for carbon sequestration activities. As a final report of the project, we present guidance of regulatory and policy aspects towards implementation of an incentive scheme. This analysis is focusing to explain the size of the potential market and it will give basic information for the project work towards description of an incentive scheme.

This market analysis consists of two parts. Part I introduces the current state of the carbon markets by introducing nine carbon market systems and what we can learn from them. The price of carbon removal credits from European domestic projects is estimated in the end of Part I. Part II estimates the demand for carbon removal credits in the case where legislation would allow the use of carbon removal credits in fulfilling emission reduction obligations. By comparing the theoretical demand of carbon removal credits with the theoretical supply, we evaluate if the supply and demand could potentially meet in an EU wide carbon removal credit market. A case study of adding carbon removal credits to the Finnish climate policy on transport fuels is conducted in Part II.

Part I of this market analysis is based on literature review of nine carbon market systems. Part II is based on literature review on emissions and emission targets in the EU, and on internal workshops and discussions on how carbon removal credits could be implemented to legislation as a solution to fulfil part of emission reduction obligations.

PART I
EXISTING CARBON MARKET SYSTEMS

2 Introduction

Carbon offsetting and sequestration with different national, regional and global carbon market systems has been practiced for decades. In Part I we step into the different voluntary or compliance carbon market systems to understand how these systems are built and how they function.

We divide carbon markets to two categories: voluntary markets and compliance markets. Compliance market is defined as a system where a company can use a Carbon Removal Credit (CRC) as a mechanism that contributes to reaching legally binding climate targets. For example, in an emission trading system where some legal entities have GHG obligations, they could use CRC, to a certain extent, for compliance. Typically, it would happen if that was economically feasible (e.g. CRCs are cheaper than actions to reduce GHG emissions resulting from own operations), or if that was the only measure left (e.g. further GHG reduction is technically not possible). On the other hand, to increase technical or nature-based carbon sinks on a large-scale, e.g. through carbon farming, a substantial and long term financing is needed. This Project aims to study and test if a substantial private financing to carbon farming, or to any other nature-based carbon sinks in general, could be mobilised through a creation of a compliance market, i.e. by allowing companies to fulfil their legal climate obligations with CRCs.

In voluntary markets, where entities cannot fulfil any legal obligations with CRCs, the incentive is to, for example, decrease carbon footprint or reach voluntary company-specific sustainability target or the incentive is purely marketing-driven. There are also mechanisms for private persons to diminish or offset their carbon footprint with CRCs provided by airlines to their customers, for example. Some countries are implementing their climate and energy policy with programs that aim to reduce GHG emissions via voluntary programs, which partly / totally concentrate on biological carbon removals. According to I4CE (2019) there are currently twelve (12) active voluntary carbon market systems in Europe. There are also plenty of initiatives and projects ongoing in Europe that are testing and supporting future carbon sequestration activities.

Based on the experiences from several voluntary carbon market systems, there are interested potential buyers in the voluntary markets. However, it is worth mentioning that it is still a long way from the willingness to buy until the final decision on buying CRCs is made on voluntary basis. One of the biggest problems is that without a clear and commonly approved standard to set rules for methods in carbon farming, customers are unable to compare CRCs offered by different marketplaces or resulting from different projects. A risk for double counting, ie. same offsets are being sold and used multiple times, is tangible. The lack of common rules, covering Nationally Determined Contributions (NDCs), in compliance markets as well as voluntary markets, may lower the potential buyers' trust in any CRCs. A commonly approved standard is therefore needed in the field. This problem shall be addressed as the EU Commission is devising a carbon removal certification mechanism, and in summer 2020 organized a tender (2020/S 125-305336) for finding support in the design process.

3 Existing carbon market systems

This section analyses the nine (9) carbon market systems listed below

- Cap-and-trade program - California
- Carbon Farming Initiative - Australia
- KliK Foundation - Switzerland
- Label Bas-Carbone - France
- New Zealand Emissions Trading Scheme – New Zealand
- Nori
- Registro de huella de carbono - Spain
- Woodland Carbon Code - United Kingdom
- Puro.earth

The following predefined questions were set as a basis of the analysis:

1. What is the basic description of the different systems?
2. How these systems solve problems such as permanence, additionality, and carbon leakage?
3. Have there been any other fundamental problems with the systems that have resulted in the climate benefits not being as expected?
4. Financing model for carbon sinks projects approved by the schemes: are carbon sinks paid ex-ante or ex-post or a hybrid model and has the financing principle caused any fundamental problems?

The links presented above and other public sources available in English were used as a material in the analysis. The methodology is based on qualitative analysis of information acquisition.

3.1 Short descriptions of the systems

This subsection provides a short description of the nine systems studied. Figure 1 shows the starting year of the carbon market systems in a timeline. Table 1 presents the key information of the carbon market systems.

Figure 1 Timeline of the starting year of the studied carbon market systems

Table 1 Key information on the studied carbon market systems

Carbon market system	Project sectors included	Compliance/ voluntary	Starting year	CRC volumes
California – Cap-and-Trade	transportation, electricity, industrial, agricultural, waste, residential and commercial sources	Compliance	2013	12 $MtCO_2$ used, 127 $MtCO_2$ issued
Australia - Carbon Farming Initiative	Waste management, vegetation management, transport, mining, oil and gas, energy efficiency actions and agriculture	Voluntary	2011	52.7 $MtCO_{2e}$ delivered, 140 MtCO2e still to be delivered
Klik Foundation	Transportation, Businesses, Buildings and Agriculture	Compliance	2013	9.6 $MtCO_2$
Label Bas Carbone - France	Until now, forestry (afforestation, coppicing, and restoration) and agriculture	Voluntary	2018	No volumes yet
New Zealand – Emissions Trading Scheme	Forestry	Compliance	2008	28.6 $MtCO_{2e}$
Nori	Soil carbon project in agriculture.	Voluntary	2017	13.5 tCO_{2e}
Registro De Huella De Carbono - Spain	Afforestation and reforestation	Voluntary	2014	123 590 tCO_{2e}
Woodland Carbon Code - United Kingdom	Afforestation	Voluntary	2011	Current projects will deliver 6.3 $MtCO_{2e}$ during their 100 years' lifetime 100
Puro.Earth	Biochar, Carbonated Building elements, Wooden building elements	Voluntary	2019	10 084 tCO_2

California – Cap-and-Trade program

In 2006, an emissions trading scheme was established in California to guide the state's climate and energy policies. It was initiated in 2012, and the program started its first compliance period in January 2013. To improve how the state addresses air quality, the California Legislature in 2017 included in its extension of Cap-and-Trade a program to further reduce local air pollution. Since 2014, entities participating have been able to use offsets up to 8% of their obligations with only

domestic projects. Offset credits are greenhouse gas (GHG) emission reductions or sequestered carbon that meet regulatory criteria. Most of the offset credits issued are from forest projects.

Carbon Farming Initiative - Australia

The Carbon Farming Initiative was a voluntary carbon scheme that ran between September 2011 and December 2014 when it was integrated with the Emissions Reduction Fund (ERF). Carbon Farming Initiative projects automatically became an ERF project. The Emissions Reduction Fund (ERF) was established in 2014 and it is the Australian Government's one central climate change policy tool.

Under the crediting mechanism, the ERF issues Australian Carbon Credit Units (ACCUs) to businesses, community organizations, local councils, individuals, and others that successfully undertake an emissions reduction project registered with the Clean Energy Regulator (CER). An ACCU represents one ton of carbon dioxide equivalent (tCO_{2e}) stored or avoided by a project. There are currently 37 approved methods under which projects can be registered in agriculture, energy efficiency, facilities, mining, oil and gas, transport, vegetation management, savanna fires, waste and wastewater management.

KliK Foundation

The KliK Foundation for Climate Protection and Carbon Offset (KliK) has been established as a sector-wide carbon offset grouping for fossil motor fuels. KliK fulfils their legal obligation to offset part of the CO_2 emissions resulting from the use of fossil motor fuels in Switzerland. The KliK Foundation currently funds domestic projects that generate offset credits based on a Swiss carbon standard.

The KliK Foundation supports carbon offset projects within four platforms - Transportation, Businesses, Buildings and Agriculture. As of yet, no carbon removal projects in agriculture sector have been found or indicated.

Label Bas Carbone - France

French Label Bas-Carbone (The Low-Carbon Label) is led by the Ministry for the Ecological Transition (Ministère de la Transition Ecologique et Solitaire). It is the first voluntary verification system in France. The scheme is described as a certified project that contributes in an additional way to climate change mitigation. Private actors or public structures can voluntarily offset their greenhouse gas emissions by financially supporting environmental services (low-carbon actions) in forest management in France. Technical methods are proposed to the ministry in charge of environment reference scenarios, which approves them. In accordance with a method, local projects can be submitted and approved by the Ministry for the Ecological Transition. Methods can cover changes in practices, the introduction of new technologies, changes in systems, behavior or any other action that makes it possible to accelerate low-carbon transition. Label Bas Carbone provides a transparent framework for guaranteeing the integrity of carbon reduction projects. Environmental integrity is ensured through the utilization of standardized methodologies in line with the overarching rules set in the regulation.

New Zealand – Emissions Trading Scheme

New Zealand's Emissions Trading Scheme was founded to enable New Zealand to meet its obligations under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. According to the scheme, compensation is given to forest owners for carbon sinks. Repayment is required when carbon is released back into the atmosphere. Forests that have been

planted before the year 1989 can be attached to the system voluntarily, and after the year 1990 planted forests are automatically part of the system.

New Zealand's emission trading system is a combined system. All sectors of the economy must report to the Government on their annual greenhouse gas emissions. These sectors are forestry, agriculture, waste, synthetic gases, industrial processes (including manufacturers of iron and steel), liquid fossil fuels (including petrol and diesel suppliers), and stationary energy (such as electricity generation and industrial heating). All sectors apart from agriculture have surrender obligations as well as reporting obligations. Just over 50% of New Zealand's greenhouse gas emissions are covered by surrender obligations. The agriculture sector was responsible for around 48% of emissions in 2017. The Government consulted on options to reduce agricultural emissions and made decisions in late 2019.

Nori

Nori platform guarantees Nori Carbon Removal Tonne (NRT) buyers that they are buying verified, quantified CO_{2e} removals from the atmosphere with the retention of the removed carbon in a terrestrial reservoir for at least 10 years. Nori is a private sector company which aims to create a platform that makes it easy to fund carbon removal.

Nori partners with COMET-Farm, a team funded by the USDA and Colorado State University, in modelling the amount of removed carbon by comparing their sustainable practices to their previous farming methods.

Registro de huella de carbono - Spain

Spain has had a national level emission trading scheme since 2014 under the authority of states Environment Ministry. The Registro de huella de carbono is a public platform consisting of three sections. One section enables organizations (private or public) to calculate their carbon footprint and monitor their reduction. Second is a phase where forestry projects sequestrating CO_2 are registered and third is a public registry of organizations offsetting their carbon footprints. Methodologies are based on the afforestation/reforestation which includes restoring forest areas degraded by fires. Duration of projects is minimum of 30 years.

Woodland Carbon Code - United Kingdom

The UK Woodland Carbon Code is a woodland planting initiative for carbon sequestration through a voluntary standard. It was initiated in July 2011 for woodland creation projects sequestering carbon. The Code sets out how to plant and manage woodlands, and how to robustly measure, report, verify and govern the resulting sequestration. As a reward, landowners receive voluntary emissions credits that can then be sold through the Woodland Carbon Code Registry to companies/private individuals to offset their emissions. It was managed by the UK Forestry Commission until March 2019, and now it is managed by Scottish Forestry on behalf of all the forestry authorities in the UK. There have been 187 projects covering by estimate of 8,261 hectares which have been validated.

Puro.earth

Puro.earth is a voluntary commercial marketplace based in Finland. Currently, Puro.earth offers three methodologies for carbon removal and storage: biochar, carbonated building elements, and wooden building elements.

3.2 Financing models

California Cap-and-Trade and **New Zealand Emissions Trading Schemes** are both emission trading schemes where carbon removals can be used to offset emissions and therefore to fulfil legal obligations. In California, the average price of California Carbon Offset (CCO) is generally lower than California Carbon Allowances (CCA) making of carbon credits a cost-effective way for entities to comply with their obligations. In New Zealand, the price of a New Zealand emission unit is equal for both carbon removals and offsets at a given time.

Carbon Farming Initiative - Australia

The scheme is an integrated component of Australia's government's policy tool Emissions Reduction Fund (ERF). The price paid by the ERF for carbon stored or reduced in average is 12.4 AUSD2 (equivalent to 7.6 EUR). The price for ACCUs advertised on the national voluntary market is 15.22 AUSD (equivalent to 9.6 EUR) which is a slightly higher than the price paid by the ERF.

In 2014, the Australian Government made an investment worth $2.55 billion so the system would hold availability of ACCU units to be purchased for over a period of ten years.

KliK Foundation

Mineral oil companies pay the costs that are created within the scheme.

Label Bas Carbone - France

Ex-ante is allowed for forestry methodologies and ex-post for agriculture. The Label Bas Carbone is result-based, which means that teh project developers receive 1 "credit" per tCO_2 sequestered/avoided. The reward is paid at the end of the 5-year project period, upon verification (i.e. ex-post).

The price of emission reductions is not framed by the Label Bas Carbone. It is the result of an over-the-counter (OTC) negotiation between the project leader and the buyer. The price can depend on many factors. As an indication, it is recommended that project promoters assess the costs related to the implementation of the project as well as the volume of emission reduction expected in order to determine an acceptable minimum price.

Woodland Carbon Code - United Kingdom

The current market is split between the sale of projected and actual units of sequestered carbon. The sold units are currently Pending Issuance Units (PIUs) – these relate to estimates of future carbon sequestration and have formed the majority of the market to-date, principally providing funding to support woodland establishment on the back of Corporate Social Responsibility (CSR) driven investment. Woodland Carbon Units (WCUs) relate to actual carbon sequestered following a verification process. Carbon removals shall only be reported, or used, after carbon is sequestered and verified (i.e. Woodland Carbon Units) in accordance with guidance. This is sometimes called ex-post reporting.

