

**Summary of study no. 2022-04
Carbon markets and links with LCA: limitations, calculation
methods and use in LCA**

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Introduction

Global carbon markets, whether regulatory or voluntary, have existed and been seen for several decades as an integral part of the fight against climate change. Their objective is to accelerate the pace of decarbonisation and adaptation of territories, organisations and individuals. The first regulatory markets created following the signing of the Kyoto Protocol helped to launch a dynamic across the signatory countries to reduce their greenhouse gas (GHG) emissions through the allocation of "carbon quotas", based on carbon accounting reports within value chains. At the same time, a similar process has been organised on a voluntary basis by organisations, with the funding of carbon avoidance and sequestration projects, in this case outside their value chains.

The state of the art of carbon markets reveals methodological shortcomings with regard to the global challenges facing humanity, which call into question existing principles. The concept of planetary limits is becoming an essential dimension to be integrated into environmental methodologies. The analysis carried out in 2023 by the French General Commission for Sustainable Development shows that 6 out of 9 limits have already been crossed, 2 of which present critical thresholds that could tip the Earth system over the edge: climate change and the loss of biodiversity.

The aim of this study, which focuses on life cycle assessment (LCA) and more specifically on organisational LCA (O-LCA) and the potential links with carbon markets, is to identify how these LCA methodologies, which are recognised as being objective, could on the one hand provide elements to improve the robustness and credibility of these markets, and on the other hand guide organisations wishing to use LCA and/or carbon markets in their decarbonisation strategy.

This report is divided into four distinct parts:

- Part 1 provides an overview of existing carbon market mechanisms, analysing voluntary and regulatory markets in the EU, California, China and Tokyo;
- Part 2 examines the place of LCA-O methodology in these markets, highlighting its advantages, benefits and potential for interaction;
- Part 3 assesses developments in the carbon markets, particularly in terms of the nature of the projects financed (sequestration, avoidance, reduction, etc.), the growth sectors (e.g. technology sinks, renewable energies, etc.) and the financing mechanisms. It also describes a number of environmental assessment approaches currently being developed based on LCA, such as project footprinting, dynamic LCA and social LCA, whose use seems relevant in view of the issues addressed in projects on the carbon markets (co-benefits on society, geographical and temporal extent of effects, etc.);
- Finally, the last section provides recommendations for improving the integration of LCA into carbon market mechanisms and analyses the benefits of integrating LCA for assessing the relevance of these projects.

A set of key concepts is presented to help readers understand the issues. These include the concepts of reduction, residual emissions, avoidance, offsetting of GHG emissions, contribution to carbon neutrality, specifying that of "net zero" or "zero net emissions", and definitions such as the right to emit CO₂eq (allowances), the global carbon budget and Nationally Determined Contributions (NDCs).

State of the art of carbone markets

Compliance (or regulatory) carbon markets

In 1997, at the 3rd United Nations Convention on Climate Change, an international agreement was signed to reduce greenhouse gas emissions: the Kyoto Protocol. Its aim is to reduce emissions of six greenhouse gases by 5% between 2008 and 2012¹, compared with 1990 levels: CO₂, CH₄, N₂O and three categories of fluorinated compounds (HFCs, PFCs and SF₆).

Several years passed before a consensus was reached between the parties and the rules for implementing the Protocol were defined, specifying the commitments to be met and the penalties to be applied in the event of non-compliance. This marked the birth of compliance carbon markets based on three so-called "flexibility" mechanisms to enable nations to meet their targets: the International Trading System (ITS), the Joint Implementation (JI) mechanism, the Clean Development Mechanism (CDM) and a 4th independent mechanism called the "domestic project". Each of these four mechanisms is explained in the report. The aim of these markets is to encourage a collective contribution to global efforts to combat climate change.

