promyc™

Environmental Impact Report

MYCORENA

Promyc Mycoprotein

Analysis Considerations

In the best case, Promyc is produced from industrial side-streams and byproducts rich in carbohydrates. In this way, resources that were destined to be waste become value without putting additional strain on the planet. We are reusing resources and increasing efficiency rather than creating more.

However, production from side-streams is not always possible due to the nature of them or to the process boundaries at the producing facility. We then can produce Promyc also from new feedstocks (such as starch) instead of using side-streams, and even in that case, Promyc is still a highly resource-efficient product as outlined in this report.

To accommodate for the two possibilities, we have calculated the different environmental impacts of our process in the two described scenarios:

Circular mycoprotein production (CMP): This is the production method where a company would use Mycorena's technology to produce mycoprotein using side-streams as a substrate. Although this might lead to a certain variability in terms of product yield and production rates, it is safe to assume that there is no relevant impact from substrate production (since the substrate is considered waste). This null impact from the substrate applies to the calculations of land use, water use and CO2e emissions.

Promyc: Promyc is produced from starch-like carbon sources. In this scenario, the impact of starch production is taken into consideration as we are using a new resource and not upcycling existing ones. This includes land and water used for this as well as CO2e emissions.

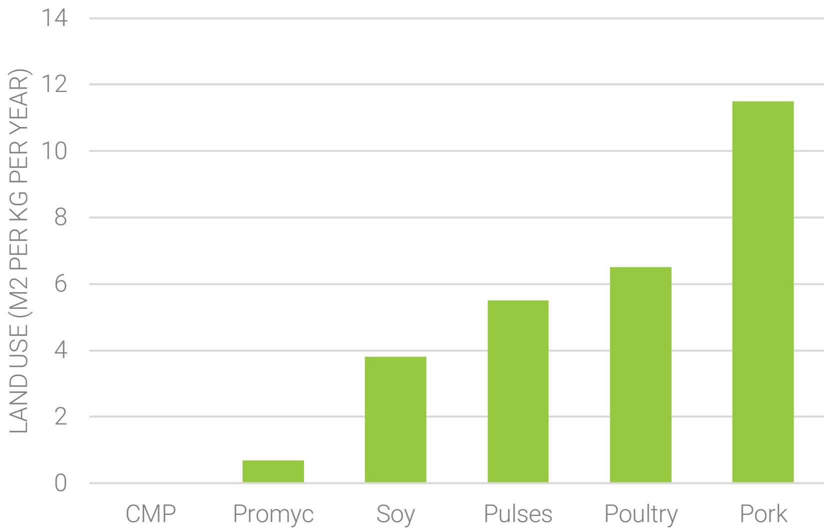
These calculations do not rely on LCA or extensive analysis but is rather an approach to estimated values in an industrial-scale scenario from iterated assumptions. For comparison to Promyc, published values from literature from typical protein-rich plant and animal products, such as soy, pork or beef were used.

Promyc Mycoprotein

Land Use

For calculating land use, we used and extrapolated real data from our process to a pilot production plant with a reactor volume of 10 m^3 using a 50 m^2 space considering the whole working facility (including production and processing).

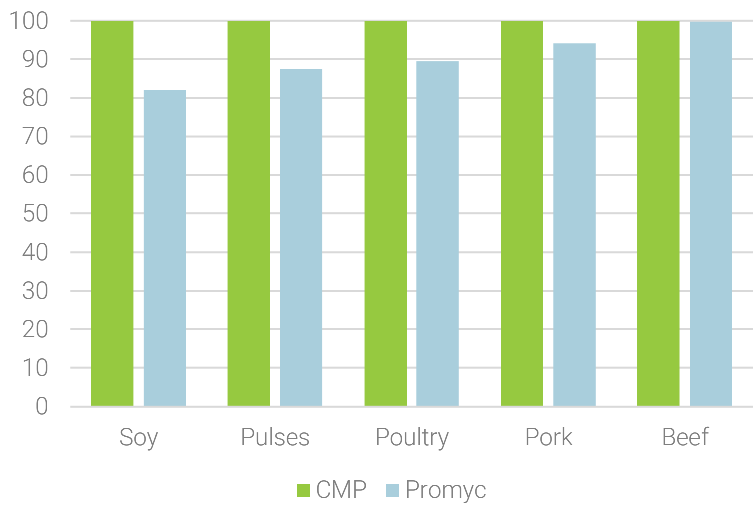
Total Land Use



	Land Use (m^2 per Kg per year)
CMP	0,002
Promyc	0.69
Soy	3,8
Pulses	5,5
Poultry	6,5
Pork	11,5
Beef	217,5