Woodland uses the credits ex-ante and post-ante. The Woodland Carbon Code is results-based structure i.e. landowners receive voluntary carbon credits for each of the sequestered carbon, which can then be sold to buyers as a voluntary offset for their emissions. Landowners will receive credits ex-ante in the form of PIUs, which they can sell to buyers, or they can sell the credits once verified at a later date. As the expected sequestration is verified, the registry will convert these into verified WCUs, which the buyer can then use to offset their own emissions. Once an entity founds carbon

units, they would like to buy they are mandated to agree a price with the project developer and pay for units. The price varies, depending upon the costs of creating and managing the woodland and the range of benefits that it provides. Within the UK, companies are paying between £7 and £20 /tCO_2 for purchases of PIU. Only a small number of verified WCUs have been sold. Woodland Carbon Guarantee fund was launched in 2019 for the next 30 years with a budget of 50M£.

Puro.earth

Trading is done with verified CORCs and the price is set by the producer. Puro.earth issues CORCs ex-post after the production volumes and emissions have been measured, recorded, and verified by the independent 3rd party auditor. The stringent verification based on ex-post metrics has been highly valued by the buyers. Puro has not seen that any eligible project complying with Puro.earth methodologies would not have joined because of ex-post. Puro.earth does not have a mechanism for pre-commitments and pre-purchases for projects that are in the planning phase and will be operational in the coming years. The contracts can be made before hand, but the actual CORC issuance is done only when the production can be verified.

3.3 Links to national climate targets and systems

Some of the studied carbon market systems allow fulfilling legal emission reduction obligations with CRCs. CRC use can be limited. One examined system (KliK) is founded solely to compensate emissions from transport. In voluntary systems no possibilities were found to compensate any entity's legal obligations. However, some of the voluntary systems were founded and maintained by national authorities. It is notable that EU climate and energy regulations strongly limit compensation possibilities between ETS, Efforts Sharing and LULUCF sectors. Member states can use flexibility if they have stricter climate change mitigation targets than EU obligations.

California – Cap-and-Trade program

The emissions trading scheme was established to guide California's climate and energy policies. Now that cap and trade has been implemented in California the responsibility of the scheme has been allocated to California Air Resources Board (CARB). The system works on regularly basis evaluating and updating the program. California has initiated regulatory updates as needed roughly every two years since the original regulation was approved. This process allows California to maintain regulatory certainty while providing a dynamic program that adapts to current needs. To improve how the state addresses air quality, the California Legislature in 2017 included in its extension of cap and trade a program to further reduce local air pollution. Since 2014, entities participating can use offsets up to 8% of their obligations with only domestic projects.

In this scheme, offsets used as a tool to meet state emissions reductions target which is to return in 2020 to 1990 emissions level and in 2030 reduce GHG emissions of 40% comparing with 1990 levels. The system started in 2013 with a cap of 162.8 $MtCO_{2e}$. With the program expanding to include fuel distribution, the cap rose to 394.5 $MtCO_{2e}$ in 2015. From 2015 through 2020, the cap declines by about 12 $MtCO_{2e}$ each year, reaching 334.2 $MtCO_{2e}$ in 2020. The cap decline factor averaged 3.1% per year in the second compliance period (2015-2017) and 3.4% in the third compliance period (2018-2020). During the period 2021-2030, the cap declines are estimated to be about 13.4 $MtCO_{2e}$ each year, reaching 200.5 $MtCO_{2e}$ in 2030. The cap decline factor averages 5.0% during this period. The 'Cap-and-Trade Regulation' sets a formula for declining caps through 2050.

Carbon Farming Initiative - Australia

The Carbon Farming Initiative was a voluntary carbon scheme integrated with the Emissions Reduction Fund (ERF). Carbon Farming Initiative projects automatically became an ERF project. The Emissions Reduction Fund (ERF) is the Australian Government's one central climate change policy making tool. Two regulation acts create the foundation for the system, Carbon Farming Initiative Act 2011 and the Carbon Credits (Carbon Farming Initiative) Rule 2015. The Carbon Farming Initiative (CFI) worked as a carbon offset scheme that credited emissions reductions from certain uncovered sources, such as forestry and agriculture.

ERF issues Australian Carbon Credit Units (ACCUs) to businesses, community organizations, local councils, individuals, and others that successfully undertake an emissions reduction project registered with the Clean Energy Regulator (CER). Projects registered with the CER must comply with methods developed by the Department of the Environment and Energy and approved by the Minister.

KliK Foundation

The Swiss CO_2 Law, which underwent a complete revision as of 1 January 2013, states that by 2020, Swiss greenhouse gas emissions must be reduced by at least 20% or 10.5 million tons below their 1990 levels. One of the legal provisions to reduce emissions is an offset obligation for fossil motor fuels, according to which between 2013 and 2020 on average 5% of CO_2 emissions resulting from the use of fossil motor fuels must be offset.

The KliK Foundation for Climate Protection and Carbon Offset (KliK) has been established as a sector-wide carbon offset grouping for fossil motor fuels. The KliK Foundation currently funds domestic projects that generate offset credits based on a Swiss carbon standard. KliK fulfils their legal obligation to offset part of the CO_2 emissions resulting from the use of fossil motor fuels in Switzerland.

The KliK Foundation funds carbon offset projects that may be imputed according to the stipulations of the Swiss CO_2 Law. It acquires attestations that are issued by the Swiss Federal Office for the Environment (FOEN) for emission reductions stemming from such carbon offset projects.

Label Bas Carbone - France

Label Bas-Carbone is led by the Ministry for the Ecological Transition (Ministère de la Transition Ecologique et Solidaire). Part of the French Climate Policy toolkit The Label Bas Carbone sets up an innovative and transparent framework offering funding prospects for local projects to reduce greenhouse gas emissions. However, offsetting emissions is voluntary, and cannot be used to fulfil regulatory obligations.

New Zealand – Emissions Trading Scheme

New Zealand's Emissions Trading Scheme was founded on the basis of the Climate Change Response Act which was enacted in November 2002 to establish a legal framework that would enable New Zealand to meet its obligations under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. The government introduced the Climate Change Response (Emissions Trading) Amendment Act 2008. The cornerstone of this Act was the New Zealand Emissions Trading Scheme (NZ ETS) in December 2007. Scheme also includes a policy that the compensation is given to the forest owners as they are paid for carbon sinks. The repayment is required when carbon is released back into the atmosphere. The forest owners joined the system on voluntary basis. Forests that have been planted before the year 1989 can be attached to the system,

voluntarily or through mandatory basis, after the year 1990 planted forests are automatically part of the system.

Registro de huella de carbono - Spain

The scheme is under the authority of states environment ministry. The scheme is part of the Spanish climate policy tool kit to achieve national and EU-based compliances. Scheme includes the efforts of Spanish organizations in the calculation and reduction of greenhouse gas emissions generated by their activity. In turn, it facilitates the possibility of offsetting all or part of their carbon footprint, through a series of forestry projects located in the national territory.

Woodland Carbon Code - United Kingdom

The scheme was managed by the UK Forestry Commission until March 2019, and now it is managed by Scottish Forestry on behalf of all the forestry authorities in the UK.

3.4 Tackling the most common challenges

In public debate there are more suspicions than solutions to solve the challenges. The measures taken for ensuring additionality, permanence and carbon leakage were studied for each system in the subsections of this subsection. Other frequently discussed viewpoints and claims are (examples):

- It is too expensive to increase sinks (Forest owner: investment and maintenance costs in the beginning of the project, and the benefit comes after many years).
- Sink increasing measures limit loggings (forest industry).
- Sink calculations are inaccurate.
- How can it be assured, that sinks are permanent?
- CRCs are way to buy good conscience and leave emissions reductions undone elsewhere.

Other challenges published in (Finnish Government 2020) on the Californian Cap-and-Trade system and the New Zealand Emission Trading Scheme are introduced below.

California – Cap-and-Trade

The system has had its problems and the main one has been high transaction costs of participation within the scheme. The start-up cost can rise close to $ 100,000 for an individual project, and the cost per area will naturally decrease significantly as the size of the project increases. This has led to the California system involving mainly large projects; the average area of projects in 2005 was 4,000 hectares, and 80% of the projects were larger than 1,200 hectares. It is estimated that the size of the project must be at least 600 hectares to be profitable if the price of the carbon sink compensation is between $ 15 and $ 20. As a comparison, in Finland only 5% of forests are owned by forest owners owning more than 100 hectares.

New Zealand Emission Trading Scheme

Some of the most significant problems related to the scheme have been:

- Forests planted before 1990 were obligated to join the scheme. The information on this was leaked before the scheme started, which lead to large amount of forest felling and change of forest land to other use to avoid payment for future cuttings.
- Forests planted after 1989 can voluntarily join to the scheme. There is incentive to join the scheme only after fellings. Therefore, fellings might be done earlier to be able to profit from joining the scheme. Normally it is anyway profitable to grow forest without thinnings after

felling, which leads to carbon sink compensation with actions which would have been performed anyway.

- The low price of international CRCs and growing price of milk lead to significant deforestation during 2009-2011 due to the fear of low future price of carbon credits.
- The low price of emission allowances has not incentivized reforestation.

3.4.1 Additionality

California Cap-and-Trade:

In the California system, carbon sink units can only be obtained through additional carbon binding process. In all the cases there is a baseline which the actual carbon stock is compared to. The methods are approved by the CARB. The carbon stock is modeled using statistical methods, and the actual carbon stock is measured every 12 years. The difference between the modeled carbon stock and the baseline carbon stock is the basis for carbon sink units.

Compliance Offset Protocols serve as a cornerstone of the Compliance Offset Program to ensure that reductions are appropriately quantified, monitored, reported, and documented. Those protocols taken to the Board for adoption will consist of standardized methods that quantify reductions based on specific criteria and pre-established calculation methods. This approach streamlines the calculation of project baselines and determination of the additionality of projects by using standard eligibility criteria ensuring that the projects are additional. By establishing the standardized criteria in the Compliance Offset Protocol, there is less subjectivity by verifiers or offset project developers as to whether a project may be additional, and this supports consistent quantification rigor in the offset program.

Carbon Farming Initiative - Australia

The offsets integrity standards, set out in the CFI legislation Act, are designed to ensure that ACCUs are for genuine emissions reductions that are additional to business as usual. They include that abatement is evidence-based, able to be measured and verified, and contributes to Australia's international obligations. To ensure the integrity of the ERF, the Emissions Reduction Assurance Committee and the Ministry have to take the standards into account when making and reviewing methods. Additionality is one of the offset standards, designed to ensure the ERF encourages activities that would not have occurred anyway. It underpins the integrity and value of offsets.

The ERF additionality requirements also include 'regulatory additionality' and 'newness'. The regulatory additionality requirements are that the activity not be required by other government regulations or already supported by some government programs. The activity also needs to be new – it cannot have already started. In 2017, the Authority considered that these requirements were generally fit for purpose and appeared to be working reasonably well.

KliK Foundation

To determine baselines and the additionality of activities, pilots often build on CDM methodologies. For example, in its first public call for proposals in early 2019, the KliK Foundation preferred CDM methodologies for activities with programmatic character, while the Standardized Crediting Framework takes CDM methodologies as a basis, with simplifications for selected parameters. The observed pilots desire to both simplify the use of methodologies as well as to preserve, and in some

cases strengthen, environmental integrity. Given that not many specific baseline methodologies and additionality tests have been published by the Paris Agreement Article 6 pilot developers, it is not clear whether these aims can be reached at the same time. The final criteria for the safeguards and eligibility principles will be based on the Swiss CO_2 law revision. It is likely that they will not significantly deviate from the criteria agreed between the CCF and the Swiss.

Label Bas Carbone - France

The Label Bas Carbone targets to projects that reduce greenhouse gas emissions compared to the baseline situation. These projects must be additional, that is, go beyond regulation and current practice.

The methods specify for a given type of projects how the baseline scenario is to be determined and how the emission reductions associated with the projects are calculated. Demonstration and associated baseline determination can represent up to 50% of costs associated drafting projects documents when an "individualized" demonstration is required, while under the CDM, 65% of certification failures were due to an unconvincing additionality demonstration. We can highlight two procedures developed in Europe to lower additionality costs. The French Label Bas Carbone relies on a 'discount principle' in order to lower additionality demonstrations costs. The method developer has two options to set the baseline: require an individual baseline or allow for a regional or national baseline. The second option is easier to implement for the project developer but comes with a higher risk of windfall effect. Therefore, a discount is applied if this second less stringent option is chosen. Additionality is based on the idea of no negative impacts on environmental and economic stakes.

New Zealand – Emissions Trading Scheme

No additionality requirement (Look-up tables / FMA).

Nori

Nori uses a project-specific approach to determine additionality. Nori does not apply either financial or regulatory additionality tests except for an existing project which uses carbon removal methods. This means that a project is deemed to meet the Nori additionality test when a potential supplier adopts new land management or production practices or installs new technologies which are reasonably expected to remove incremental CO_2 from the atmosphere and retain the recovered carbon in a terrestrial reservoir for at least 10 years.

In essence, Nori's additionality test is incorporated in the method for defining the project baseline. If the new practices are an improvement over the project baseline scenario, they are considered additional. Nori will only issue NRTs representing incremental CO_2 drawdown and retention that arising from an activity or practice change that is reasonably expected (given the scientific evidence available at the time) to result in a net new CO_2 removal. Nori employs COMET-Farm's dynamic baseline, which makes it possible to control for weather and climate conditions.

Woodland Carbon Code - United Kingdom

The term additionality is used to mean the carbon sequestration over and above which would have happened anyway in the absence of a given project or activity. Buyers of carbon units want to know that their input has enabled more carbon sequestration than would otherwise have happened under existing legal, financial, and business circumstances. Under the financial consideration, a project is only 'additional' if it requires carbon income to turn it from a project which is not financially

viable/worthwhile (in its own right or compared to an alternative non-woodland use) to one which is financially viable. Additionality is also legal, either financial additionality or barrier additionality must be proven (could be social, legal). Co-benefits are based on Woodland Benefits Tool to assess the project outcomes for wildlife/community/water/ economy. There are four tests for additionality: legal test, contribution of carbon finance, investment, and barrier.

Puro.earth

Puro.earth underlines that the client (buyer) decides the additionality level of preference. Puro.earth certificates offer data for different additionality perspectives: commissioning date, first-of-a-kind installation, what will the CORC income be used for by the project.

