S&P Global
Ratings

Powered by Shades of Green

Climate Transition Assessment

Solar Foods Oyj

July 4, 2025

Location: Finland **Sector:** Consumer goods

Primary contact

Sofia Singh Digpaul
London
sofia.singh.digpaul
@spglobal.com

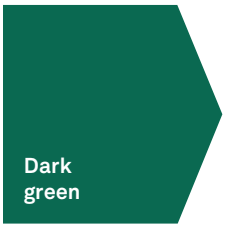
Climate Transition Summary

Solar Foods is a start-up company entirely focused on the development of its proprietary novel microbial biomass rich and low-carbon protein source, Solein ®. Solein ® can be used as an alternative to animal ingredients (dairy, eggs) in foods such as ice cream and protein beverages. Because Solein ® has substantially lower emissions and environmental impacts than animal and processed plant-based protein, it could play a role in the decarbonization of greenhouse gas and land-intensive food systems. We therefore assign a Dark green shade to Solar Foods' current revenue, operating expenses (opex), and capital expenditure (capex).

The climate and environmental benefits of Solein ® and the Future Shade assigned depend on the source of electricity used, as well as Solar Foods' ability to realize its projected production capacity and bring the product to market. The main feedstock used to produce Solein ® is electricity sourced from the Finnish grid, which has low fossil fuel use, and with guarantees of origin. The company's ability to produce and sell its products hinges on obtaining regulatory approval in each market, and on customer sentiment. To date, this has been achieved in Singapore and the U.S. It has yet to establish emissions reduction targets, and does not disclose its carbon footprint. This is in line with its status as a company shifting to commercialization.

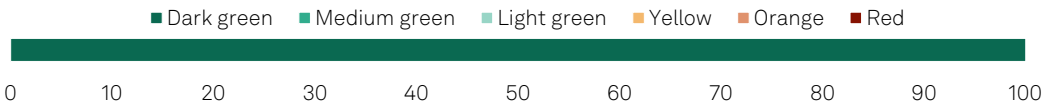
Given the climate and environmental benefits of Solein ® and the company's focus on developing low-carbon food products for human consumption, we believe it will remain Dark green for the foreseeable future.

Future Shade
For Foreseeable Future

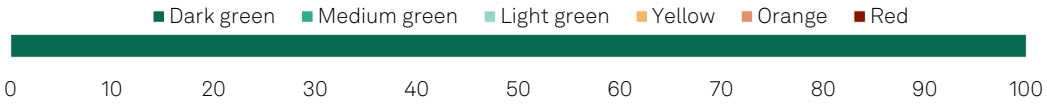


A Climate Transition Assessment shows the expected alignment of a company's activities with a low carbon climate resilient future once its planned transition changes are realized, considering implementation actions and risks.

Current activity: Revenue 2024 (% of total)



Investments: Capex 2024 (% of total)



Strengths

Solar Foods' business model could play a role in the decarbonization of food systems. This is because its products offer an alternative to greenhouse-gas- and land-intensive animal and plant-based protein sources.

Weaknesses

No weaknesses to report.

Areas to watch

As the production of Solein ® expands, lifecycle impacts will depend on Solar Foods' ability to manage them. This includes addressing transport emissions and continuing to source renewable electricity.

Solar Foods' ability to sell Solein ® hinges on regulatory approval and customer sentiment. To date, it has obtained approval in the U.S. and Singapore.

Company Description

Solar Foods is a Finnish food technology company focused on the production of ingredients, marketed using a business-to-business (B2B) model, and the associated food production technology. The company currently operates a pilot factory and a demonstration scale facility, Factory 01, that began operating in April 2024. It is also evaluating sites for its future facilities--Factory 02, 03, and 04--and it is conducting pre-engineering work at a preferred location in Lappeenranta, Finland. The final investment decision is targeted for 2026.

