

Calculating the Carbon Footprint of Potatoes in KMC TracelT

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1 Background

This document describes the sources, data, methodologies, and calculation principles used in the carbon footprint calculation in KMC TracelT. The purpose is to ensure transparency, traceability, and a consistent understanding of the underlying data, including data sources, assumptions, emission factors, and calculation methods.

The carbon footprint is calculated using a methodology shared across SEGES Innovation's digital platforms, including ESGreenTool, TracelT, and Field Online. This version of the calculation has been updated to follow the *GHG Protocol Land Sector and Removals Guidance Draft for Pilot Testing and Review (September 2022)*, including requirements related to land management non-CO₂ emissions and land use change.

1.1 System Boundary

The system boundary is defined as cradle-to-farm gate. The assessment includes upstream emissions from the production and transport of agricultural inputs, as well as on-farm emissions associated with potato cultivation.

Activities occurring after the farm gate are excluded from the assessment, including transportation, processing, packaging, distribution, retail, and product consumption.

The calculation covers the most significant emission sources associated with potato cultivation, including crop codes 151 (starch potatoes) and 155 (potatoes for powder/granules). The emission sources included in the calculation are described in this document.

1.2 Inventory boundary

The inventory includes all material greenhouse gas emissions associated with potato production within the defined system boundary.

Included on-farm emission sources are:

- Direct N₂O emissions from fertiliser application
- Indirect N₂O emissions from leaching, volatilisation and crop residue
- CO₂ emissions from cultivated organic soils
- CO₂ emissions from lime application
- CO₂ emissions from burning of fuel

In addition, relevant upstream emissions are included, such as emissions associated with the production and transport of:

- Mineral fertilisers
- Pesticides
- Seed potatoes

- Fuel
- Electricity
- Plastics
- Capital goods

Statistical land use change (sLUC) emissions are also included using the product expansion method, applying a 20-year lookback period and linear amortisation.

The inventory boundary is limited to emissions attributable to potato cultivation and excludes downstream activities occurring after the farm gate, such as transportation, processing, packaging, distribution, retail, and consumption. Consistent with the current scope of this calculation, changes in soil organic carbon stocks, carbon removals, and potential leakage effects are not included in the inventory.

1.3 Activity data

Activity data are based partly on field-specific information registered by individual farms and partly on secondary sources, including national statistics and analyses conducted by SEGES Innovation.

KMC has full traceability of its supplying farms, enabling emissions to be modelled using primary data wherever possible. The primary source of activity data is the Danish Field Database (Dansk Markdatabase), which is operated and maintained by SEGES Innovation. The database enables farmers to record and store detailed production data, including crop production, fertiliser applications, and management practices. Farm-level data are not shared with third parties without prior consent from the farmer. Consent management is administered through KMC TracelT.

1.4 Calculation updates

The methodologies and underlying datasets are continuously updated as new research findings or improved data become available. Consequently, the carbon footprint calculation in TracelT may be adjusted over time due to changes in parameters, emission factors, or underlying datasets. In the case of significant updates to the calculation methodology, TracelT users will be informed.

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2 Emission Sources

2.1 Direct Nitrous Oxide Emissions from Mineral Fertiliser

Nitrous oxide emissions associated with application of nitrogen in mineral fertiliser is calculated based on the applied amount of nitrogen.

Activity data: Danish Field Database, SEGES Innovation
N₂O emission factor: IPCC, 2006
GWP100 N₂O: 2019 Refinement to the 2006 IPCC Guidelines

2.2 Direct Nitrous Oxide Emissions from Livestock Manure and Other Organic Fertilisers

Nitrous oxide emissions associated with application of livestock manure and other organic fertilisers is calculated based on the applied amount of total nitrogen. Plant-available nitrogen in the nutrient plan is converted to total nitrogen using the fertiliser utilisation factor.

Activity data: Danish Field Database, SEGES Innovation
N₂O emission factor: IPCC, 2006
GWP100 N₂O: 2019 Refinement to the 2006 IPCC Guidelines

2.3 Nitrification Inhibitors

Nitrification inhibitors may be applied with both livestock manure and mineral fertiliser. For fertiliser applications where the use of a nitrification inhibitor is registered in Mark Online, nitrous oxide emissions are assumed to be reduced by 40% of the potential nitrous oxide emissions from both mineral fertiliser and livestock manure.