A. Financial additionality: understood that by additional financing on this project made it happen. This is similar to project financing.
B. New installation: commissioning date to define additionality as an impact of new assets. Typically, a "cut year" for example only commissioned 6 years ago or newer qualify for my procurement.
C. Technological additionality: Only technology that is not yet mature, needs support for piloting is procured by a client (buyer). Supporting emerging technologies is a preference of additionality.

There was no information about additionality found in English for **Registro de huella de carbono – Spain**.

3.4.2 Permanence

Permanence is often considered by correction factors, which try to estimate the uncertainty which is related to forest fires etc. (estimated carbon sink – correction factors -> carbon removal credit).

California Cap-and-Trade:

If the project ends after the 25-year project period, the carbon stock must be maintained for at least 100 years. The scheme has a reserve, where 11-28% of CRCs are placed depending on the risk level of the projects.

Carbon Farming Initiative - Australia

At project registration, scheme participants nominate a permanence period of either 25 or 100 years for sequestration projects. Projects that nominate a 25-year permanence period are generally subject to a 20% discount on the number of ACCUs issued by the CER. Over 60% of contracted sequestration projects have nominated the 100-year permanence period.

The CFI legislation contains permanence arrangements so that if sequestered carbon is released within 100 years (for example, through fire), project proponents are obliged to either restore carbon stocks or hand back credits. A 5% risk of reversal buffer adjusts for the carbon that is temporarily lost before carbon stocks are restored and for carbon losses due to wrongdoing by the project proponent that are unable to be restored. The authority has not identified any specific problems with the permanence arrangements. Given that these arrangements manage the effects of events that might only occur infrequently, such as drought or fire, it is too early in the scheme to judge whether they will continue to work smoothly or whether the 5% risk of reversal buffer is set at the right level.

Label Bas Carbone - France

As most GHG reductions associated with CARBON AGRI are avoided emissions, there is low non-permanence risk. For farms that sequester carbon in biomass or soil (where non-permanence risk exists), a 20% discount is applied to their payments. Management of the risk of non-permanence in forestry methodologies is as follows: 10% to 25% discount is applied depending on the project risk level. Carbon Agri: a 10% to 20% discount is applied.

New Zealand – Emissions Trading Scheme

Calculated or measured via periodical reporting obligation. Compensation is given to the forest owners for carbon sinks. Repayment is required when carbon is released back into the atmosphere.

Registro de huella de carbono - Spain

Management of the risk of non-permanence scheme includes a buffer with a fixed rate of 10% of estimated carbon units. No other information was found in English.

Woodland Carbon Code - United Kingdom

To minimize risks of impermanence, landowners must identify and mitigate risks. They are required to restock if wood is harvested and replant if woodland is lost. They are also contractually obliged to manage their forest in accordance with their project plan. Initial carbon sequestration estimates are reduced by 20% to cover any modelling errors. In addition, all projects must contribute a further 20% of credits to the Woodland Carbon Code shared buffer. These cover any losses of verified credits over the project duration (which if drawn down must be replenished e.g. through replanting) and are then retired at the end of project life.

Puro.earth

Puro.earth guarantees a minimum of 50 years durability for any carbon removal (CORC). The actual permanence varies per removal method:

- carbonated building elements= permanent,
- biochar = hundreds of years, verified producers' laboratory results have varied between 600-1,500 years
- wooden building element = survey of housing in the United States found that more than half of wood-based housing stock was at least 80 years old (Winistorfer et al. 2005). In EU building permits is only granted if planned lifetime of the house is minimum 50 years

No information was found in English regarding permanence in **KliK Foundation** and **Nori**.

3.4.3 Carbon leakage

The topic has been debated mostly from the energy intensive industries point of view. When the mill is included to the ETS, it raises the production costs and weakens its competitiveness compared to the competitors, who do not have similar additional costs. In the worst case, production at an ETS-mill decreases or ends, meanwhile in a non-ETS-mill it increases. In EU ETS, this effect is tried to be minimized by free allowances and ETS compensation for energy intensive industry.

Carbon leakage can also happen in agriculture and forest sectors. If carbon removal decreases loggings somewhere, it can increase loggings somewhere else. This effect can be taken into account, for example, by correction factors, but in practise quantification of the factor is very complicated.

California Cap-and-Trade:

To take into account carbon leakage, reduction of 20% is made for forestry-based projects and 10-15% for reforestation projects.

Carbon Farming Initiative - Australia

According to Australian Climate Change Authority review, carbon leakage has been proven to be a difficult issue within the legal framework which guided the process of creating Australia's scheme back in 2011. In some instances, if a proponent sources additional water by securing newly acquired water from an in-stream water or groundwater water access entitlement or irrigation right, rather than irrigation efficiency savings, a potential carbon leakage risk arises. In some cases, such as fully allocated catchments, the entitlement may have been acquired from another irrigator resulting in displaced biomass growth. Although the project area in which the management action is undertaken will experience an increase in soil carbon, a different area of land outside of that project area may no longer be used to grow irrigated crops or pasture—potentially leading to a reduction in soil carbon that could offset project sequestration.

New Zealand – Emissions Trading Scheme

New Zealand's scheme focuses on economical carbon leakage which means that it is possible that some production that occurs in New Zealand will relocate to other countries as a result of the introduction of the ETS. New Zealand's government's website indicates that although some carbon leakage could occur, the magnitude would be small from a global viewpoint. It has been argued that it would be unwise for New Zealand to attempt to address leakage concerns through ETS design as this would risk increasing the overall economic cost that New Zealand faces to meet its international obligations but fail to secure any significant global environmental gain. Ultimately, the only effective solution to carbon leakage concerns is to improve the design of international agreements. From an environmental viewpoint according to New Zealand's government, the major way in which New Zealand can contribute to ameliorating the challenge that climate change poses is through encouraging effective international action, not through avoiding carbon leakage.

Puro.earth

Carbon leakage refers to the situation that may occur if production is transferred to other countries with laxer emission constraints. Puro.earth does not see that type of production transferring related to carbonated/wooden building element or biochar. In fact, if there is any transfer of business/production it is "positive" moving from traditional-emitting material to these new carbon-sequestering-materials. Regarding the forest biomass that can be used as eligible feedstock in biochar and wooden building elements manufacturing, Puro.earth requires that the wood comes from FCS/PEFC-certified forests that are sustainably harvested and regrown.

No information was found in English regarding carbon leakage in **KliK Foundation, Label Bas Carbone – France, Nori, Registro de huella de carbono – Spain** and **Woodland Carbon Code - United Kingdom.**

4 Price and cost of carbon sequestration

The price of CRC depends on many factors. Naturally, the price is formed in the market setting. However, the cost of carbon sequestration influences on the supply of CRC units, and if the price level of CRC is low compared to the cost of producing the CRC, then the supply will probably be low. The cost of producing a CRC includes the cost of the actions taken at the farm/forest, MRV and other costs that depend on the criteria and marketplace (e.g. fee for the market place or register holder).

According to the analysis of I4CE (2019) EU domestic carbon sequestration projects had a higher price than international projects. The weighted average price of carbon in the European domestic carbon standards was 13 EUR/tCO_{2e}, ranging from 6 to 110 EUR/tCO_{2e}. The average price on international markets was 4.6 EUR/tCO_{2e}, ranging from 0.4 to 72 EUR/tCO_{2e}. The European domestic price is based on nine European domestic carbon standards included in the I4CE analysis.

I4CE (2019) and a study ordered by the Finnish Ministry of the Environment (2019) identified the high cost of MRV (monitoring, reporting and verification) as one problem in the current European CRC market. Complicated, burdensome, and expensive processes related to MRV can be a barrier for market entry for farmers and foresters. Some carbon market systems have already implemented simplified and innovative ways to lower these costs, yet more solutions are still needed to be implemented to encourage the participation of all the projects with high potential on carbon farming.

PART II
DEMAND FOR CARBON REMOVAL CREDITS

5 Introduction

The aim of the part II is to estimate the demand for carbon removal credits (CRC) in the compliance markets in the European Union (EU). In this analysis compliance markets refers to the demand potential among the actors obligated to contribute to EU's emissions reduction targets under EU climate policy sectors: Emission Trading System (ETS), Effort Sharing Decision (ESD) and Land Use and Land Use Change (LULUCF). This analysis indicates the CRC demand potential in the case where legislation would allow the use of CRC in fulfilling emission reduction obligations in the mandated sectors would create.

Section 6 briefly introduces the current EU climate policy and the planned changes. Section 7 introduces the biggest emission and carbon sink sources in the EU, and their progress in achieving the EU climate targets. The carbon sink potential is also estimated in section 7.3. In section 8 the theoretical demand of CRC's is evaluated based on the policy framework and current prices for emission reductions. In subsection 8.6, the theoretical demand is compared with the theoretical supply to see if they could potentially be met. In section 9 a case study is conducted on adding CRC's to the Finnish climate policy on transport fuels. Finally, discussion and further questions are provided in section 10.

6 EU climate policy

The current EU climate policy divides emission sources into three sectors: EU Emissions Trading system (EU ETS), the Effort Sharing Decision (ESD), and the Land Use, Land Use Change and Forestry (LULUCF).

The Emissions Trading System covers power and heat generation, energy-intensive industry, and commercial aviation inside the European Economic Area (EEA). Emissions from flights from or to outside the EEA do not belong under the EU ETS, but from 2020 the aviation industry has committed itself to offsetting their emission growth covering other flights according to the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).

The ESD covers almost all other sectors excluded from the EU ETS, including road transport, heating and cooling of buildings, emissions from agricultural practices, and small industries. The LULUCF sector covers GHG emissions from land use, land use change and forestry. Carbon sequestered in the biomass or soil due to agricultural or forestry practices is currently calculated under the LULUCF sector's emissions balance. Figure 2 presents the sectors covered by EU ETS, ESD, and LULUCF, and the climate targets 2030 in each sector.

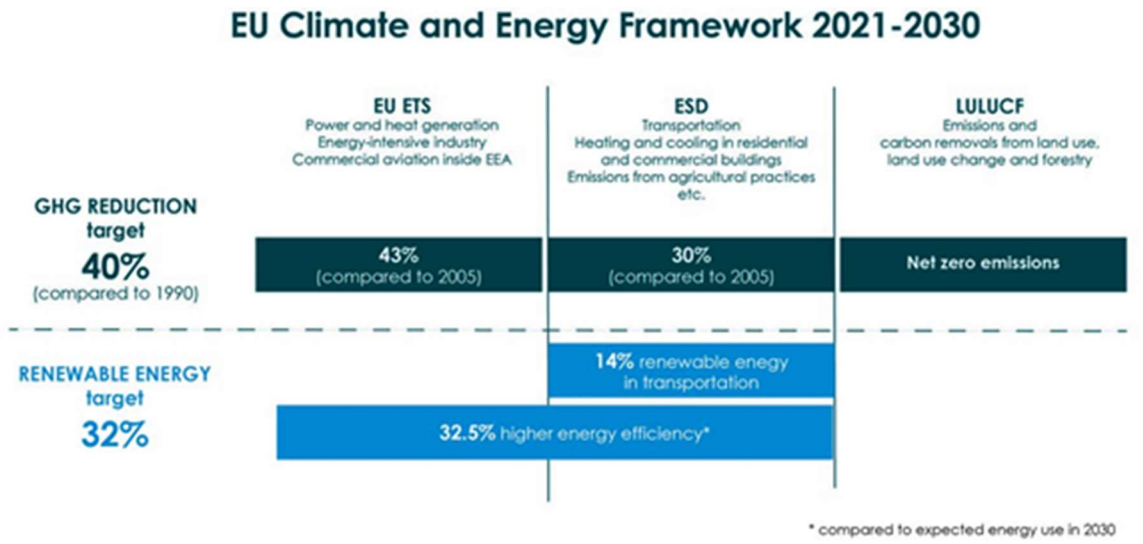


Figure 2 EU emission sectors and their climate targets for 2030

As presented in Figure 2, in addition to EU's overall emission reduction and renewable energy targets, each EU climate policy sector has its own emission reduction target. Furthermore, the transport sector has its own target for the share of renewable energy.

There is some flexibility between the sectors in fulfilling the emission reduction targets. The Effort Sharing Regulation allows nine Member States, Iceland, and Norway to offset 2-4% of their emissions in the ESD with emission allowances from the EU ETS sector in the period of 2021-2030. The maximum amount allowed to be offset with emission allowances in the ESD sector is 107 million tonnes of CO_2. Only the Netherlands and Sweden have stated that they will not use the flexibility option, so nearly all the 107 million emission allowances are available to be used in the ESD sector. (EC 2020a.)

Another flexibility option given in the Effort Sharing Regulation is the possibility to use the extra sequestered carbon in the LULUCF sector to offset up to 280 $MtCO_2$ in the ESD sector. Similarly like with the flexibility option between ESD and the EU ETS, the Effort Sharing Regulation gives a maximum amount of emissions to be transferred between the LULUCF and ESD sectors in each country.

6.1 Future path to climate neutrality

The EU Commission with the lead of Ursula Von Der Leyen has made a sustainable path with European Green Deal (EC 2019) to achieve climate neutrality by 2050 in European Union in proposal for the European Climate Law (COM/2020/80 final). The Commission presents an EU-wide, economy-wide greenhouse gas emissions reduction target of at least 55% by 2030 compared to 1990 including emissions and removals. And therefore, as communicated in the European Green Deal a review of a set of actions is required across all sectors of the economy. This will be done by revising all key legislative instruments to achieve increased ambition. Also, the Commission has assessed that by reinforcing and expanding emission trading tool to other sectors currently not included in EU ETS, EU can achieve climate ambition of 55% in an economically efficient manner. As announced, the Commission is evaluating whether the emissions of fossil fuel combustion from road transport and buildings could be included to revised emission trading and legal frameworks will be further developed in parallel. Similarly, the Commission will propose extending EU emission trading to the maritime sector and reducing the amount of free EU ETS allowances allocated to airlines in coordination with global organizations (airlines with the International Civil Aviation Organization and

maritime with International Maritime Organization). The Commissions view on the emission reductions and removals required to reach the climate neutrality target by 2050 are illustrated in Figure 3.