Land Use Savings (%)

	Promyc (circular)	Promyc (standard)
Soy	99,945	81.963
Pulses	99,962	87.538
Poultry	99,968	89.456
Pork	99,982	94.040
Beef	99,999	99.685



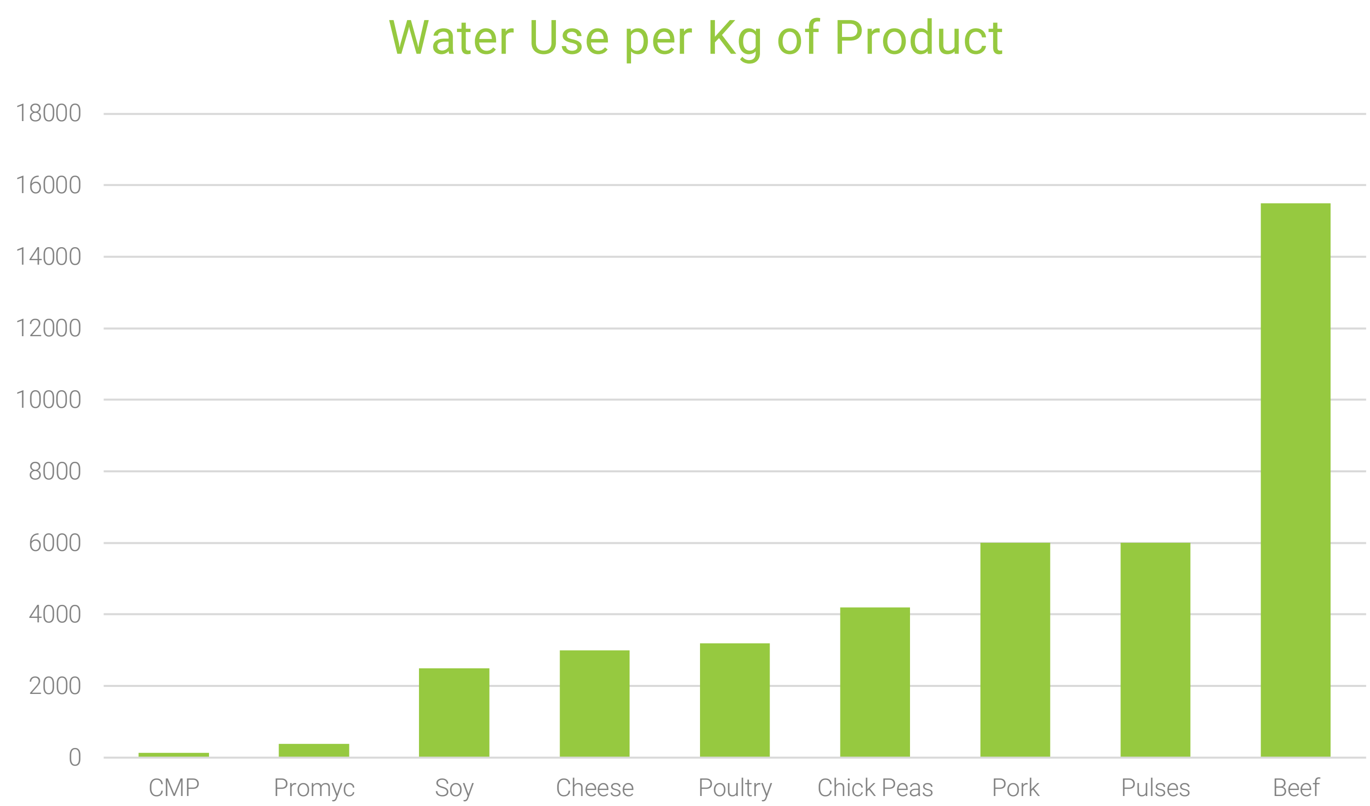
Data sources:

- Nijdam, D et al. 2012 The price of protein: Review of land use and carbon footprints from life cycle assessments of animal food products and their substitutes *Food Policy*
- FAO (https://ourworldindata.org/crop-yields)

Promyc Mycoprotein

Water Use

For calculating water use, we used data assuming a Promyc production in a reactor volume of 10 m3. The amount of used water for all the steps involved was estimated by using known values obtained from Mycorena's operations at smaller scales.