Compliance carbon markets, also known as regulatory markets, are based on a fundamental principle: the right to emit a given quantity of GHGs, defined by the allocation of emissions "quotas" to the emitters concerned. The quantity of "quotas" to be distributed depends on the cap set by the State, or group of States, setting up the market. The cap on GHG emissions not to be exceeded is based on the results of an assessment of GHG emissions in the territory in question over a given year. The quantity of emissions "quotas" that can be allocated must correspond to a lower level of emissions than that calculated as the cap and used as the reference year. Emitters must report to the public authority on their compliance by submitting a volume of quotas equivalent to their emissions during this period. Emitters must submit inventories of their emissions and justify the balance between their allowances and their emissions to the public authority. Transactions can take place on an organised market or over-the-counter, must be completed within a timeframe specified by the market, and penalties are imposed for non-compliance.

An emblematic example of these compliance markets is the EU ETS, the largest carbon 'quotas' market in the world, launched in 2005 in response to the Kyoto Protocol targets, paving the way for similar schemes in other countries. Regulatory markets established in California, China and Tokyo are also presented and detailed in the report.

However, the international economic crisis of 2008 had a profound impact on the activity of these markets, due to major relocations from industrialised countries to developing countries not covered by these regulatory markets at the time. This led to a general drop in GHG emissions, a fall in the price of a tonne of CO₂e with an oversupply of 'quotas', and a withdrawal of commitment on the part of manufacturers to reduce their GHG emissions. Free "quotas" have been allocated to certain manufacturers to prevent "carbon leakage".

In addition to the economic factor, other problems intrinsic to the very operation of market mechanisms remain, such as the scope of these systems (few sectors of activity concerned), the divergent political ambitions of the States concerned, the procedures for allocating "quotas" and the financial value awarded for 1 tonne of CO₂e.

¹ On 8 December 2012, the Kyoto Protocol will be extended until 2020

The Paris Agreement and international initiatives

The Paris Agreement, signed in 2015 at COP21, marks a major turning point towards a low-carbon global economy with the aim of limiting global warming to well below 2°C compared with pre-industrial levels and continuing efforts to 1.5°C. Article 6 of the Paris Agreement is intended to replace the mechanisms proposed under the Kyoto Protocol. Discussions are still underway on how certain mechanisms should evolve, and in particular on possible bridges.

Against this backdrop, the Science Based Targets (SBTi) initiative has been launched to help companies commit to this international effort. Its aim is to provide a science-based framework for companies to set GHG emission reduction targets aligned with the objectives of the Paris Agreement.

Since 2021, SBTi has aimed to encourage companies to contribute to carbon neutrality by 2050 with robust, verifiable and science-based commitments. To achieve this, the benchmark has introduced Net-Zero criteria that include: absolute emissions reductions across the organisations' value chain, investment in carbon sequestration projects for residual emissions, the definition of intermediate targets (short and medium term), a sectoral approach, a demonstration of consistency with 1.5°C scenarios, justification for the elimination of GHG emissions and a guarantee of transparency in their commitment by publicly reporting on their progress towards their Net-Zero targets with validation of the targets by SBTi. However, it should be noted that the emissions avoided by organisations working on carbon-free products and services are not valued. The carbon sequestration projects recommended by SBTi are part of voluntary carbon markets.

The voluntary carbon market

The voluntary carbon market is emerging as a crucial response to today's climate challenges. Contextualised by the IPCC's sixth report, which highlights the urgent need to drastically reduce CO₂ emissions, this market is positioned as a major lever for action for companies wishing to contribute to carbon neutrality. It complements compliance markets by enabling voluntary organisations to contribute to achieving a global balance between anthropogenic emissions and sources of absorption.

Like the regulatory carbon markets, which operate on a system of "quota" trading based on the GHG emission reports submitted by the organisations concerned, the voluntary carbon market is based on the financing of GHG emission reduction or sequestration projects within (in-setting projects) or outside (off-setting projects) the value chain of the financing organisation in exchange for what are known as "carbon credits".