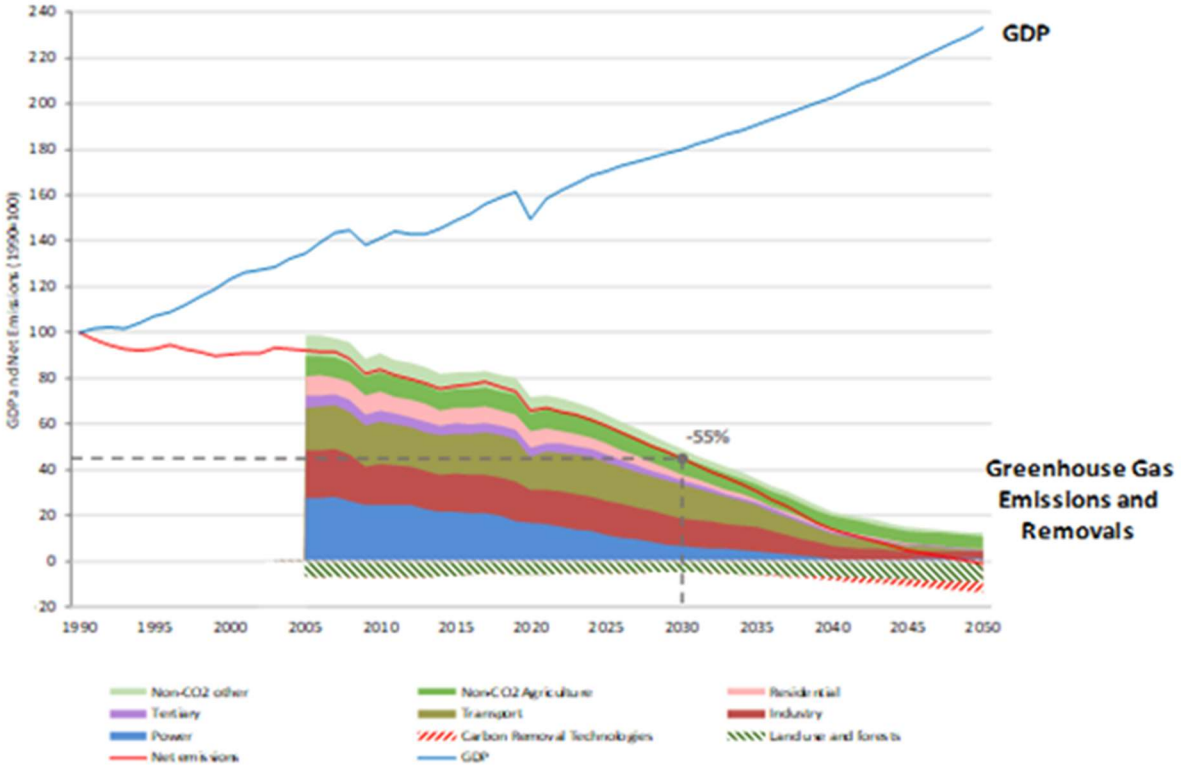


Figure 3 EU pathway to climate neutrality (EC 2020f)

7 EU emissions and emission reductions

This section introduces the biggest emission sources in the EU and evaluates the emissions and carbon sinks in each of the current EU climate policy sectors (ETS, ESD, LULUCF). The following points are analysed regarding each sector:

- Emissions and targets
- Projection on achieving the targets

The GHG emissions from the EU27 in 2018 were 3,893,095 million tonnes including international aviation and excluding LULUCF (EEA 2020a). Figure 4 shows the emissions by sector. Most of the EU's emissions come from fuel combustion, which can be divided into further uses. The biggest single emitting sector is the energy industries (26.1%), after which comes transport (including internal aviation) (24.6%). As can be seen from Figure 5, most of the emissions belong to the ESD sector. However, the EU ETS also covers a significant part of the EU's emissions.

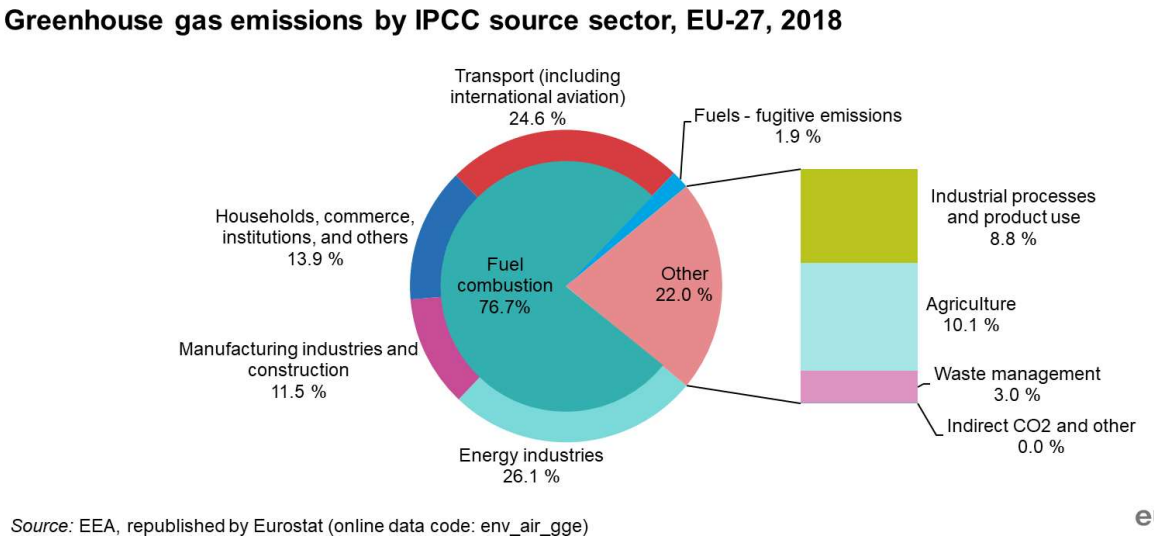
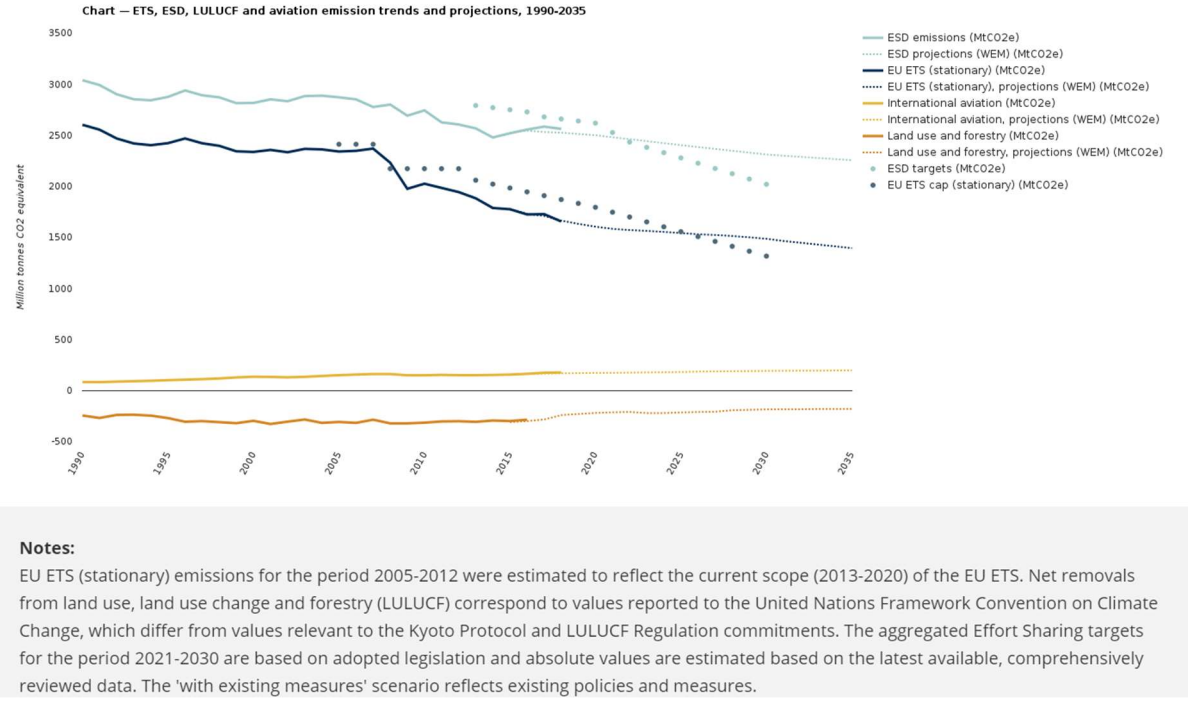


Figure 4 GHG emissions in EU-27 in 2018 by source sector



Notes:
EU ETS (stationary) emissions for the period 2005-2012 were estimated to reflect the current scope (2013-2020) of the EU ETS. Net removals from land use, land use change and forestry (LULUCF) correspond to values reported to the United Nations Framework Convention on Climate Change, which differ from values relevant to the Kyoto Protocol and LULUCF Regulation commitments. The aggregated Effort Sharing targets for the period 2021-2030 are based on adopted legislation and absolute values are estimated based on the latest available, comprehensively reviewed data. The 'with existing measures' scenario reflects existing policies and measures.

Figure 5 Progress on decreasing emissions in the EU by policy sectors (EEA 2019b)

To achieve the EU overall target of 40% reduction by 2030, the annual emission reduction will need to be 81 $MtCO_2e$ per year, on average, from 2017 until the target year of 2030. This is almost twice the rate until now (46 $MtCO_2e$ has been reduced since 2005). As Figure 5 indicates, at the moment it seems that the EU is not on track to achieve the 40% GHG emission reduction target nor the 32% renewable energy share target in 2030. According to the country projections submitted under the Monitoring Mechanism Regulation (MMR) and the additional policies and measures planned as of early 2019, overall emissions would be decreased only 36%. The EU ETS sector is projected to achieve the emission reduction target of 43% by 2030 compared with 2005 levels with the national

projections with additional policies and measures. However, reaching the ESD sector's target of 30% GHG reduction in 2030 compared to 2005 will require more stringent actions than what are planned. (EEA 2019a.) Table 2 presents a summary of the targeted emission levels in the EU ETS and ESD sectors and compares them with the projected emission levels in 2030. The targeted and projected emission levels are further introduced in subsections 7.1 and 7.2.

Table 2 Targeted and projected emission levels in EU ETS (EEA 2019b) and ESD (EEA 2020b) sectors in 2030. The projected emission levels are based on the existing and additional planned policies and measures reported by the member states under the Monitoring Mechanism Regulation.

Sector	Targeted emission level in 2030 ($MtCO_{2e}$)	Projected emission level in 2030 ($MtCO_{2e}$)	Additional measures required to meet the target level ($MtCO_{2e}$)
EU ETS	1,316	1,364	48
ESD	2,019	2,111	92
Sum	3,335	3,475	140

In addition to the difficulties in meeting the emission reduction target in the ESD sector, the transport sector is facing challenges in meeting the target on renewable energy share in transport. Until now, the growth of renewable energy in transport has been very slow. (EEA 2019a.)

Achieving all the targets for 2030 is challenged by the increasing final consumption of energy in recent years. The biggest energy consumption increase has been experienced in buildings sector (8.3% increase between 2014 and 2017) and in transport sector (5.8% increase in the same period). The target of decreasing energy consumption by 32.5% is not easy to achieve without member states adopting new policies and implementing additional measures. (EEA 2019a.)

7.1 EU Emission Trading System (ETS)

In the phase 3 of the EU ETS (2009-2012) the emission cap decreased 1.74% annually. In the phase 4 (2021-2030) the emission cap is reduced by 2.2% annually. This reduces the total emissions in the EU ETS sector to 1,316 $MtCO_{2e}$ in 2030.

Table 3 Targeted annual emission reductions in the EU ETS between 2020 and 2030 (EEA 2019b)

Year	Cap ($MtCO_{2e}$)	Decrease from previous year ($MtCO_{2e}$)
2020	1,794	
2021	1,746	48
2022	1,699	47
2023	1,651	48
2024	1,603	48
2025	1,555	48
2026	1,507	48
2027	1,460	47
2028	1,412	48
2029	1,364	48
2030	1,316	48

According to scenarios that consider planned measures, total reductions of 287 $MtCO_{2e}$ (14%) are projected in the EU ETS sector between 2018 and 2030. Projections based on additional measures taken to decrease emissions lead to emissions of 1,364 $MtCO_{2e}$ in 2030, which is 1.3 percentage

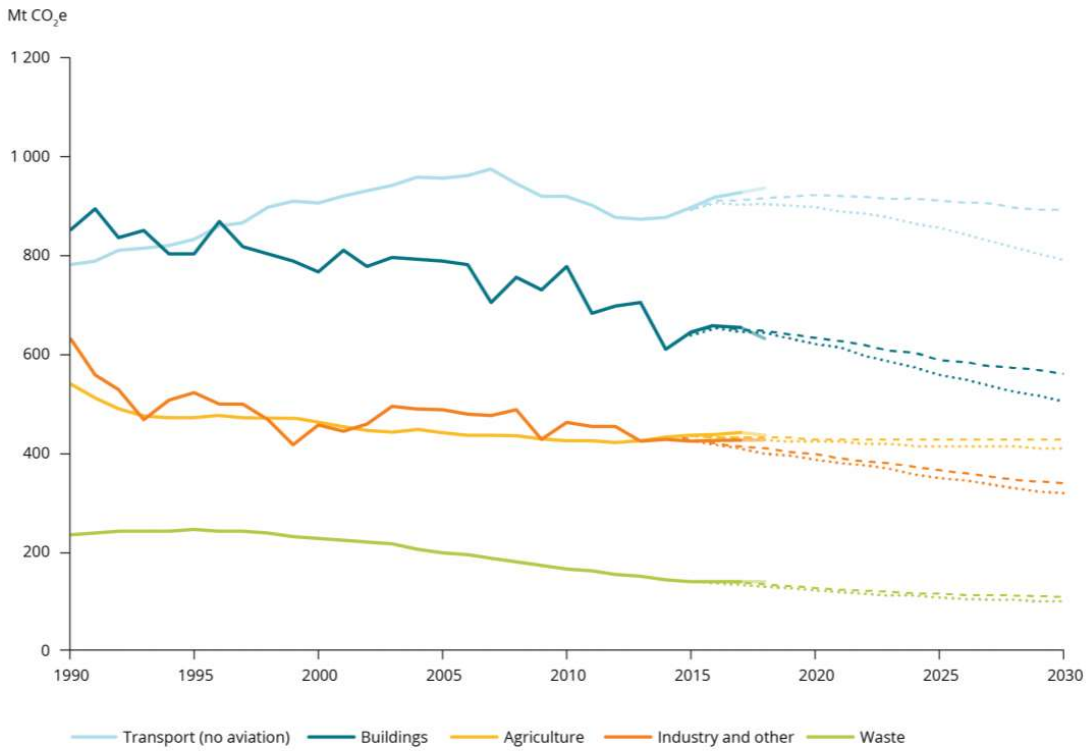
points higher than the target of 1,316 $MtCO_{2e}$. (EEA 2019b.) The annual emission reductions that would be required in the ETS sector to achieve the 1,316 $MtCO_{2e}$ in 2030 are presented in Table 3.