	Litres of Water per Kg
CMP	130
Promyc	377
Soy	2500
Cheese	3000
Pultry	3200
Chick Peas	4200
Pork	6000
Pulses	6000
Beef	15500

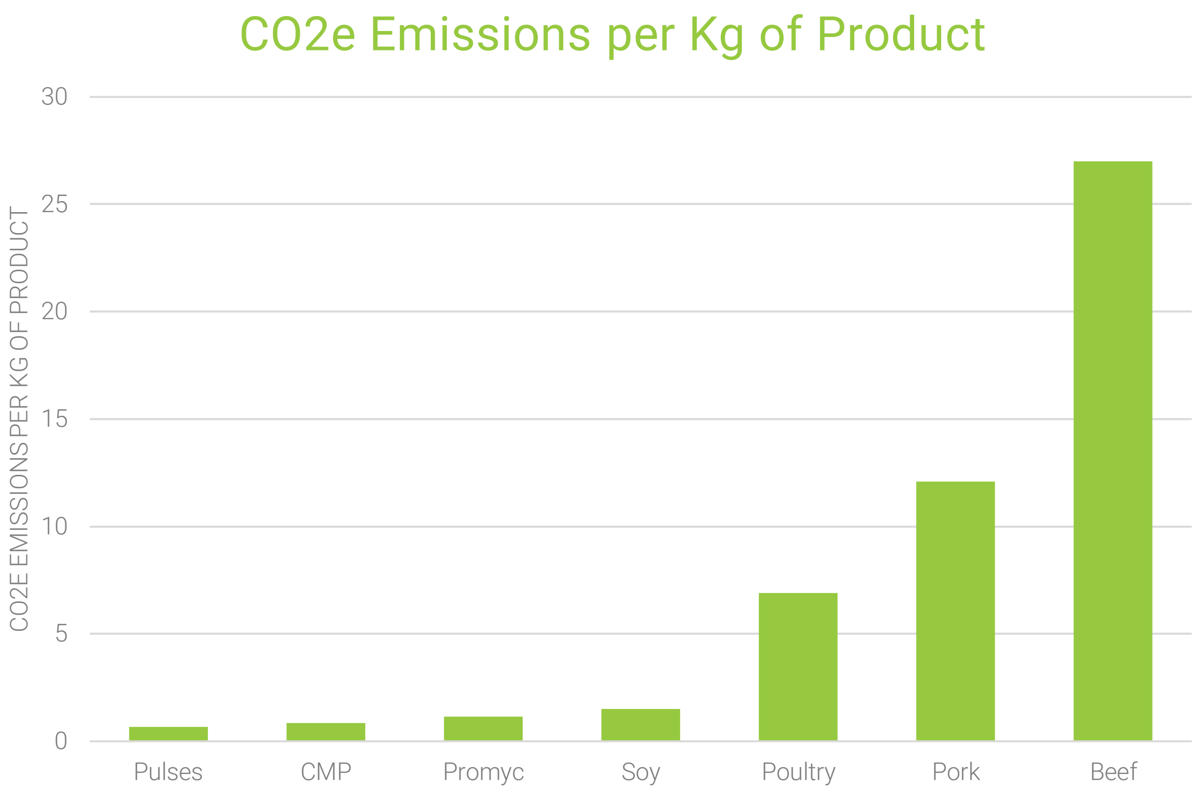
Data sources:

- https://waterfootprint.org/media/downloads/Report47-WaterFootprintCrops-Vol1.pdf

Promyc Mycoprotein

GHG Emissions

For these calculations, we started with determined values from Mycorena's lab-scale fermentation process and matched them against existing, published data on CO2e emissions of large-scale mycoprotein production. By comparing with data on the impact of substrate production, we adapted the calculations for CMP accordingly.