This balance is achieved in part by sequestering carbon through so-called "natural" sinks, by funding initiatives such as mangrove restoration, sequestration in agricultural soils, tree planting and so on. It can also be achieved through so-called "technological" sinks, with CO₂ capture and storage projects, such as CO₂ mineralisation, biochar spreading, etc. In addition to carbon sequestration projects, the voluntary market also covers avoidance (also known as reduction) projects, which encompass a range of initiatives such as renewable energy production solutions, energy efficiency, sustainable forest management, reduction of methane emissions from landfill sites and recycling projects.

This voluntary market includes specific project development mechanisms, such as CDMs and REDD+ projects. The CDM, created as part of the Kyoto Protocol, aims to encourage organisations to finance reduction projects outside their value chain in developing countries. REDD+ projects, on the other hand, specifically aim to reduce deforestation and forest degradation in developing countries, offering a dual opportunity to reduce emissions and preserve biodiversity.

The allocation of carbon credits to financing organisations is decided by project certification bodies, more commonly known as "standards". The best known are Gold Standard, VERRA, ACR, Plan Vivo, Label Bas Carbone (only in France) and Climat Action. The role of these standards is to guarantee the

quality of the projects and compliance with the four fundamental criteria for carbon 'credits'²: the additionality of the project (climate, financial, regulatory), permanence (reduction or sequestration), measurability (following a recognised methodology) and verification that the project has been properly implemented by an independent third party (during the life of the project).

Many organisations use carbon 'credits' as part of their decarbonisation drive, and many use the carbon neutrality contribution (or offset) for marketing purposes, combined with a lack of transparency, without necessarily committing to real structural changes (detailed transition plan) to reduce their own emissions in line with scientific recommendations. To meet the objectives of the Paris Agreement, immediate and substantial action is needed to reduce GHG emissions worldwide. Efforts must focus initially on real reductions rather than offsetting, to ensure a sustainable transition to a low-carbon economy.

More generally, carbon offsetting, which is widely used, remains controversial, particularly because of questions about the permanence of projects, the use of questionable evaluation methodologies resulting in potentially undeserved carbon credits (e.g. the "phantom credits" scandal), poor management in host territories (depriving local populations of land, means of subsistence, etc.) and the lack of regulation and transparency that undermines the credibility of this market. It therefore seems essential to rigorously assess the social and environmental impact of these contribution projects. A diversification of projects, focusing on the preservation of biodiversity and support for local communities, is necessary for a transition towards fair and sustainable carbon neutrality.

Finally, the "Global Carbon Budget 2023" report published by the international team of researchers at the Global Carbon Project in December 2023 reveals an increase in global CO₂eq emissions of 1.1% compared with 2022, for a total of 36.8 GtCO₂e from the use of fossil fuels and 4.1 GtCO₂e from changes in land use, mainly deforestation. In order to achieve the objectives of the Paris Agreement, it is crucial to balance anthropogenic emissions with carbon sequestration sinks by 2040.

Although carbon markets have great potential for facilitating this transition, their results have been limited. For example, in 2022, the voluntary carbon market accounted for just \$1.2 billion, equivalent to mitigating just 0.39% of 2023 emissions. These figures raise concerns about the effectiveness of existing systems in limiting global warming in line with the targets set out in the Paris Agreement. At present, there is a 50% chance that global warming will exceed 1.5°C in the next 7 years.

How could the principles of life cycle assessment and associated methodologies improve the robustness and credibility of these markets and guide organisations wishing to use LCA and/or carbon markets in their decarbonisation strategy?

Current links with LCA practice

The benefits of LCA-O for decision support

Life Cycle Assessment, or environmental LCA, emerged in the 1960s and gained international recognition with the ISO standards of the 2000s. Now widely recognised, it continues to evolve methodologically in order to incorporate scientific advances, meet society's current challenges and assess the effectiveness of the solutions put in place. In fact, LCA is increasingly used by public decision-makers and organisations to facilitate decision-making in favour of environmentally-friendly projects. The method has thus become essential for assessing the environmental impact of products (goods and services) placed on the market.