Only flights inside the EEA belong to the EU ETS. From 2020, other flights must offset their emission growth according to the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). Aviation inside the EU counts only for less than 0.5% of the EU´s emissions (without LULUCF). For the EU ETS period of 2013-2020 the emissions cap for flights inside the EEA is 95% from the emissions between 2004-2006 (221.4 $MtCO_2$). While there are EU aviation allowances for use in only the aviation sector, the aviation sector is allowed to use also EU ETS allowances to comply with the emissions cap. (EEA 2019a.) Since 2021, the aviation emission allowances are reduced in the same pace of 2.2% than the other EU ETS emission allowances.

The EU ETS offers flexibility in the emission reductions by Clean Development Mechanism (CDM) and Joint Implementation (JI) mechanisms. Through CDM, countries obligated under the emission reduction targets of Kyoto Protocol (Annex I countries) can reduce emissions by projects in developing countries, while JI allows Annex I countries to reduce emissions in any other Annex I country. Projects under the LULUCF sector, such as deforestation, are not allowed under the CDM or JI. One ton of CO_{2e} reduced can be converted to a Carbon Emissions Reduction (CER) unit under CDM, and to an Energy Recovery Unit (ERU) under JI, which can then be used instead of an emission allowance in the EU ETS system. CDM's and JI's are eligible only until 2020. Instead, a new market mechanism, Sustainable Development Mechanism (SDM), is established in the Paris Agreement. As SDM's have not been fully implemented yet there is no further information on the details related to them.

7.2 Effort Sharing Decision (ESD)

Figure 6 presents the share of emissions of each sector in the ESD sector, and the projected emission reductions. The largest emitter in the ESD sector is transport, which is responsible for more than one third of emissions in the sector. The second biggest emitter is the buildings sector. Until now, the buildings sector has committed the most emission reductions, while in the transport sector emission reductions have been very small or emissions have even increased. A significant change is expected, as the transport sector is expected to take the lead in emission reductions in the period of 2018-2030. The third biggest emitter, agriculture has a 17% share of emissions in the ESD sector, and only low emission reductions are planned in agriculture. (EEA 2020b.) Projected emission reductions in periods 2005-2020 and 2020-2030 are presented in Table 4.



Notes: Solid lines represent historical GHG emissions (available for the period 1990-2018). Dashed lines represent projections for the scenario with existing measures. Dotted lines represent projections for the scenario with additional measures.
The Effort Sharing sector emissions presented are estimated based on the attribution of GHG emissions, reported by source categories in national GHG inventories and national MMR projections, to EU ETS sectors and/or Effort Sharing sectors. See Annex 1 (Section A1.2) for additional information on data sources for GHG emissions.
The sector summarised here as 'industry and other' aggregates emissions from energy supply, manufacturing, industrial processes and product use (GHG inventory source categories 1.A.1, 1.A.2, 1.B, 1.C and 2), which are not covered under the EU ETS.

Figure 6 GHG emission trends and projections in the ESD sector (EEA 2019a.)

Table 4 Projected emissions reductions in the ESD sector in periods 2005-2020 and 2020-2030 when additional policy initiatives are considered (EEA 2020b)

Sector	Emissions in 2020 ($MtCO_{2e}$)	Emissions share in 2020 (%)	Reductions in 2005-2020 ($MtCO_{2e}$)	Reductions in 2020-2030 ($MtCO_{2e}$)
Transport	898	37	57	112
Buildings	623	25	164	119
Agriculture	423	17	15	15
Small industry and other	392	16	96	76
Waste	123	5	79	25
TOTAL	2,460	100	411	347

Table 5 lists the required emission reductions based on the 30% emission reduction target in the ESD sector. The target emission level in 2030 is 2,019 $MtCO_{2e}$. According to Table 4 the emission reductions projected in the ESD sector in the 2020-2030 period are 347 $MtCO_{2e}$, leading to the emissions level of 2,111 $MtCO_{2e}$ in 2030, which means the sector is not on track in achieving the 2030 emission reduction target. If only existing and adopted policy measures are considered in the member states, the EU would reach 20% reduction in the ESD sector compared to 2005 level (2,871 $MtCO_2$). With additional policies and measures, 27% emission reduction would be achieved. To

achieve the targeted 30% reduction compared to 2005 levels is therefore not possible without additional measures to reduce additional 92 $MtCO_{2e}$. (EEA 2019a.) As the Effort Sharing Regulation offers flexibility of maximum 280 $MtCO_{2e}$ from LULUCF sector to ESD sector and 107 $MtCO_2e$ from EU ETS to ESD sector, the 92 $MtCO_{2e}$ could potentially be covered by carbon sequestration in the LULUCF sector or emission reductions in ETS sector.

Table 5 Emission reduction target in the ESD sector translated to required annual emission reductions (EEA 2020b)

Year	Target ($MtCO_{2e}$)	Required decrease previous year ($MtCO_{2e}$)
2020	2,618	
2021	2,526	92
2022	2,433	93
2023	2,381	52
2024	2,329	52
2025	2,278	51
2026	2,226	52
2027	2,174	52
2028	2,123	51
2029	2,071	52
2030	2,019	52

7.3 LULUCF

The historical emissions and sinks, as well as the projected net sinks in the LULUCF sector are presented in Figure 7. The size of the future sinks has been estimated based on the EU member states' existing policies and measures (WEM) and the additional planned measures (WAM) reported by the member states under the Monitoring Mechanism Regulation. The net carbon sink in the LULUCF sector was 258 $MtCO_{2e}$ in 2017. The largest emission source in the LULUCF sector is the conversion of forest into other land use types. The largest carbon sink is forest land. (EEA 2019a.)

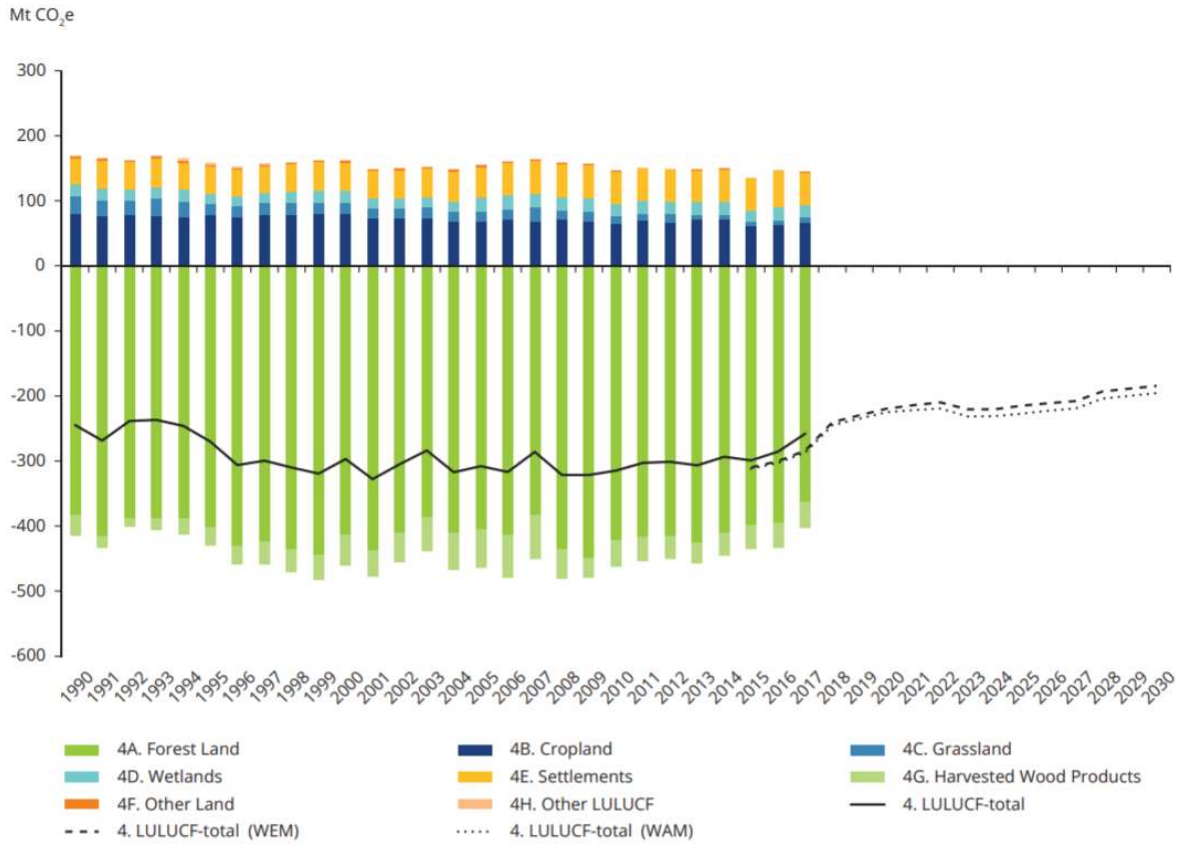


Figure 7 Reported EU LULUCF emissions and removals by land-use categories. WEM=with existing policies and measures, WAM=with additional planned measures reported by the member states under the Monitoring Mechanism Regulation (EEA 2019a)

As can be seen from Figure 7, the carbon sinks in the LULUCF sector have been decreasing in recent years. This has also resulted to the decrease of net carbon sinks in the sector. Unless land use practices and harvesting trend are changed, the sink might further decline to 225 $MtCO_{2e}$ by 2030. However, a growing sink is needed to achieve the EU's climate targets in 2050. In order to increase the sink instead of the current path of decreasing it, significant actions are needed. Increasing the sink to above 300 $MtCO_{2e}$ in 2030 could be achieved with actions such as improved and enforced forest protection and more sustainable forest management, sustainable re- and afforestation and improved soil management through the restoration of wetlands, peatlands and degraded land, and changing croplands to grow woody biomass, including as a feedstock for advanced biogas and biofuels. (EC 2020f.)

There are different ways in which the CRC potential from LULUCF sector can be estimated. The European Commission working document (2020g) has been used as a source for estimating the potential of CRC credits in the LULUCF sector in 2030. However, it should be taken into consideration that the additionality and baseline criteria affect highly on the amount of CRC's created. Criteria that must be defined in a carbon system are discussed in more detail in the final report of working package A2 to be finalised in 06/2021 which covers the description of an incentive scheme for foresters and farmers.

Table 6 presents the potential CRC generation in the LULUCF sector according to different scenarios assessed in the European Commission's working document (2020g). The "No Debit" scenario represents the abovementioned scenario on no improvements in current practices, which would result to a decrease of the net sink to 225 $MtCO_{2e}$ in 2030. In the European Commission working

document (2020f) this scenario is considered as a baseline, and the sinks additional to the "No Debit" baseline are considered as eligible for CRC's to be used in other EU climate sectors. Thus, the potential amount of CRC's in 2030 would be 32-115 $MtCO_{2e}$ depending on the scenario.

Table 6 LULUCF credits generation estimates by 2030 ($MtCO_{2e}$) according to different scenarios (EC 2020g)

	No Debit	FRL	LULUCF-MIX	LULUCF+
Forest Land*	0	26	64	84
Agricultural Land	0	6	6	21
Wetlands**	0	0	0	10
Total Credits	**0**	**32**	**70**	**115**
Reported sink	-225	-257	-295	-340

*Note: *Forest land includes managed forest land, afforested land and deforested land; ** the inclusion of managed wetlands in national LULUCF accounts is currently optional but this should be revised for the period 2026-2030*

Source: UNFCCC inventories, GLOBIOM model

The amount of carbon sinks is estimated to grow until 2050. Figure 8 shows the European Commission's estimation on carbon removal potential in the EU until 2050 when additional policy incentives are implemented. Carbon removal potential is projected to increase to 500 $MtCO_2$ in 2050.

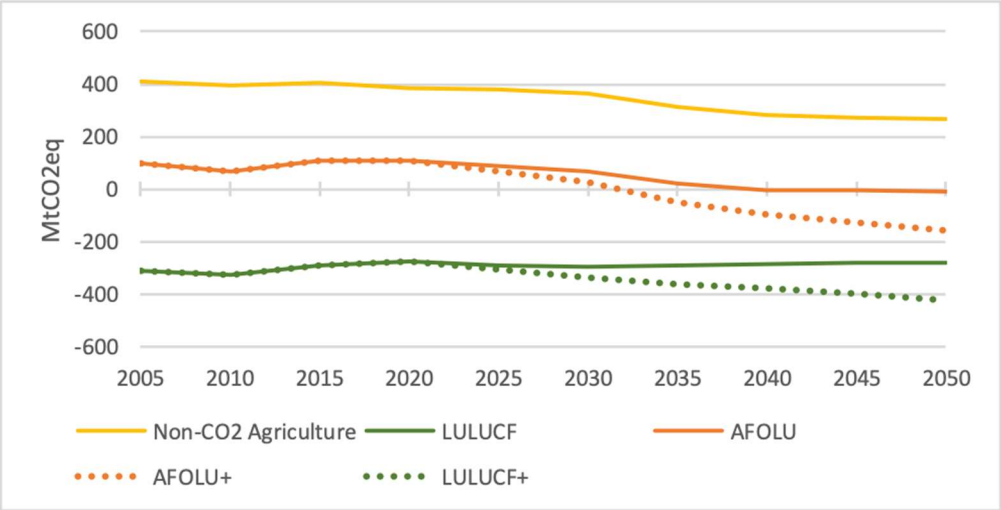


Figure 8 Potential amount of carbon removals in the EU (EC 2020h)

8 Introducing carbon removal credits to compliance markets

"Carbon removal credits should not be used as an excuse to emit more and offset all emissions", is an often expressed view when a the use of CRC as an offsetting tool is being discussed. This concern is legitimate but might sometimes be over dimensioned. Comparing the potential total EU level carbon sink above the baseline (32-115 $MtCO_{2e}$ in 2030) against the total emission reductions required in the ETS and ESD, it is evident that significant emission reductions will be required in any case, even if the nature based carbon sinks of the entire land use sector would fully be eligible for

CRC's to be used in other sectors. However, using nature-based CRC's in the emitting sectors would be, from the legislative perspective, a novel solution in the EU, why a cautious and phased approach against the 2030 target could be justified. Targets can only be achieved, if significant investments are directed to the needed measures. As the previous section presents, already achieving the current climate targets for 2030 is challenging, especially for the transport sector. At the same time EU is worryingly losing its' carbon sinks, while they should be increased instead. Thus, it is evident that not enough investments are currently channelled into the land use sector. Therefore, it is appealing to analyse how an increased flexibility between sectors could contribute to an accelerated achievement of higher overall climate targets, set out in the Green Deal. The working hypothesis of this work is that an increased flexibility, in a form of using CRC's in the emitting sectors, would channel private financing to land-use sector to increase carbon sinks vs. the baseline scenario, without compromising the respective sector specific emission reduction targets. It is also assumed that such a market based mechanism would lead to a lower overall societal cost level, than in the current regime.