To date, Solar Foods has developed a microbial biomass rich protein called Solein ®, for which it has obtained 28 patents. Solein ® can be used as an alternative ingredient to animal-based products such as dairy and eggs in several food applications, including ice cream, beverages, and snacks. Solar Foods has yet to generate revenue from the sale of Solein ®. In 2024, the company's operating income was €8.1 million, with an operating loss of €8.9 million and a net turnover of €19,000. The company was founded in 2017 and as of 2024 it has 42 employees.

Current Activity

2024 activity by shade (% of total)

Shade	Revenue (%)	Opex (%)	Capex (%)
Dark green	100	100	100
Activities: Production of Solein ®, research and development of associated technologies and production processes and the development of Factory 02.			
Medium green	0	0	0
Activities: none			
Light green	0	0	0
Activities: none			
Yellow	0	0	0
Activities: none			
Orange	0	0	0
Activities: none			
Red	0	0	0
Activities: none			

Opex--operational expenditure. Capex--Capital expenditure. Source: S&P Global Ratings.

Solar Foods operates within the field of biotechnology known as cellular agriculture and focuses on developing food products that provide sufficient nutritional value with a lower carbon and environmental footprint. The Intergovernmental Panel on Climate Change (IPCC) found that the food-system value chain accounted for 31% of global anthropogenic greenhouse gas emissions in 2018, with the largest sources being livestock, crop farming, land-use change, and forestry. With consumption of animal-based products expected to increase by 70% by 2050, according to the World Resource Institute, shifting to plant-based diets and low-carbon protein sources will be essential to limit the rise of global temperatures to 1.5 degrees Celsius by the middle of the century. Cellular agriculture is one way to support this shift, and it involves the closed production of animal, microbial, and plant cells in bioreactors.

The main feedstocks for Solein® are air and electricity. Solein® is biomass produced through aerobic bacterial gas fermentation in continuously operated bioreactors using carbon dioxide, oxygen, and hydrogen gases as the main feedstocks. Minor amounts of minerals (phosphorous and calcium) are also used in the growth medium. In the downstream process, the biomass and water are separated, and the biomass is subsequently dried, becoming a powder called Solein®. The product can be then used to replace dairy and meat-based ingredients in different food applications.

We assign a Dark green shade to Solar Foods' revenue, which we use as a proxy for its activities in 2024. This is in line with the company being in a transitory phase from start-up to commercialization. Solar Foods' main focus last year was the launch of its Factory 01, its first demonstration scale production facility in Finland with a targeted annual production capacity of 160 tons, to be expanded to 230 tons in 2026. Toward the end of 2024, it started to produce its first batches of Solein's ® to be used in Fazer's "Taste the Future" chocolate bar and Ajinomoto's "Flowering Mooncakes and Ice Cream Sandwiches" sold exclusively in Singapore. The Dark green shade reflects Solein ®'s nature as an alternative to dairy, eggs, meat, and plant-based substitutes, with lower greenhouse gas emissions and land use pressures.

We consider Solar Foods' operating expenses related to the procurement of its product feedstocks to be Dark green. The driver of this shade is the source of electricity used to produce Solein ®, which is the principal cause of its lifecycle climate and environmental impacts, according to an assessment by Järviö et al. The company uses electricity from the national grid, which is almost entirely powered by renewable and low-carbon sources, and is thus in line with a Dark green shade. The sourcing of minerals could expose the company to value chain environmental and social risks, such as pollution, carbon emissions from energy-intensive processes, and harm to biodiversity. Nitrogen, in particular, has considerable lifecycle emissions because it is obtained from ammonia produced with fossil-fuel based hydrogen. Although the proportion of minerals in the production process is small compared to electricity, it is positive that Solar Foods has strengthened its due-diligence process for the supply chain.