At the level of organisations, the use of so-called organisational LCA (O-LCA) remains marginal. The approach of quantifying GHGs at the level of organisations (BEGES in France) remains the dominant

² One carbon credit is equivalent to 1 t CO₂e

and widely used method, particularly in the context of allocating "quotas" from compliance contracts. Examples of LCA-O implementation have mainly occurred in companies that already have experience with product LCA, and that wish to integrate environmental performance into their corporate strategy.

However, LCA-O has had a dedicated standard since 2014, ISO 14072, specifying guidelines and a framework for its application. At the same time, in 2013, the European Commission drew up recommendations to harmonise methods for measuring and communicating the environmental performance of products and organisations, with an update due in 2019. Finally, in 2015, UNEP-SETAC was published to help organisations implement the principles set out in ISO 14072.

The specific features of LCA-O are based on principles similar to those of LCA of products (goods and services), but with key differences in the definition of the objectives and systems studied. LCA-O does not define a functional unit as such; the unit of analysis is the organisation itself, as are the flows. Product LCA studies reference flows, while LCA-O studies reporting flows (generally a reference year) which include all the organisation's products during the reference period.

The methodology must take into account the diversity of activities and stakeholders within the organisation. Consolidation methodologies, such as financial control, operational control and share, determine which parts of the organisation should be included in the analysis. This is similar to the allocation of co-products in product LCAs.

In addition, LCA-O must take into account both the direct and indirect activities of the organisation, as well as the upstream and downstream phases of its life cycle.

LCA-O is a relevant and comprehensive tool for assessing and improving the environmental performance of organisations in line with international standards and best practice. Like methods based on the quantification of GHG emissions, it makes it possible to distinguish between direct and indirect impacts across the entire value chain, based on an analysis of all the organisation's products and activities over a reference period. It also has other advantages:

- It enables a multi-criteria approach to be adopted, by identifying potential transfers between categories of environmental impact;
- It provides a quantified understanding of the environmental impact of decisions taken at the organisational level by analysing not only the organisation's operations, but also its upstream and downstream activities. The results can then be used to identify the specific areas of the supply chain and operations that are responsible for the greatest impacts, enabling specific processes to be targeted;
- LCA-O is particularly relevant for organisations with a large portfolio of products, or companies wishing to take action involving operational processes, sites and activities within the company.
- Particularly when it comes to its use in the voluntary carbon market, LCA-O makes it possible to measure and integrate the impacts and benefits of this type of project into the company's overall performance. This seems particularly interesting for in-setting contribution projects, since they involve several activities and processes within the value chain.

Despite all these advantages, LCA-O is still less widespread than other approaches to environmental analysis, such as GHG emissions assessments or initiatives like the Greenhouse Gas Protocol (GHG Protocol), which focuses on the climate change indicator. This is due to the greater complexity of implementation compared with standardised GHG quantification methods, the absence of LCA experts in the departments responsible for organisational strategy, and the lack of a standardised framework for implementation (which databases, which impact method, which allocation methods, etc.).

However, as the European regulatory framework evolves to take account of a wider range of issues beyond the climate (such as governance, societal issues, biodiversity, etc.), there is growing interest in and adoption of LCA-O by organisations and public bodies, to help them make strategic decisions and promote a more sustainable society.

Links between LCA methods and carbon markets

The life cycle approach, whether in the context of LCA, LCA-O or GHG protocol, appears to be essential for identifying and monitoring projects financed by the carbon markets. While LCA focuses on products, LCA-O and GHG protocol focus on organisations. Here is a comparative summary of the characteristics of these approaches:

- In product LCA, the system analysed is defined in terms of the **product's function and characteristics**, whereas in LCA-O and GHG protocol, the focus is on the **reporting organisation and the consolidation methodology**;
- The **functional unit** is used to quantify the system's performance in product LCA, whereas in LCA-O and the GHG protocol, a **portfolio of products or activities and sites** is used;
- The flows analysed also differ, with **reference flows** in product LCA, **reporting flows** in LCA-O (similar to the product portfolio) and **activity flows allocated to sites** in the GHG protocol;
- Data collection methods also vary, with a preference for **product-specific data** in the Product LCA, more **generic data** in the LCA-O, and the use of **generic or extrapolated data** in the GHG protocol;
- As far as impact assessment is concerned, the same methods are used for LCA and LCA-W once the inventory has been compiled, whereas the GHG protocol uses only the IPCC method (100 years);
- In terms of interpretation and uncertainty, a **sensitivity analysis** is common in LCA and LCA-O, while qualitative uncertainties are attributed to primary data and quantitative uncertainties only to secondary data (e.g. BDD) in the GHG protocol;
- Finally, with regard to reporting and communication, whether it is an LCA-O or a GHG protocol, it is first and foremost an assessment designed to improve the company's performance over time, and comparison is not encouraged.

Under the voluntary carbon market, in order to obtain carbon credits, GHG emission avoidance or sequestration projects must be certified or labelled according to specific methodologies. More and more methodologies are based on single-criteria LCA principles and methods (impact on climate change).

LCA is also beginning to appear in regulatory frameworks, such as the EU's RED II directive, which requires a rigorous environmental assessment, including the reduction of GHG emissions measured by an LCA approach. This directive reinforces the importance of considering the full life cycle of renewable energy sources when assessing their environmental performance.

New standards for generating carbon credits are emerging, such as Riverse, which incorporate LCA-based methodologies for calculating avoided or stored emissions, thereby ensuring a degree of methodological robustness and credibility for the allocation of carbon credits.

Other organisations, such as SustainCERT, also offer LCA-based accounting methods, making it possible to trace emissions reductions throughout a company's value chain, thereby avoiding double counting and encouraging investment in decarbonisation.

LCA plays a crucial role in promoting sustainable practices and improving carbon market mechanisms by providing robust methodologies and comprehensive assessment frameworks. However, certain methodological difficulties and a lack of a standardised framework are holding back its adoption. The main methodological difficulties are as follows:

- The definition of the baseline scenario, which enables the relevance of a project to be assessed;
- The question of temporality: most of the projects financed by the voluntary carbon market are biogenic carbon sequestration projects, for which the duration of additional carbon storage is essential (risks of possible rapid destocking when the projects extend over several decades);

- The rules for attributing impacts and benefits, and the rules for allocating co-products/sub-products (to avoid double counting);
- Specific databases that are not royalty-free;
- Whether or not specific project characteristics are taken into account or whether inventory data is used, etc.

The definition of sector-specific methods, setting out precise rules for each stage of the evaluation process, seems necessary to help clarify the remaining ambiguities depending on the framework of application and to enable the relevance of projects submitted by project sponsors to be analysed. For example, for the Low Carbon Label, sector-specific methods are emerging, supported by third parties grouped together in consortia, to ensure that all project sponsors can implement the evaluation process, by applying similar principles and methodological requirements.

Finally, it is essential to stress that the voluntary carbon market is constantly evolving, with ongoing discussions aimed at improving methodologies and guaranteeing greater environmental integrity. This dynamic reflects the growing importance of this market in the transition to a low-carbon economy and the global fight against climate change.

To ensure the effectiveness and environmental integrity of these projects, certification bodies are putting in place rigorous methodologies, verifying criteria such as the additionality, measurability, permanence and uniqueness of carbon credits. However, challenges remain in the application of LCA in this context, due to the potential variability of results linked to methodological and interpretation choices.

Developments and outlook

Growing consideration of social issues

The social dimension in the fight against climate change has become a major imperative, as highlighted by the 6th IPCC report. To achieve the objectives of the Paris Agreement, it is crucial to drastically reduce GHG emissions and implement actions that strengthen the rights and livelihoods of local communities.

Companies must therefore set transparent targets for reducing their emissions and sequestering carbon, while ensuring that carbon offset projects respect the rights of local communities and are subject to social and environmental safeguards. The integration of a social dimension in the assessment of contribution projects is essential and could be inspired by the principles of social LCA (S-LCA).