	Kg CO2e per Kg Product
Pulses	0,68
CMP	0,84
Promyc	1,14
Soy	1,49
Poultry	6,9
Pork	12,1
Beef	27

Main Data sources:

- Nidjam, et al. 2012 The price of protein: Review of land use and carbon footprints from life cycle assessments of animal food products and their substitutes *Food Policy*
- Clune et al., 2015 Systematic review of greenhouse gas emissions for different fresh food categories *Journal of Cleaner Production*

Application to the Swedish Market Case

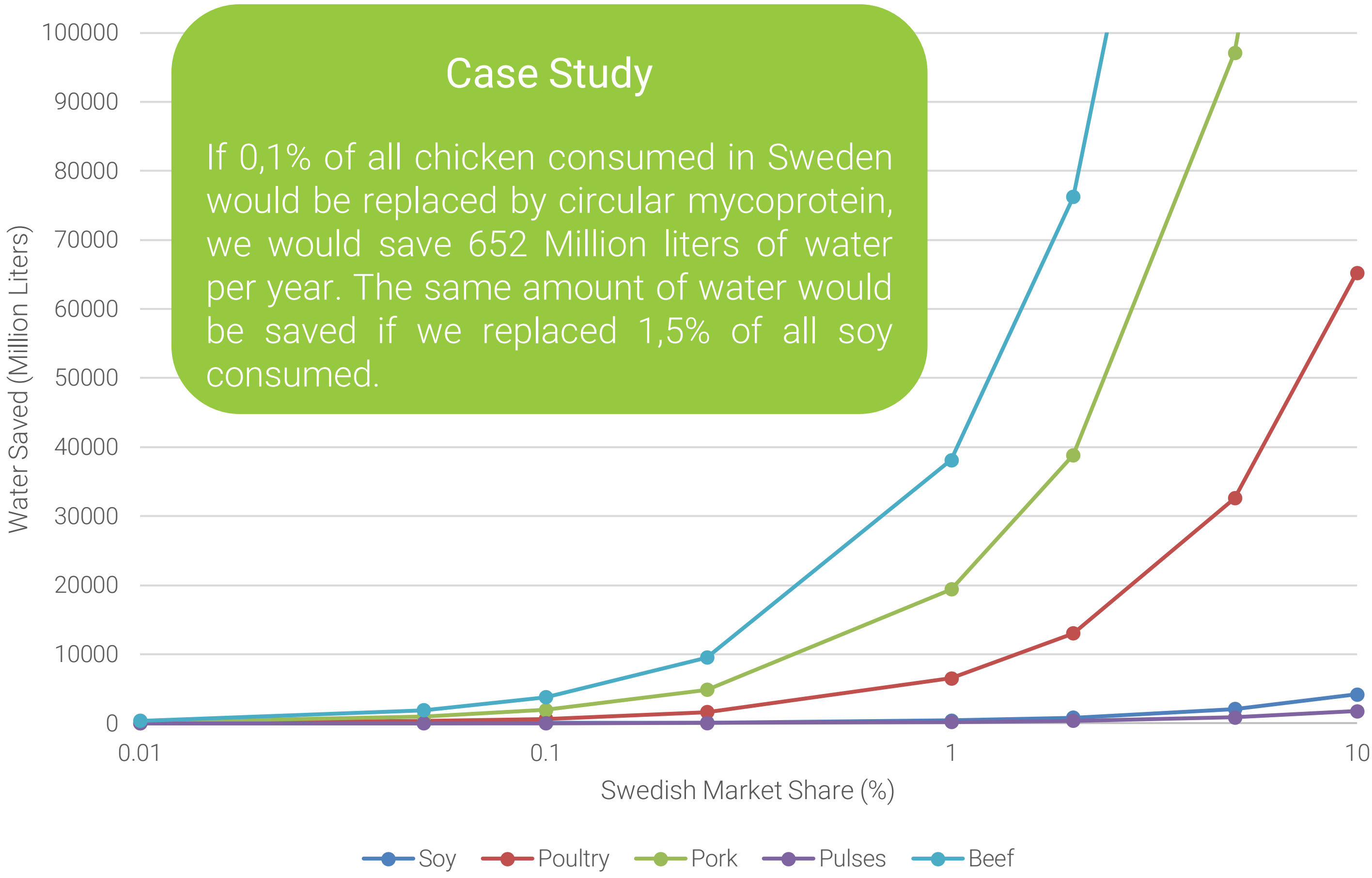
Environmental Impact

Swedish Protein Consumption

	Yearly Consumption (Kg) per capita	Total Consumption Sweden (avg, ton)	Water per Kg of Product (L)	CO_2e per Kg of Product (kg)
CMP	-	-	130	0,84
Soy	1.75	17710*	2500	1,5
Poultry	21	212520	3200	5,18
Pork	32.7	330924	6000	9
Pulses	0.3	3036	6000	0,68
Beef	24.5	247940	15500	27

** Assuming only soy used for direct consumption as food products. Excluding feed and soybean oil production, which accounts for 94% of all soy used in Sweden.*