In 2024, Solar Foods' capex was dedicated both to the pre-engineering of its Factory 02 and further developing production process in its demonstration plant Factory 01, which we consider Dark green because it will enable the production of Solein ®. The company capitalized costs related to the development of Solein ®, including activities such as identifying product applications, production process optimization, and the construction of Factory 02. Any construction of new buildings results in substantial emissions from the materials (cement, steel) and equipment used. However, the shade of Solar Foods' capex is driven by its role in enabling the production of an alternative to carbon-intensive animal-based protein products by an entity whose sole activity is to produce such alternatives. The company has yet to define a formal strategy to address risks related to the construction process beyond its compliance with regulatory requirements. For example, it is working with Sweco to assess the requirements for conducting an environmental impact assessment, which may be needed as part of the permit application process. We view it as positive that Solar Foods is considering the applicability of using brownfield sites for this facility, since this could limit the impact of land-use change.

Climate Transition Plan

Metrics And Targets

Transition targets

Transition metrics	2023	Baseline metric (2024)	2026	2028	2029	2030
Production capacity of Solein ® at Factory 02 (kilotons/year)	-	-	-	3.2	3.2	6.4
Capex for phase 1, 2, and 3 of Factory 02 (mil. €)	-	-	-	134	48	135
Revenue from sale of Solein ® from operationalization of Factory 02 (mil. €)	-	0	-	48-55	48-55	96-109
Targeted production capacity of Solein ® at Factory 01 (tons)	-	160	230	-	-	-
Energy consumption (MWh)	0.409	5567	-	-	-	-
Scope 1 and 2 emissions (tons CO2e)	10	134	-	-	-	-
Scope 3 emissions	7	29	-	-	-	-

Targets beyond the time frame of our analysis do not influence our Climate Transition Assessment (CTA) outcome because the CTA analyzes more specific actions that the company has planned and the implications of those actions.
Source: Company Reporting and S&P Global Sustainable1.

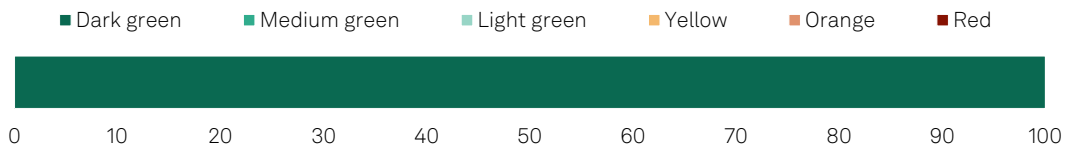
Solar Foods has yet to define an overarching sustainability and carbon reduction strategy, though this is consistent with it being at the start of its commercialization and production journey. Solar Foods has not outlined emissions reduction targets or publicly disclosed its internal greenhouse gas emissions estimates. The company may be exposed to emissions from the construction of its new production facilities, as well as from the transport of Solein ® to the markets in which it is approved for sale. It expects to conduct a lifecycle emissions analysis using its operational data once it achieves a reasonable production level, though it has not defined what this will be. Its current focus is on the commercialization of a low-carbon protein source.

The expected production capacity and associated capex amounts are used as indications of Solar Foods' potential future climate impacts in the absence of emissions-reduction targets. Increasing the production of Solein ® may result in climate benefits, providing lifecycle environmental risks are mitigated.

Solar Foods started production in 2023, and therefore has only limited data on its carbon footprint. The company estimated its scope 1, 2, and 3 emissions from its operations for the purpose of this report and did not follow the Greenhouse Gas Protocol. The estimates have not been reviewed by a third party. In 2024, Solar Food finalized construction of Factory 01, followed by a ramp-up period, meaning the reported figures do not represent a comprehensive inventory of emissions from a fully operational facility. However, they provide an indication of the scale of emissions, with scope 2, associated with purchased electricity, being the largest source.

Actions And Investments

2024 capex breakdown by shade (% of total)



Source: S&P Global Ratings.

Solar Foods' Solein ® offers a low-carbon alternative to greenhouse-gas- and land-intensive animal and plant-based protein sources, providing the company can realize its projected production capacity. The lifecycle climate and environmental benefits of Solein ® will depend on the company's ability to identify and address potential risks as it expands.