Activity data: Danish Field Database, SEGES Innovation
Emission factor: Olesen et al., 2018

2.4 Production and Transport of Mineral Nitrogen Fertiliser

Emissions from nitrogen fertiliser production are calculated based on the amount of nitrogen applied in mineral fertilisers and a generic emission factor.

Activity data: Danish Field Database, SEGES Innovation
Emission factor: BAFU, 2025

2.5 Production and Transport of Phosphorus Fertiliser

Emissions from phosphorus fertiliser production are calculated based on the amount of phosphorus applied and a generic emission factor.

Activity data: Danish Field Database, SEGES Innovation
Emission factor: BAFU, 2025

2.6 Production and Transport of Potassium Fertiliser

Emissions from potassium fertiliser production are calculated based on the amount of synthetic potassium applied and a generic emission factor.

Activity data: Danish Field Database, SEGES Innovation

Emission factor: BAFU, 2025

2.7 Production and Transport of Pesticides

Emissions from the production and transport of pesticides are based on pesticide use in potatoes, expressed as kilograms of active ingredient per hectare, and a generic emission factor.

Activity data: Danish Pesticide Statistics, Danish Environmental Protection Agency

Emission factor: BAFU, 2025

2.8 Seed Potatoes

Emissions from the production and transport of seed potatoes are included using a standard application rate of 2,300 kg seed potatoes per hectare and a generic emission factor.

Activity data: Estimate provided by SEGES Innovation

Emission factor: BAFU, 2025

2.9 Lime

Emissions from lime application are included as a standard value based on annual statistics on agricultural lime consumption.

Activity data: Annual statistics on agricultural lime consumption

Emission factor: IPCC, 2006

2.10 Nitrous Oxide from Crop Residues

To estimate emissions from crop residues, residues are divided into aboveground and belowground biomass. For both pools, dry matter production and nitrogen content are estimated.

Activity data: Danish Field Database, SEGES Innovation

Emission factor: 2019 Refinement to the 2006 IPCC Guidelines

2.11 Nitrous Oxide from Ammonia Volatilisation and NO_x Emissions

Indirect nitrous oxide emissions from ammonia and NO_x emissions are calculated based on estimated ammonia volatilisation and NO_x emissions from fertilisers and a standard emission factor.

Activity data:	Danish Field Database, SEGES Innovation
NH ₃ emission factor:	Nielsen et al., 2023
NO _x emission factor:	EMEP Guidebook 2019
N ₂ O emission factor:	IPCC, 2006
GWP100 N ₂ O:	2019 Refinement to the 2006 IPCC Guidelines

2.12 Nitrous Oxide from Nitrate Leaching

A standard value for nitrogen leaching per crop is applied to estimate nitrous oxide emissions associated with nitrate leaching.

Activity data:	Danish Field Database, SEGES Innovation
N ₂ O emission factor:	IPCC, 2006

2.13 Organic Soils

According to the IPCC (2006), soil is organogenic if the carbon content in the soil is greater than 20 %. This corresponds to a humus content of 35 %. There is no Danish survey of areas with a carbon content above 20 %. However, in Denmark we categorize soils as carbon rich, if the soils have a carbon content above 6 %, which corresponds to 10 % humus.

To estimate CO₂e emissions from carbon-rich soils, an emission map published by Aarhus University (AU) is used. The map divides all of Denmark into a pixel grid of 10 × 10 meters. For each of these ~22 million pixels, an annual CO₂ emission has been calculated by Aarhus University. This emission map is combined with field polygons for each individual field, and CO₂ emissions per field are therefore calculated as the sum of the emissions from the pixels that fall within a given field polygon.

Activity data:	Danish Field Database, SEGES Innovation
Emission factor:	Nielsen, et. al., 2026

2.14 Fuel

The fuel-consumption is estimated as liters per hectare per crop.

Activity data:	Estimate provided by SEGES Innovation
Emission factor:	ISCC EU 205 Greenhouse Gas Emissions

2.15 Waste

Emissions from the production and end-of-life treatment of plastics are estimated based on nitrogen fertiliser and pesticide use per hectare.

Activity data:	Danish Field Database, SEGES Innovation
Emission factor:	BAFU, 2025

2.16 Electricity

Electricity consumption for irrigation and cooling is estimated based on the following assumptions:

- All fields identified in the Danish Field Database as irrigable are assumed to receive 100 mm of irrigation per hectare per year.
- For potatoes for powder/granules (crop code 155), cooling is assumed. For starch potatoes (crop code 151), no storage-related electricity use is assumed.