The current target is to decrease the EU's emissions by 40% by 2030 compared to the 1990 level. According to the Green Deal, this target is going to be increased to 55% by 2030 compared to 1990 level.

According to the Green Deal impact assessment, the EU emissions on 1990 were 4,928.4 $MtCO_{2e}$ excluding LULUCF and 4,673.6 $MtCO_{2e}$ including LULUCF (EC 2020c). Using these as a reference value, the total emissions reductions required by 2030 with a 40% target would be 1,971.4 $MtCO_{2e}$ (reference value excludes LULUCF), and with 55% target 2,570.5 $MtCO_{2e}$ (reference value includes LULUCF), which results in a 599.1 $MtCO_{2e}$ difference. In other words, according to the 55% target, we should reduce emissions with 599.1 $MtCO_{2e}$ more than planned during 2020-2030. This means 59.1 $MtCO_{2e}$ incremental annual reductions assuming a 10 year period. Practically, the remaining period, for how long the relevant legislation would be in force until 2030, is likely to be 4 – 7 years, as the revision and implementation of the directives will take its' time.

We could assume that annually 59.1 $MtCO_{2e}$ additional reduction would be eligible to be achieved with CRC's by 2030. Compared to the current carbon sink of the LULUCF sector (258 $MtCO_{2e}$ in 2017 (EEA 2019a)), the required addition seems relatively high. With the 32-115 $MtCO_{2e}$ potential for carbon sequestration in the LULUCF sector (EC 2020g), significant emission reductions are still needed to cover the tightening target for 2030. Thus, the risk of watering out emission reduction efforts by allowing of the use of CRC's, is deemed low.

There are different ways in which flexibility between the EU climate policy sectors can be increased with CRC's, depending on how they would be implemented in the EU legislation and member states' national legislation. The legislative aspects are discussed in further details in the upcoming report of working package A2 (finalised in 06/2021) covering the description of an incentive scheme for foresters and farmers, and in the report of working package A3 which gives guidance for regulatory and policy aspects towards implementation of an incentive scheme. If the possibility to create and use CRC's was implemented in the EU legislation, it would be possible to create demand for carbon sequestration within sectors currently belonging in the EU ETS and ESD. This would trigger financial flow from emitting private sectors to carbon sequestration and decreases the cost of achieving the EU's climate targets by allowing the use of the least expensive means in achieving emission targets.

The following subsections is an initial analysis of an introduction of carbon removal credits in the EU climate policy. The biggest emitters are considered: EU ETS sector and transport sector, which here is divided into road transport, aviation and maritime. We will assess and outline how the use of CRCs

could be enabled through an EU level legislative framework. The ways in which CRCs could be implemented to the EU legislation are explored in more detail in the upcoming report of working package A2 covering the description of an incentive scheme for foresters and farmers, and in the report of working package A3 which gives guidance of regulatory and policy aspects towards implementation of an incentive scheme.

The current cost of emission reductions is assessed for each sector. Finally, in subsection 8.6, the potential theoretical CRC demand and current price of emission reductions are compared with the theoretical CRC supply and the current price of CRC's to see if they could be met.

8.1 Carbon removal credit criteria

This subsection analyses the use of CRC's as a tool to comply with emission reduction targets. If CRC's were used instead of reducing emissions, the climate impact resulting from the CRCs should be at minimum equivalent to the actual emission reductions. CRCs from both carbon sequestration and emission reduction as a substitute for emission reductions should have an equivalent impact on total emissions when the given criteria are fulfilled.

To be eligible as equivalent with emission reductions, CRCs from carbon sequestration or emission reduction must fulfil EU level criteria set, at least, for the following elements:

- Additionality
- Permanence
- Carbon leakage

Additionality: If the CO_2 covered by the CRC would have been sequestered or reduced anyway, it does not cover actual emission reductions, and the total impact on emissions is undesirable.

Permanence: CO_2 reduced will be out of the atmosphere for ever. However, a share of CO_2 sequestered for example by afforestation will be released back to the atmosphere in case of logging, or for a natural reason such as forest fire. The permanence issue can be solved by setting the project duration time so high that the sequestration can be considered as permanent, or the emission impact of the projects with short duration can be calculated and be related to permanent CO_2 sinks. (Finnish Ministry of the Environment 2019.)

Carbon leakage: if CO_2 reduced or sequestered leads to CO_2 emitted elsewhere (except for where the credit is used), the total impact on emissions is undesirable. For example, if a CRC were based on forest preservation in one place, the existing demand for the timber could be met by logging somewhere else.

These criteria for carbon credits are discussed in more detail in the final report of working package A2 (finalised in 06/2021), which covers a description of an incentive scheme for foresters and farmers.

8.2 EU ETS

Adding CRCs to an emission trading system would mean that emitters under the ETS could choose between reducing emissions from their processes, buying emission allowances or CRCs to cover their emissions. In this kind of a system the CRCs would be considered as equal with the emission allowances, and their price would be equal with the emission allowance price.

The theoretical behaviour of an emission trading system when CRCs are added is explained in a report ordered by the Finnish Government (2020), and this is demonstrated in Figure 9. The upward going line in Figure 9 represents the social cost of emissions. In an economically optimal emission

trading system, a cap is set for emissions in a way that the abatement cost is equal to the social cost of emissions. This is demonstrated with the point A in the chart. In this case the price of emission allowance would be the value of the Y axis in the point A. If CRCs were added to the emission trading system (point B), the "emission allowance pool" would increase, but as the emission cap is the same as before, less emissions will actually need to be decreased and the price of emission allowances decrease. To return to the economically optimal situation, the emission cap must be lowered (point C). As a summary, adding CRCs to an emission trading system, and lowering the emission cap to the optimal, will lower the abatement cost of companies, decrease emissions, and create demand for CRCs.

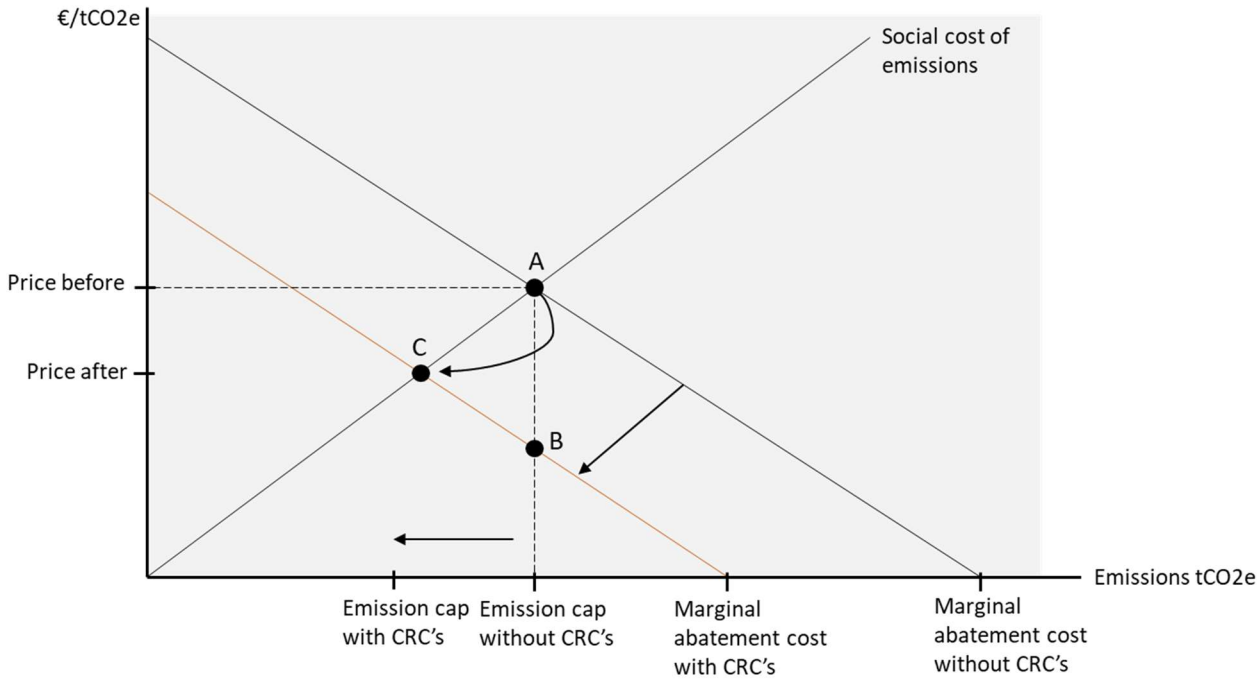


Figure 9 Adding CRC's to an emission trading system

There are, however, some possible problems that this kind of change can face. First of all, as a result of adding CRCs to the system the price of emission allowances together with the price of CRCs will be lower than the price of emission allowances before the change. Considering the historic price of EU ETS emission allowances (see Table 7), the price might be too low for any CRCs to be brought to the market. Even though the price of emission allowances has been predicted to increase (e.g Thomson Reuters), this might be too high risk to take for farmers and foresters. Other problems mentioned in the report ordered by the Finnish Government (2020) are:

- The EU ETS emission cap has not been set according to the optimal, instead, it was a compromise made by EU member states
- New changes, such as lowering the emission cap require time, new negotiations and probably even a new phase for learning

The problem of too low price of emission rights, described above, is a result of a non-optimal cap level, with or without CRCs included. Therefore, the conclusion should not be to abandon the inclusions of CRS into ETS outright. Instead, it is worth to explore further how to determine an optimal cap level, that would enable an inclusion of CRC. In other words, if the problem is the wrong level of the cap, try to set it on the right level.

Table 7 Emission allowance price in EU ETS in 2018-2020 (Ember 2020)

Year	Price range €/tCO_{2e}
2018	7.8 - 25.2
2019	18.7 - 29.8
2020 until 5.8.2020	15.2 - 29.7

8.3 Road transport

The transport sector has renewable energy and emission reduction targets which help in achieving the emission reduction target set for the ESD sector. The EU aims to achieve at least 10% renewable energy share in transport by 2020 and 14% by 2030. The Renewable Energy Directive (RED I, 2009/28/EC) sets the targets and rules for 2020 and the recast Renewable Energy Directive (RED, II (EU) 2018/2001), sets the targets and rules for 2030. With the Fuel Quality Directive (2009/30/EC), a target for fuel emission intensity reduction of 6% is set for 2020, compared to the 2010 levels. The 6% reduction obligation has been agreed to continue after 2020, until the legislations have been re-evaluated.

Biofuels have a significant role in achieving the EU's renewable energy target in transport: approximately 90% of renewable energy in transport comes from biofuels (EEA 2018). The renewable energy target does not directly require reducing emissions. However, biofuels do have a limit for GHG emissions. Biofuels must fulfil the sustainability criteria set in the RED, of which one sets a lower limit for GHG emissions of biofuels: the GHG emissions of the biofuel life cycle must be lower than the life cycle emissions from an equivalent fossil fuel. The reduction must be:

- 65 % for biofuels produced in installations starting operation on or after 1 Jan 2021
- 60 % for biofuels produced in installations starting operation between 5 Oct 2015 and 31 Dec 2020.
- 50% for biofuels produced in installations in operation on or before 5 Oct 2015.

The avoided GHG emissions due to the use of biofuels in the EU in the transport section were 51.22 $MtCO_2$ (proxy) in 2018. This resulted from the use of 16.7 Mtoe (proxy) biofuels in transport. (EEA 2019c.)

The member states have implemented the transport renewable energy target in their national legislations in different ways. A biofuel obligation has been set in each member state except for Sweden and Germany, which have an emission reduction obligation (Ecofys 2019). For example, the Swedish emission reduction obligation obligates fuel suppliers to reduce emissions by 21% in diesel and 4.2% in petrol in 2020. The emission reductions can be achieved only by supplying biofuels to consumption. The Swedish emission reduction obligation ensures high emission reductions in transport, but at the same time forces fuel suppliers to supply biofuels to consumption. Not all the countries have set the obligations beyond 2021 yet as the RED II must be implemented only by the end of June 2021.

Member states can choose their own best ways to achieve the emission targets in the ESD sector. As all member states have set biofuel or emission reduction obligations for fuel suppliers, they already have an instrument in the legislation for fuel suppliers to reduce emissions. These biofuel or emission reduction obligations could potentially be one way to be used as a base for implementing CRCs to the transport sector. By tightening or modifying the biofuel or emission reduction obligations to be able to introduce CRCs, more emission reductions could be reached in transport.

CRCs could be integrated to the fuel suppliers' renewable energy obligations by at least the following ways:

A. emission reduction obligation, where emissions can be reduced by supplying renewable energy to consumption or by using CRCs
B. renewable energy obligation of more than the required 14% in 2030, where a certain percentage could be filled with CRCs

As renewable energy obligations often calculate the share of renewable energy in litres or share of energy, the option B would require a conversion of renewable energy amount to emission reductions. Here for example the minimum or historical average biofuel or renewable energy emission reduction could be used in the calculations.