Social risks can be assessed using tools such as the Social Hotspot Database (SHDB), which identifies social impact "hotspots" by country and sector. By integrating this social dimension, it is possible to identify and prevent negative impacts on local communities, such as forced displacement, child labour or corruption.

In the context of the voluntary carbon market, the use of LCA-S principles in the development of methodologies for avoidance and sequestration projects would make it possible to broaden the assessment of environmental benefits while limiting social damage.

The co-benefits generated by contribution projects

Carbon projects have potentially major co-benefits for society, local populations and biodiversity. By focusing on the potential for GHG sequestration/reduction/avoidance, these effects are not taken into account, or are poorly taken into account, in the decision-making process.

However, the overall environmental dimension, over and above the effects on the climate, is a decisive criterion in assessing the relevance of a project.

The Project Footprint method, developed by ADEME in 2021, would appear to be an interesting approach for application to projects financed by the carbon markets. This method uses a progressive and iterative approach to identify, qualify and then quantify the effects induced and avoided by a project. Although designed to assess environmental impacts, this method is based on the preliminary construction of a tree of consequences, which may be environmental, but also of a socio-economic or societal nature. In the environmental field, aspects such as the consequences on ecosystem services can also be included alongside the effects induced by the physical flows traditionally studied in LCA.

The temporality and permanence of GHG emissions and impacts

The methods used to calculate the potential for sequestration and/or avoidance of GHG emissions are generally not very robust when it comes to dealing with the problem of permanence. For a credit to be valid, the sequestration capacity must be effective over time. However, particularly for sequestration projects using natural sinks, time is a decisive factor in the methodological evaluation parameters.

To meet this methodological challenge, the introduction of dynamic LCA in projects, which takes into account the temporality of GHG emissions, would be relevant for assessing the effectiveness of carbon sequestration projects over the long term.

In conclusion, an integrated approach to LCA, combining social, environmental and temporal elements, would make it possible to guarantee a fair and sustainable ecological transition, while reducing social inequalities and preserving the rights of local communities.

Recommendations

The study provides methodological improvements for the voluntary carbon market and practical recommendations for companies. Some examples of recommendations are listed below:

- Favour "in setting" projects, carried out within the organisation's value chain, in order to have better control over project implementation;
- Ensure transparency in its communications by providing tangible and transparent informations on its progress in reducing emissions and sequestering carbon, while acknowledging its responsibility;
- Use the LCA approach in contribution projects, to value the co-benefits induced by carbon projects. In particular, the implementation of a Project Footprint, combined with dynamic LCA, would seem to be of interest for understanding all the specific features of these projects;
- Raising awareness, thanks to LCA practitioners who play a crucial role in educating companies about environmental and social issues;
- Collaborate and promote the sharing of knowledge between LCA specialists and climate experts: the implementation of LCA-O would be a concrete opportunity for climate and LCA teams to work together. In addition, LCA-O makes it possible to assess a company at different levels, from product production to all of its activities.

In this way, LCA-O is a powerful tool for bringing together climate and LCA expertise in joint projects, to help transform activities and organisations as a whole. Companies with LCA teams and a climate department could be good ambassadors for contributing to the growth of LCA-O.

Furthermore, by using LCA methodology rather than approaches based strictly on GHG quantification, companies could promote the co-benefits of projects financed by the carbon market in a more robust and rigorous way. In particular, the implementation of the Project Footprint, adopting the LCA logic

while integrating other societal and environmental issues, and combining dynamic GWPs for carbon sequestration projects, could be a useful tool.

Finally, it seems important that methodological frameworks be developed to support organisations in implementing robust and comprehensive environmental assessment methods. This will require the development of calculation rules for each sector, the systematisation of the multi-criteria approach, and the provision of tools and databases that are both educational and transparent.

In the meantime, hybrid approaches appear to be a powerful way of helping to improve the implementation of project financing mechanisms.