Water Use Impact by Percentage of Market Replaced



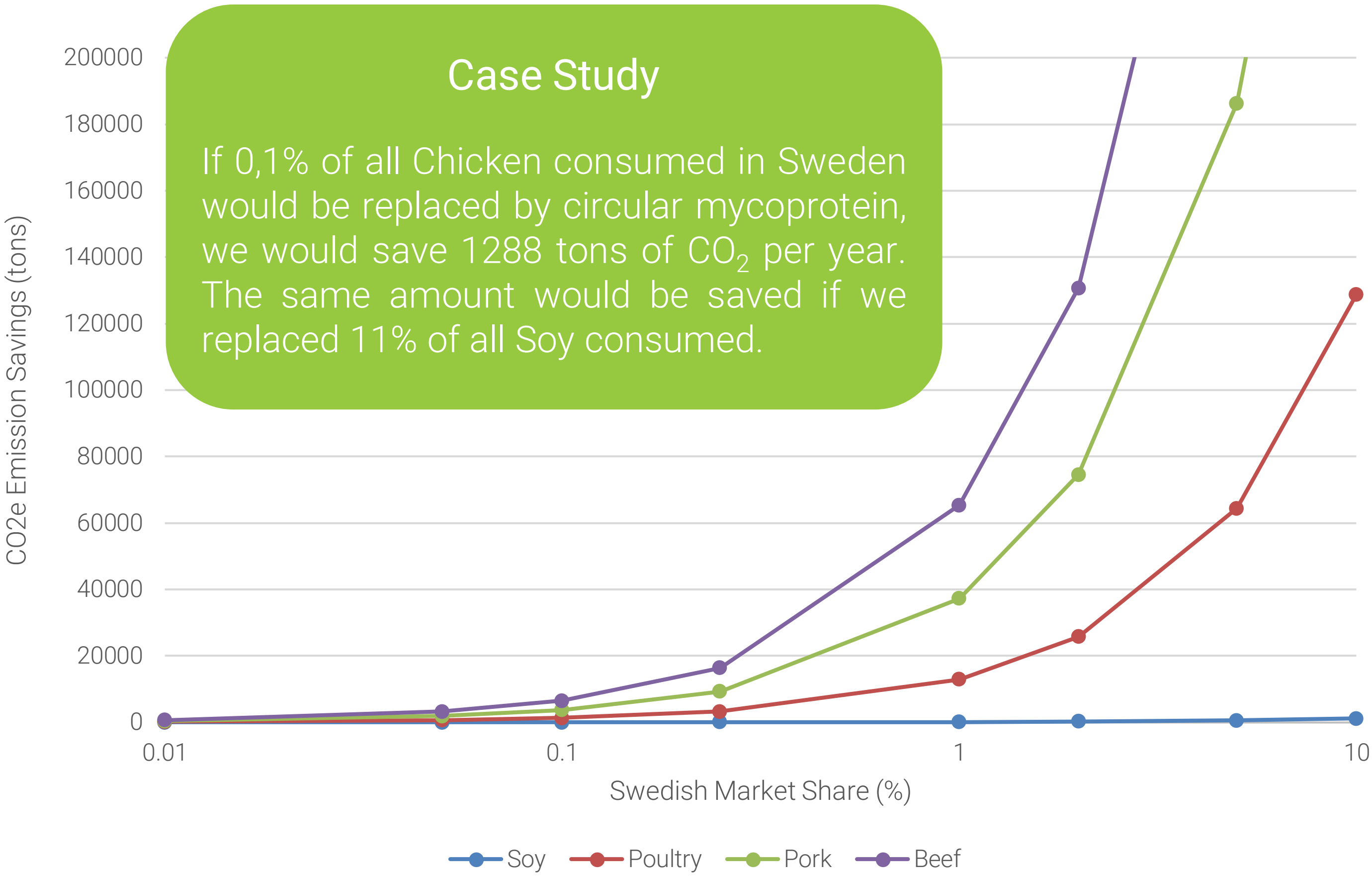
Case Study

If 0,1% of all chicken consumed in Sweden would be replaced by circular mycoprotein, we would save 652 Million liters of water per year. The same amount of water would be saved if we replaced 1,5% of all soy consumed.