A case study on adding CRC's to the Finnish biofuel obligation is conducted in section 9.

The Fuel Quality Directive (2009/30/EC) and its implementing directive ((EU) 2015/652) allow two types of carbon credits to be used to achieve emission reductions. According the FQD 7a § 2 c countries may set an indicative additional target of 2% reduction for fuel emission intensity to be achieved with CDM projects in the fuel supply sector. We are not aware of any country that has implemented the indicative additional targets the FQD offers. The FQD's implementing directive offers upstream emission reductions (UER) as a mean to achieve the 6% emission reduction obligation. The UER credits can be achieved only from emission reductions achieved in fossil fuel production prior to the raw material entering a refinery or a processing plant. According to the Commissions guidance note on UER's, UER's resulting from CDM or JI projects can be used as long as the constraints set in the FQD implementing directive are followed. As the first year of binding emission reduction obligation from the FQD is 2020, it is still not known if fuel suppliers in any country will utilize the UER credits as a mean to achieve the target.

Fuel suppliers are able to comply with their legal emission obligations by using CRCs at least in Switzerland and Colombia. In Switzerland, the KliK foundation funds carbon offset credits eligible to fulfil the emission obligation set for fuel suppliers in the Swiss CO_2 law. The Swiss system is further introduced in Part I of this report. In Colombia, fuel suppliers are exempted from CO_2 tax if they offset emissions with CRCs from national projects (I4CE 2019).

Other possible ways to implement CRCs to transport sector would be transport specific emission trading system or by adding it to the EU ETS, with a CRC mechanism included. The European Commission is assessing a possibility of using emissions trading scheme as a mechanism to achieve emission reductions in other sectors than the sectors currently covered by EU ETS. According to the Green Deal, at least road transport, buildings and bunker fuels are being considered.

According to a study of DG of internal policies (2015), a ton of CO_2 avoided by replacing fossil fuel with biodiesel costs EUR 100-330. The cost with bioethanol from e.g. from sugars is 100-200 EUR/tCO_2, and higher for bioethanol from wheat. Emissions from indirect land use change (ILUC) are not considered in the calculations. At the moment it seems that these cost estimations are too low for the period of 2020-2030, especially regarding advanced biofuels. For example, the price of non-crop biofuels in the German ticket market has ranged from 248 to 430 €/CO_2 during 1.1.2020-20.11.2020 (STX 2020). With the increasing mandates the cost is likely to increase up to the penalty levels of non-compliance. As biofuels are a finite source of renewable energy, more climate solutions are needed in transport sector in addition to biofuels. Due to the limited amount of biomass, the price of biofuels can be expected to grow as the biofuel obligations grow in and outside the EU.

8.4 Aviation

Currently, at least three types of policy frameworks are implemented or planned to be implemented in the aviation sector. These are the EU ETS, a Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) and blending mandates for sustainable aviation fuels.

Currently, the EU ETS includes emissions from flights within the EEA. The EU domestic aviation counts almost 0.5% of the EU's emissions (excl. LULUCF), international aviation counting 3% of the emissions (EEA 2019a).

In 2016, the UN's International Civil Aviation Organization (ICAO) agreed on a Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) to address emissions from international aviation starting from 2021. The aim of the CORSIA is to stabilize emissions from international aviation to 2020 levels by offsetting the growth in emissions after 2020. Upon revising the EU ETS Directive due to Green Deal, the EU is able to implement CORSIA in a way that it will be in line with the EU's emission targets (EC 2020b).

Increasing amount of EU countries are planning to establish a mandate for renewable aviation fuels of emission reductions in aviation. In Norway, an aviation biofuel mandate took place in 2020 (Norwegian law on aviation mandate 2020). The law sets a 0.5%-vol mandate for advanced biofuels in aviation. Sweden is planning to set an emission reduction obligation for aviation starting from 0.8% emission reduction in 2021 and growing to 27% reduction in 2030 (Swedish Government Official Reports 2019). The Finnish Government program set in 2019 states that a blending obligation for 30% advanced biofuels in 2030 is going to be set for aviation (Finnish Government 2020). France is planning to set a mandate for sustainable aviation fuels of 2% in 2025, 5% in 2030 and 50% in 2050.

REFuelEU Aviation initiative aims to boost the supply and demand for sustainable aviation fuels in the EU. Different ways to increase sustainable aviation fuels are explored and analysed, of which one is a blending mandate. (EC 2020d)

Due to CORSIA and EU ETS, CRCs seem to have a place in the future of aviation. However, it is still of great importance to support the use of sustainable aviation fuels instead of offsetting all the emissions from aviation. Decreasing the usage of fossil fuels in aviation is important, because it will help to decrease fossil fuels in other sectors too. Due to the distillation curve of crude oil, the refining process will result in certain amounts of certain fractions. Therefore, if the aim is to produce kerosine for aviation, most of the crude oil will be anyway converted into other fractions such as diesel and petrol. In other words, as long as we use crude oil to produce kerosine, we will end up with significant amounts of other fuels which will always be used somewhere. If not in transport, then in power generation or some other appliance.

The cost of avoiding the GHG emissions, as in other sectors, depends greatly on the measures applied. For example, when using biobased sustainable aviation fuels, the lower limit of the CO_2 mitigation cost would be the same as using HVO in road transport, added with the incremental cost of further processing the fuel to Jet. Upper limit would be set by a potential penalty of non-compliance. The cost of using synthetic sustainable aviation fuel would follow the same logic as biogenic sustainable aviation fuel.

8.5 Maritime

Maritime transportation has remained the only sector with no specific EU commitments to reduce greenhouse gas emissions. Currently the International Maritime Organisation (IMO) is the main

international organisation working on the regulation of GHG emissions from international shipping. IMO has been referred to be very ineffective in its efforts to tackle shipping's climate impact (Transport & Environment 2020) and therefore the EU is now aiming to forward reducing emissions in the maritime transport through EU Green Deal. Emissions from maritime transport are not currently covered by the EU ETS or other EU climate legislation and EU Commission is now considering adding the maritime emission under the EU ETS. (EC 2020e.)

The EU international maritime transport emitted around 146 $MtCO_{2e}$ in 2017. As can be read from Figure 10, the share of CO_{2e} emissions resulting from maritime from the total transportation emissions in the EU is about 13% (2017). (EEA 2019d.)

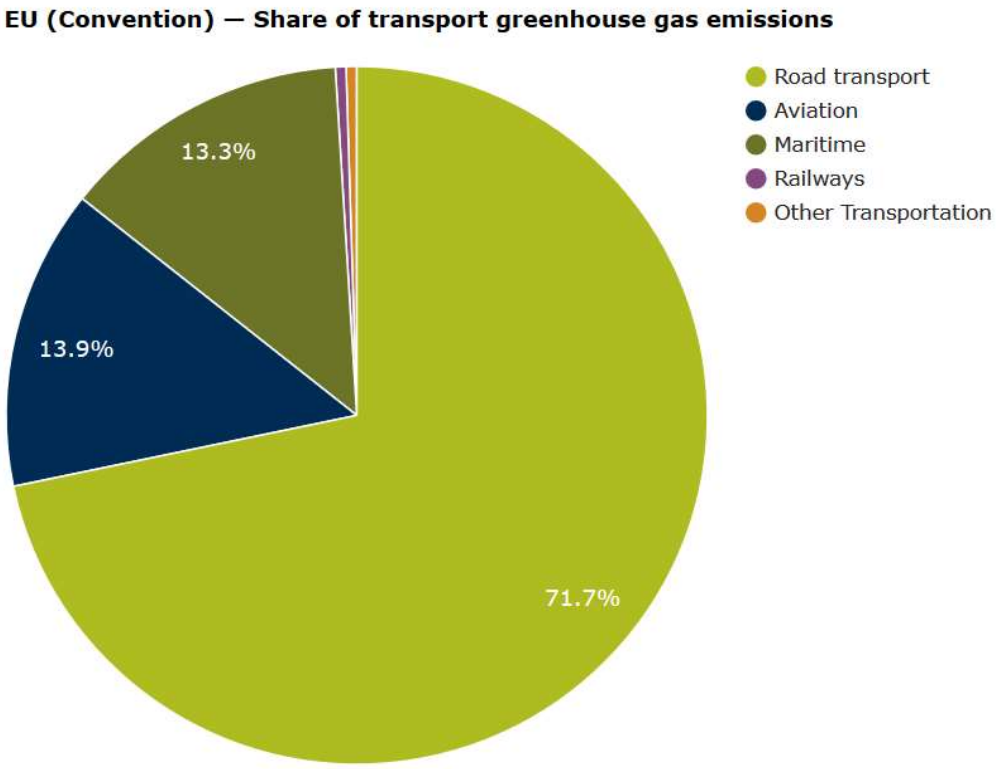


Figure 10 Share of transport GHG emissions in the EU28 in 2017 (EEA 2019d)

Despite of the set targets by the industry in IMO's initial strategy to reduce greenhouse gas emissions published in 2018, according to a report published in 2020 also by IMO the shipping industry's GHG emissions have increased by nearly 10% between 2012 and 2018 (IMO 2020). The same report also forecasts that shipping emissions will increase by up to 50% until 2050 relative to 2018, which is not in line with EU's climate targets. Thus, it seems that the efficiency gains achieved in the industry will not enable reducing emissions as transport demand is expected to continue to grow.

Also market based measures (MBM) have been discussed for many years within IMO and the maritime industry as mechanisms to reduce CO_2 emissions. These types of measures have not been adopted to this day but it has been predicted that in the long term, certain MBMs should be adopted as a supplementary method of reducing shipping GHG emissions in addition to the currently used energy efficiency measures. (Shi 2016.)

8.6 Summary on supply and demand

Most of the EU's current emissions come from fuel combustion, of which most of the emissions are from the energy industries and transport. Based on this analysis, the ETS and transport sectors have potential for implementing CRCs. The potential for volumetric demand of CRCs, if accepted as a CO_{2e} mitigation tool, is evident in all of the studied sectors. Also, the sector specific mitigation costs, especially in all of the transport sectors, would favour the use of CRCs as an additional tool for complying with sector specific targets. The potential demand is far greater than the potential of nature-based CRCs supply in the EU. Thus, the risk of watering out the sector specific emission reduction target, if CRCs were introduced, is deemed low, and could effectively be mitigated with a robust policy design.

The structure of the ETS is technically best suited to take CRCs into use, as the unit of trade (ton of CO_2) would be the same, and the existing EU wide downstream market structure is already in place. However, a great deal of legislative design would be needed to bridge the CRC upstream into the system, i.e. the entire value chain from the actual carbon sink creating activities, through a rigorous MRV to the creation of a CRC.

Climate regulation structures the different transport sectors differ significantly, from nationally driven (road transport) to EU level (Aviation) regulation, and partly from no regulation (Maritime) to voluntary or global agreement-based measures (Aviation / CORSIA). Using CRCs in the transport sectors, in the regulation driven compliance market at the EU level, would require different levels of harmonisation, in order to be effective. National pilots can, of course, be justified for the learning and design purposes.

A natural starting point for using CRCs, would be the aviation sector, where the global agreement based implementation is already taking place via CORSIA. As the intra EU aviation is already included in the ETS, it would be natural to explore further, in what way CRCs could be included as an eligible tool, in parallel with the envisaged introduction of sustainable aviation fuels. The potential EU level CRC rules should be, ideally identical, but at least as close as possible with rules of CORSIA. From the market effectiveness perspective this would be highly desirable. The number of (potentially obligated) parties, whether airlines or fuel suppliers, would be limited and inherently competent in participating the trade, and the administrative burden would be lower.

Road transport holds the biggest volumetric demand for CRCs, and likely the highest paying power together with aviation. As the Green Deal offers a great possibility for harmonising the regulation on road transport, the potential inclusion of the CRC should be kept as an option, alongside with the sector specific policy design.

Maritime also holds significant volumetric demand, but assumingly a lower paying price than other transport modes. Currently, the lack of common EU level approach prevents the inclusion of the regulation-based CRC into the sector. However, the Green Deal is aiming at setting common rules for maritime, too. As a global industry, with a limited number of companies in the market, and with an increasing emission trend, the use of CRCs, alongside with sector specific measures, looks appealing, and should be kept as an option, alongside with the sector specific policy design.

The policy instruments are further evaluated in the final report of working package A2 covering the description of potential incentive scheme for foresters and farmers, and in the report of working package A3 which gives guidance of regulatory and policy aspects towards implementation of such an incentive scheme.

The potential demand of CRCs in the EU sectors outside LULUCF is 599.1 $MtCO_{2e}$ during 2020-2030 if only the tightening emission reduction target is considered as available to be fulfilled with CRC's. Divided to 10 years, this would mean 59.9 $MtCO_{2e}$ yearly reduction. Assuming the above baseline carbon sink, estimated by the European Commission (2020g), the potential supply of CRCs could be 32-115 $MtCO_{2e}$ in 2030 depending on the scenario. Based on the analysis in this document, we can assume most of the CRC supply potential would be consumed, as the price of CRCs is expected to be competitive with other alternative actions.

Table 8 presents the current carbon prices in different sectors. The price of European domestic CRCs is currently significantly lower than the price of emission reductions achieved in transport with biofuels and the highest price of emission allowances in the EU ETS during 2018-2020. Naturally, all these prices will change over time, assumably increase, as the more emissions are needed to decrease or sequester, the higher the price of the actions will grow.

Table 8 Carbon price in different sectors

	European domestic CRC	**ETS**	**Road transport**
Carbon price (€/tCO_{2e})	13	7.8 - 29.8	100 - 330
Explanation	Weighted average price of carbon in the European domestic carbon standards), range being from 6 to 110	Price of emission allowances between 1 Jan 2018 and 5 Aug 2020	Price of emission reductions in transport with biofuels
Source	I4CE 2019	Ember 2020	DG internal policies 2015

As a summary, according to the estimates on the potential supply and demand of CRCs and the carbon price in different sectors, it seems likely, that there would be demand for CRCs in the EU's compliance markets. However, in the end, the supply, demand, and the price are formed by the market setting, and this evaluation can only give us a hint on what the market could possibly look like.