Activity data: Estimate provided by SEGES Innovation

Emission factor: BAFU, 2025

2.17 Capital Goods

Capital goods are estimated as 0.3 kg tractor per kg diesel consumed.

Activity data: Estimate provided by SEGES Innovation

Emission factor: BAFU, 2025

2.18 Statistical Land Use Change (sLUC)

sLUC is calculated using the Product Expansion Method. A 20-year lookback period and linear amortisation are applied.

Activity data: FAOSTAT and National Inventory Document (Nielsen, et. al., 2026)

Emission factor: IPCC, 2026

2.19 Total Carbon Footprint per Hectare

The carbon footprint per hectare is calculated as the sum of all the emission sources described above.

2.20 Emission sources not included in the calculation

- *Land Management Net CO₂ Emissions and Removals* are not included due to ongoing methodological uncertainties and limitations in the underlying data.
- *Potential leakage effects*: Based on an assessment of KMC's operations in 2026, no activities have been identified that are expected to result in leakage, as defined in both the Draft Land Sector and Removals Guidance: Part 2. Calculation Guidance (2022) and the GHG Protocol Land Sector and Removals Guidance (Version 1.0) (2026). In accordance with Requirement 13 of the 2026 guidance, no high-leakage-risk activities are undertaken within KMC's inventory boundary.
KMC's primary outputs are food and feed products. Furthermore, no changes in cropland management, land management, or land use have been reported by participating farmers that would be expected to cause significant reductions in agricultural yields.

Consequently, there is no evidence that KMC's activities have displaced production or induced compensatory production increases outside the inventory boundary.

3 References

- Andersen, M.N., Adamsen, A.P., Lærke, P.E., Larsen, S.U., Jørgensen, U., Olesen, J.E., et al. 2024. Mitigation measures for reducing greenhouse gas emissions in agriculture 2024 (Virkemidler til reduktion af klimagasser i landbruget 2024). DCA – Danish National Centre for Food and Agriculture, Aarhus University.
- European Environment Agency (EEA). 2019. EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019. European Environment Agency.
- Federal Office for the Environment (BAFU). 2025. Database of the Swiss Federal Administration (BAFU), 2025 Edition. Bern, Switzerland: Swiss Federal Administration.
- Hansen, M.N. 2024. Annual Statistics on Agricultural Lime Consumption (Årlig statistik for kalkforbruget i landbruget). LandbrugsInfo.
- Intergovernmental Panel on Climate Change (IPCC). 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. IPCC.
- Intergovernmental Panel on Climate Change (IPCC). 2019. 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 4: Agriculture, Forestry and Other Land Use. IPCC.
- International Sustainability and Carbon Certification (ISCC). 2022. ISCC EU 205 Greenhouse Gas Emissions, Version 4.0. ISCC System GmbH.
- Danish Environmental Protection Agency. Latest available edition. Pesticide Use Statistics (Bekæmpelsesmiddelstatistik). Danish Ministry of Environment.
- Nielsen, O.-K., Plejdrup, M.S., Winther, M., Nielsen, M., Gyldenkerne, S., Mikkelsen, M.H., et al. 2023. Denmark's National Inventory Report 2023: Emission Inventories 1990–2021 Submitted under the United Nations Framework Convention on Climate Change. DCE – Danish Centre for Environment and Energy, Aarhus University. Scientific Report No. 541.
- Nielsen, O.-K., Plejdrup, M.S., Winther, M., Nielsen, M., Gyldenkerne, S., Mikkelsen, M.H., et al. 2026. Denmark's National Inventory Document 2026: Emission Inventories 1990–2024 Submitted under the United Nations Framework Convention on Climate Change and the Paris Agreement. DCE – Danish Centre for Environment and Energy, Aarhus University. Scientific Report No. 706.
- Olesen, J.E., Petersen, S.O., Lund, P., Jørgensen, U., Kristensen, T., Elsgaard, L., Sørensen, P. & Lassen, J. 2018. Mitigation Measures for Reducing Greenhouse Gas Emissions in Agriculture (Virkemidler til reduktion af klimagasser i landbruget). DCA Report No. 130. DCA – Danish National Centre for Food and Agriculture, Aarhus University.