GHG Emission Impact by Percentage of Market Replaced

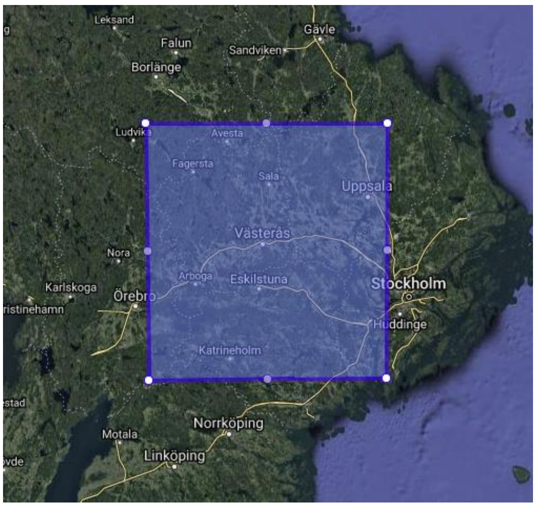
Case Study

If 0,1% of all Chicken consumed in Sweden would be replaced by circular mycoprotein, we would save 1288 tons of CO_2 per year. The same amount would be saved if we replaced 11% of all Soy consumed.



Land Comparison

Area needed for soybean cultivation to meet Swedish soy demand in food
8360 sq Km



Production area for circular mycoprotein for the same volume of production
4.5 sq Km

Impact Over Time

CO_2 and Water Impact until 2030

Assumptions

Production Roadmap

We assume the following production roadmap:

- Pilot Stage (2020 to 2021): One 10 m^3 bioreactor able to produce 22,5 tons/year at maximum capacity.
- Demo Stage (2022-2023): One additional 100 m^3 bioreactor at a customer facility using side-streams for production.
- Commercial Stage (2024-): Starting with one 500 m3 bioreactor at a customer facility using side-streams as substrate. Scale would be linear from this phase onwards with the building of similar reactors at other customer sites (assuming here construction of an additional facility in 2027, 2029 and 2030)

Production Efficiency

Efficiency of water and energy use per ton of product is much higher in a larger bioreactor compared to a smaller one. For the calculations in this document we considered a pilot-scale reactor (10 m^3) which would - in comparison to a commercial-scale bioreactor - emit about two times more CO2e per ton of product and consume five times more water. A demo-stage bioreactor would emit 50% more CO2e and use 100% more water than at a commercial stage.

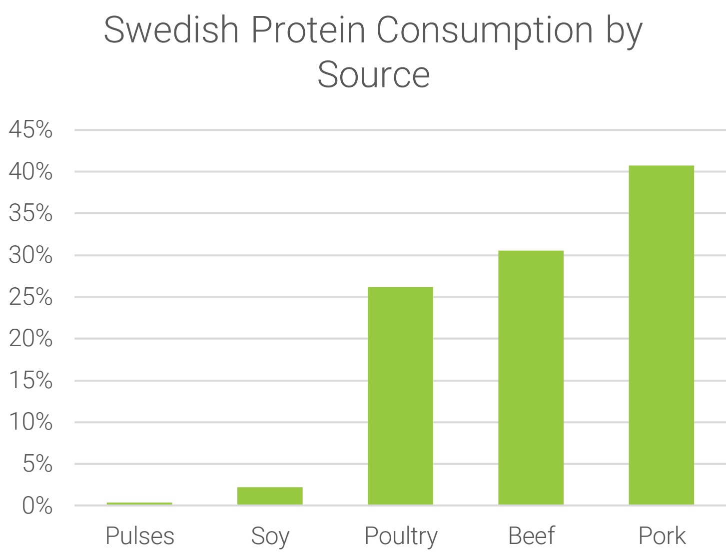
Also not considered in the calculations is the expected improvement in yield of product per volume the closer we get to commercial scale. It can be expected that with further process optimization the production of product per bioreactor volume can be increased up to 10-fold. This will consequently improve efficiency of energy, water and land use per product unit. However, since the numbers can vary by whole order of magnitude, this was not included in the calculations to keep estimations as realistic as possible.

Market

Even though we plan to expand outside of Sweden into other EU countries, we have created the current model considering only that we are targeting the **Swedish market**. This is simply because it is not clear at which stage expansion outside Sweden will happen and this extra dimension would introduce unnecessary complexity in the model.