9 Case study on adding CRC's to the Finnish biofuel obligation

This section studies the theoretical situation where CRCs would be implemented as a way to fulfil part of the Finnish climate targets in road transport in 2030. First, the Finnish policy framework for biofuel legislation is introduced. Next, the amount of CRCs that could be used to fulfil part of the Finnish biofuel obligation in 2030 is estimated, and the cost difference of using CRCs instead of biofuels is estimated.

9.1 Policy framework

The Finnish national climate law (609/2015) aims to establish a framework for planning and monitoring the implementation of Finnish climate policy. According to the law, Finland aims to lower the greenhouse gas emissions by 80% by 2050 compared to 1990. This reduction target is in line with the target set in the EU commission's roadmap for moving to a competitive low carbon economy in 2050 (COM (2011) 112), according to which EU aims to decrease GHG emissions by 80% by 2050 compared to the 1990 level. The target has been set to meet the target of stopping the global warming to 2 Celsius. However, these targets might be still tightened in order to stop the global warming to 1.5 Celsius.

The Finnish national climate law also sets the obligation for creating a long-term climate policy plan and a mid-term climate policy plan. The long-term climate policy plan is approved at least once in ten years and the mid-term climate policy plan is approved for every parliamentary term.

The latest mid-term climate policy plan was created by the Finnish government in 2016 and it sets the targets for the year 2030. After the latest change of the government, preparation of a new mid-term plan started on April 2020. The aim of the mid-term plan is to set clear targets and a pathway to reach the targets during the existing parliamentary term. The current government plan sets a target of carbon neutrality in 2035.

The renewable transport fuel obligations given in the RED and RED II will be achieved in Finland with biofuels. Finland has implemented a national biofuel obligation based on the energy content in the fuels (MJ). The biofuel obligation was 10% of the total fuel distributed in 2016, growing to 20% in 2020. Fuels produced from feedstocks mentioned in RED Annex IX can be counted as double. Later the biofuel obligation law has amended so that the obligation continues to grow, until in 2029 and after it is 30%. The double counting will be ceased after 2020. There is a penalty fee of 0.04 EUR/MJ in case the biofuel obligation is not met.

The obligation for advanced biofuels (RED annex IX part A) starts in 2020, growing yearly from 0.5% in 2020 to 10% in 2030 and after. The cap for food and feed crops is implemented from 2020 as stated in the RED I: maximum 7% of the biofuels supplied can be produced from food and feed crop feedstocks in 2020, after which the cap decreases. (446/2007.) An additional penalty fee of 0.03 €/MJ is charged in case a sub mandate for advanced biofuels is not met.

The EU FQD directive was implemented in the national legislation with a law obliging fuel suppliers to reduce their emissions at least 6% in 2020 (170/2018). The obligation of 6% emission reduction continues also after 2020. There is a penalty fee of 1 EUR/kgCO_{2e} in case the obligation is not met.

As the biofuel obligation is growing every year, the transport fuel emissions are also decreasing. Therefore, it can be assumed that fuel suppliers will meet the FQD fuel emission reduction automatically just by complying with the biofuel obligation.

9.2 Introducing carbon removal credits

9.2.1 Used values

As a source for transport fuel demand in 2030 we have used the results of the Finnish ALIISA vehicle fleet model constructed by Technical Research Centre of Finland (VTT 2020). The ALIISA model is based on the already implemented legislative targets in transport.

We did not find any reference value for the emission reduction of transport biofuels, as EU member states report biofuels as zero-emissions. However, biofuels do have emissions due to the possible cultivation of the biomass and processing to biofuel. The emission reduction of biofuels compared to fossil transport fuels is at minimum 50% (the minimum requirement in the RED), but according to our own estimation more probably lies somewhere around 80%. As third of the Finnish biofuel mandate in 2030 must be filled with advanced biofuels, which often have relatively high emission reduction value, we anticipate that the average emission reduction of biofuels will not be under 80% in Finland in 2030. Therefore, we have chosen 80% reduction as an average value for the case study. Reference values stated in the FQD implementing directive for the fossil diesel and petrol have been used in the calculations.

According to the study ordered by DG internal policies (2015) the cost of reducing emissions with biofuels is 100-330 EUR/tCO_2 with biodiesel and 100-200 EUR/tCO_2 with bioethanol e.g. from sugars

and higher with bioethanol from wheat. Due to the increasing cost of biofuels, and demand for advanced biofuels, the price of biofuel is expected to grow. According to our internal estimation, the cost from fulfilling the obligation with biofuel in Finland in 2030 can be even triple of the cost calculated on 2015 in the study of DG internal policies. Our estimation is based on the assumption that the biofuel price in Finland would be 95 % of the Finnish biofuel obligation's penalty fee. In the calculations we used both the upper cost estimation of DG international policies (2015) for biodiesel (330 EUR/tCO_2) and ethanol (200 EUR/tCO_2), and our own cost estimation.

9.2.2 Results

With 30% of biofuels in 2030 Finland is able to reach 24% (3.46 $MtCO_{2e}$) emission reductions in transport. With the renewable fuel target of 14% in 2030 set in the RED II, Finland would be able to reach only 11% (1.59 $MtCO_{2e}$ in 2030) emission reductions, which results in difference of 1.87 $MtCO_{2e}$. If CRCs would be allowed in the Finnish biofuel obligation after the EU target on 14% renewable energy in transport is reached, to reach the same 2 % emission reduction as with 30% biofuels, the up to 23.3 PJ biofuels could be replaced with CRCs covering 1.87 $MtCO_{2e}$. This option would allow fuel suppliers to use the most cost-effective way of filling their climate targets.

Using the cost calculation from DG internal policies (2015), the total cost of using 30 % biofuels in Finland in 2030 would be 1,109 MEUR. Using our estimation of the maximum cost, the total cost would be 3,015 MEUR. According to the calculations, with 30 % biofuel share, 24 % (3.46 $MtCO_{2e}$) emission reductions can be achieved in transport. Assuming the 14 % EU target of renewable energy is fulfilled with biofuels, the remaining 16 % biofuels would contribute to 1.87 $MtCO_{2e}$ emission reductions. With the current average CRC price of 13 EUR/tCO_{2e}, offsetting the 1.87 $MtCO_{2e}$ would cost 24 MEUR. Table 9 lists the potential savings from using CRC's instead of biofuels, calculated with the two different biofuel cost estimations. As a result, reducing the 1.87 $MtCO_2$ with biofuels would require 25 to 62 times the money than offsetting it with CRCs. This implies that if fuel suppliers would be able to choose between emission reductions and CRCs, with current prices they would choose CRCs.

Table 9 Potential savings from using CRC's instead of biofuels to offset 1.87 $MtCO_{2e}$ emission reductions resulting from 16 % biofuels in Finnish transport

	Total cost of 30 % biofuels (MEUR)	**Cost of biofuels exceeding the EU 14 % target (16 %) (MEUR)**	**Price difference of reducing emissions with 16 % biofuels versus CRC's (MEUR)**
Min (DG internal policies 2015)	1,109	618	593
Max (our own estimation)	3,015	1,479	1,511

10 Conclusion and discussion

According to the analysis based on the current emissions, emission targets and prices for carbon reductions in each EU emissions sector, there is at least a clear theoretical demand for carbon removal credits in the mandated markets. To evaluate the feasibility and efficiency of the market, there should be more information about the supply of carbon removal credits. There is a theoretical potential also on the supply side of carbon credits but at the moment it is unclear what would be the thresholds for risk, cost and profitability for carbon sequesters that would make carbon farming practices appealing and what kind of incentive mechanisms would support this. This will be assessed in the reports of action A4 and in the report of action A2 covering the description of an incentive scheme for foresters and farmers.

The case study from Finland clearly demonstrates the economic benefits from including carbon removal credits as a mean to fulfill current emission obligations in the transport sector.

Further questions that need assessing in order to design a functional carbon farming scheme operating in compliance markets:

- The carbon farming scheme should be made attractive for farmers and foresters by managing the risk, cost and profitability of carbon sequestration. One single component that rose in our literature research was the cost and bureaucracy of MRV. Means to decrease the cost and effort of the process should be found, without significantly compromising accuracy and reliability.
- There are many options on how to implement CRC's in the EU legislation. The options should be evaluated as well as how much freedom the member states should have in the implementation.

11 References

DG internal policies. 2015. The impact of biofuels on transport and the environment, and their connection with agricultural development in Europe (IP/B/TRAN.IC/2012_117).

EC. Guidance note on approaches to quantify, verify, validate, monitor and report upstream emission reductions. Available at: https://ec.europa.eu/clima/sites/clima/files/guidance_note_on_uer_en.pdf.

EC. 2019. Communication from the Commission to the European Parliament, the European Council, the Council, the European economic and social committee and the committee of the regions. The European Green Deal. COM(2019) 640 final.

EC. 2020a. Effort sharing 2021-2030: targets and flexibilities. Available in: https://ec.europa.eu/clima/policies/effort/regulation_en. Accessed on 7th Aug 2020.

EC. 2020b. Reducing emissions from aviation. Available in: https://ec.europa.eu/clima/policies/transport/aviation_en. Accessed on 5th Nov 2020.

EC. 2020c. Commission staff working document. Impact assessment accompanying the document: Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. SWD(2020) 176 final. PART 2/2 Available at: https://ec.europa.eu/clima/sites/clima/files/eu-climate-action/docs/impact_part2_en.pdf.

EC. 2020d. ReFuelEU Aviation – Sustainable Aviation Fuels. Inception impact assessment. Available in: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12303-ReFuelEU-Aviation-Sustainable-Aviation-Fuels

EC. 2020e. Amendment of the EU Emissions Trading System (Directive 2003/87/EC). Inception impact assessment. Available in: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12660-Updating-the-EU-Emissions-Trading-System

EC. 2020f. Stepping up Europe's 2030 climate ambition Investing in a climate-neutral future for the benefit of our people. 17.9.2020 COM(2020) 562 final.

EC. 2020g. Commission staff working document, impact assessment, accompanying Commission communication Stepping up Europe's 2030 climate ambition, 17.9.2020, SWD(2020) 176 final PART 1/2.

EC. 2020h. Commission staff working document, impact assessment, accompanying Commission communication Stepping up Europe's 2030 climate ambition, 17.9.2020, SWD (2020) 176 final PART 1/2. Available at: https://ec.europa.eu/clima/sites/clima/files/eu-climate-action/docs/impact_en.pdf

Ecofys. 2019. Technical assistance in realisation of the 4 th report on progress of renewable energy in the EU: Member States' Factsheet on Progress on Renewable Energy. Available in: https://ec.europa.eu/energy/sites/ener/files/documents/technical_assistance_in_realisation_of_the_4th_report_on_progress_of_renewable_energy_in_the_eu-member_states-factsheets.pdf.

EEA. 2018. Progress of EU transport sector towards its environment and climate objectives. Briefing no. 15/2018.

EEA. 2019a. Trends and projections in Europe 2019: Tracking progress towards Europe's climate and energy targets. Report No 15/2019. Available in: https://www.eea.europa.eu/publications/trends-and-projections-in-europe-1.

EEA. 2019b. Total greenhouse gas emission trends and projections in Europe. Indicator Assessment: Data and maps. Available in: https://www.eea.europa.eu/data-and-maps/indicators/greenhouse-gas-emission-trends-6/assessment-3.

EEA. 2019c. Renewable energy in Europe: Benefits for climate and energy and interplay with air pollutant emissions. Available in: https://www.eea.europa.eu/themes/energy/renewable-energy/renewables-crucial-for-eu-decarbonisation.

EEA. 2019d. Greenhouse gas emissions from transport in Europe. Available in: https://www.eea.europa.eu/data-and-maps/indicators/transport-emissions-of-greenhouse-gases/transport-emissions-of-greenhouse-gases-12

EEA. 2020a. Greenhouse gas - data viewer. Available at: https://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer. Accessed on 16.10.2020.

EEA. 2020b. National action across all sectors needed to reach greenhouse gas Effort Sharing targets. Briefing no. 16/2019. Available in: https://www.eea.europa.eu/themes/climate/trends-and-projections-in-europe/national-action-across-all-sectors.

Ember. 2020. Available in: https://ember-climate.org/carbon-price-viewer/. Accessed on 6th Aug 2020.

Finnish Government. 2020. Programme of Prime Minister Sanna Marin's Government 2019. Available at: https://valtioneuvosto.fi/marinin-hallitus/hallitusohjelma/liikenneverkon-kehittaminen. Accessed on 29.9.2020.

Finnish Ministry of the Environment. 2019. Kohti hiilipörssiä? Suomessa esitetyt hiilipörssiin liittyvät aloitteet tutkimuskirjallisuuden ja kansainvälisten kokemusten valossa. Ympäristöministeriön julkaisuja. Vol. 2019:17.

I4CE. 2019. Domestic carbon standards in Europe: Overview and perspectives. Available in: https://www.i4ce.org/wp-core/wp-content/uploads/2020/02/0218-i4ce3153-DomecticCarbonStandards.pdf

IMO. 2020. Fourth IMO Greenhouse Gas Study.

Norwegian law on aviation mandate. FOR-2019-04-30-555. Available at: https://lovdata.no/dokument/LTI/forskrift/2019-04-30-555. Accessed on 29.9.2020.

Shi, Y. 2016. Reducing greenhouse gas emissions from international shipping: Is it time to consider market-based measures? Marine Policy. Vol. 64. Pp. 123-134.

STX. 2020. Biokraftstoffquoten pricing. Accessed on 20.11.2020.

Swedish Government Official Reports. 2019. Betänkande av Utredningen om styrmedel för att främja användning av biobränsle för flyget. SOU 2019:11. Available at: https://www.regeringen.se/493238/contentassets/6d591e58fd9b4cad8171af2cd7e59f6f/biojet-for-flyget-sou-201911

Thomson Reuters. The MSR: Impact on market balance and prices. Available at: https://ec.europa.eu/clima/sites/clima/files/docs/0094/thomson_reuters_point_carbon_en.pdf

Transport & Environment. 2020. Shipping body's climate plan 'ignores Paris Agreement'. Chris Bowers. Accessed on 18.11.2020. Available at: https://www.transportenvironment.org/news/shipping-body%E2%80%99s-climate-plan-%E2%80%98ignores-paris-agreement%E2%80%99

VTT. 2020. ALIISA vehicle fleet model. Available at: http://lipasto.vtt.fi/aliisa/index.htm. Accessed on 10.11.2020.