Product Replacement

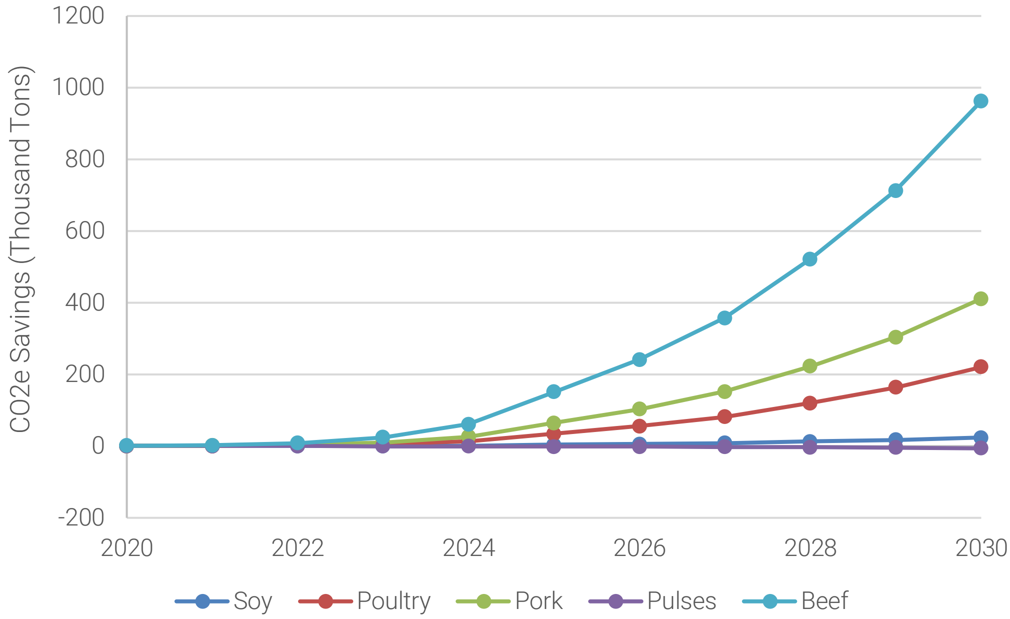
Resource savings need to be calculated in comparison to replacing a given protein source (will mycoprotein be consumed instead of chicken, pork, soy or pulses?). We assumed that at the given production capacity above, all produced material would be consumed as a replacement to another protein source. In the graph on the right, the average distribution of protein consumption in Sweden is shown.



We have calculated values of CO2e and Water savings in the case of replacing a single protein source by Promyc to the capacity of our production. For a practical and realistic outcome, we also took the weighted average of how much these types of protein are consumed among the average swedish consumer.
We also assumed to be using Promyc produced in a circular manner for the following analysis.

Analysis Results of GHG and Water Impact until 2030

Cumulative CO2e savings when circular mycoprotein replaces an equal amount of a single protein source

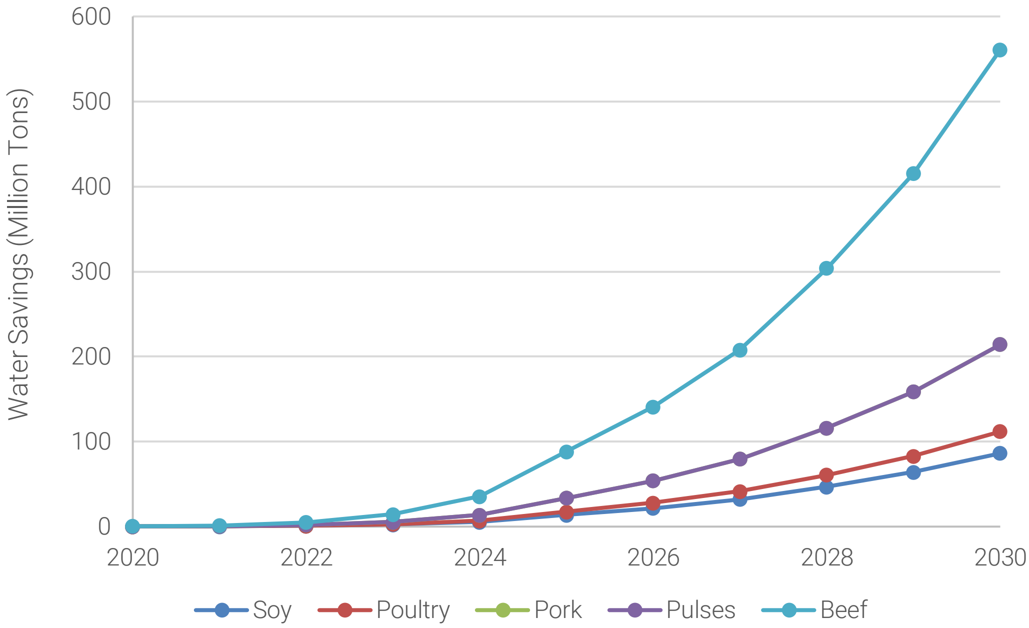


By 2030

Protein Source	CO_2 Savings (ktons)*
Soy	23,25
Chicken	220,9
Pork	410,88
Beef	962,55
Pulses	-5,69

* Total CO2 savings, considering all Promyc produced is used to replace a single protein source.

Cumulative water savings when circular mycoprotein replaces an equal amount of a single protein source

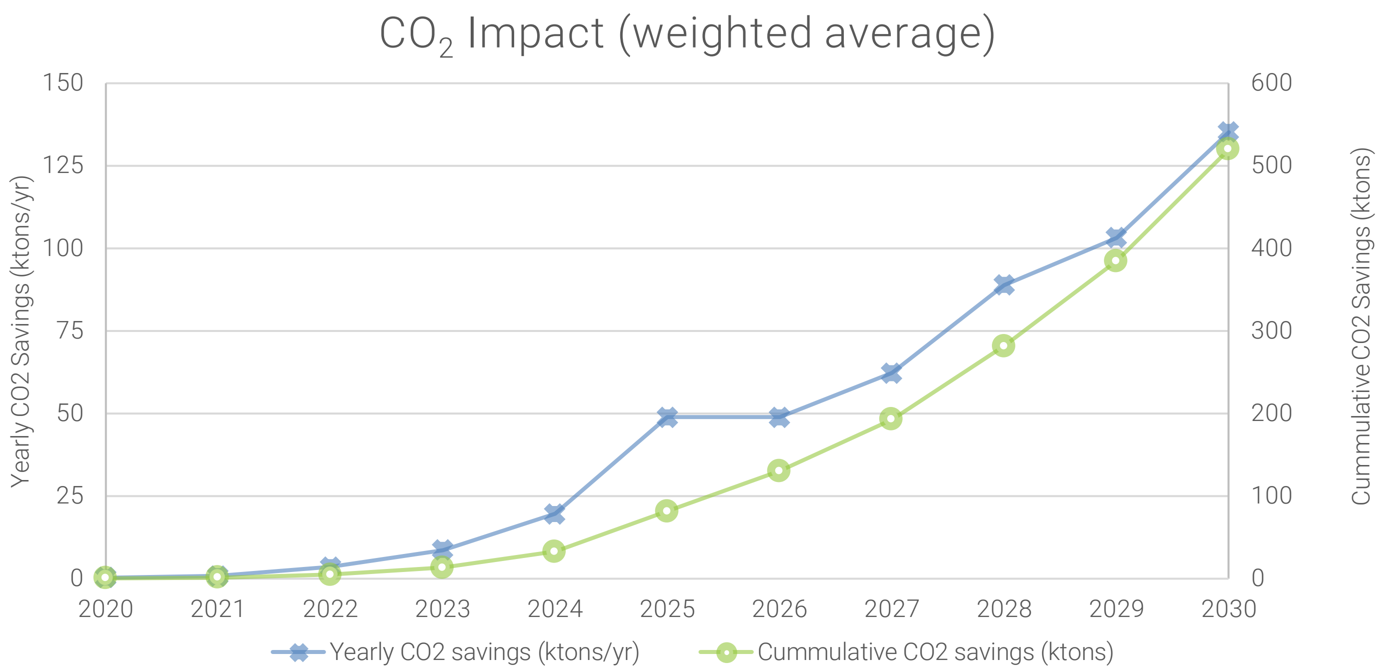


By 2030

Source	Water Savings (Mtons)**
Soy	86,4
Chicken	112
Pork	214
Pulses	214
Beef	561

** Total water savings, considering all Promyc produced is used to replace a single protein source.

Assuming that all circular mycoprotein produced according to the production roadmap in page 7 will be used as a protein replacement in regular meals for the Swedish market, the total impact we will achieve is shown in the graphs below. As an example of what these volumes mean, by 2026 we consider that on average every Swedish citizen would be replacing one of their meals in a year by circular mycoprotein. By 2028, this would be 2 meals per year. As a comparison, today an average Swedish citizen consumes 7 meals of soy per year.



By 2030, by offering circular mycoprotein on the Swedish market we estimate to have saved **513 thousand tons of CO_2** and **290 Million tons of water.**