We anticipate that the expansion of Solar Foods' production capacity may contribute to reducing the climate impact of food systems, particularly if Solein ® replaces carbon-intensive food ingredients. With its capex investments dedicated to the expansion of capacity of Factory 01 and the phased development of Factory 02, 03, and 04, Solar Foods has projected production of about 78,500 tons of Solein ® by 2031. Factory 02 in particular will have a production capacity of 12,800 tons per year, 80 times greater than that of Factory 01. If these targets are met, the company expects that it will help lower the emissions of global food systems. An attributional lifecycle assessment (which determines the proportion of global environmental impacts that can be associated with an activity) by Järviö et al found that the global warming potential of Solein ® was 6.2% that of bovine protein and 7.3% that of dairy herd protein, when using electricity from the Finnish grid. Shifting to this microbial powder could also result in substantial agricultural land savings, namely 15.9 square meters (m2) per 100 grams (g) of protein from dairy herd and 35.6 m2 per 100g of protein from bovine meat. That said, there is some uncertainty about the full lifecycle emissions of Solein ®. This is because the lifecycle assessment includes only the stages from resource extraction to finished product, that is, it excludes what happens once Solein ® leaves the factory, for example, during transport.

Solar Foods has expanded its market reach to the U.S., where it has identified health and performance nutrition as a strategic growth area. In 2024, the company was granted a self-affirmed Generally Recognized as Safe (GRAS) status in the U.S., which enabled it to register Factory 01 with the U.S. Food and Drug Administration and start exporting Solein ® to this market. Solar Foods will focus on health and performance nutrition segments, including ready-to-mix powders, protein bars, and ready-to-drink beverages, due to their market size and growth rates driven by continued consumer interest in health, wellness, and fitness. The industry is dominated by whey protein isolate, which is carbon intensive. As Solein ® is comparable in nutrition, taste, and texture, its expansion in this market could contribute to substantially reducing emissions from fitness food and beverage products in the U.S. This is because whey protein is derived from the dairy value chain, which is exposed to considerable lifecycle greenhouse gas emissions and biodiversity risks. The company will continue to operate as a B2B producer, collaborating with its customers to develop food products that contain Solein ®. Its U.S.-focused strategy is complemented by its activities in Singapore, where, having obtained regulatory approval in 2022, Solein ® has already been available for sale in food products by established food companies Fazer and Ajinomoto.

Solar Foods has no immediate plans to use Solein ® in feed products and based on its estimates, it is unlikely due to the lower price point. Although this could help reduce emissions from feed production, the broader feed value chain is exposed to considerable climate and environmental risks associated with livestock and crop farming. These include pollution, land use change, deforestation, and greenhouse gas emissions. Such risks would therefore be in line with lighter shades of green.

Because the majority of its climate and environmental impacts are driven by the feedstocks it uses to produce Solein ®, it is positive that Solar Foods has strengthened its due diligence regarding its supply chain. This is mainly the result of the development of a questionnaire designed to complement its Supplier Code of Conduct. The due diligence assessment focuses on safety, quality control, and environmental considerations, namely regulatory compliance, management systems, water, energy consumption, the use of hazardous chemicals, and the circularity of materials. That said, it does not include requirements or thresholds, which somewhat limits its effectiveness at mitigating potential exposures. All of Solar Foods' energy needs are met by electricity, which it obtains from VENI Energy, an electricity trading company that purchases electricity from Finland's power grid, which is supplied principally by low carbon sources. According to the International Energy Association, in 2023, 38% of Finland's electricity generation came from renewable sources (hydropower, wind, and solar), 42% nuclear, 13% biofuels, 5% fossil fuels (coal, oil, and natural gas) and 1% waste. Solar Foods uses guarantees of origin for its procurement of electricity, which we consider to be a weaker emissions abatement strategy. This is because, though it ensures that a certain amount of low-emission electricity exists in the grid, it does not affect the amount of emissions related to the delivered electricity. Although proportionally smaller than electricity, the other feedstocks are minerals from Bang & Bosomer and Algol Chemicals. Both of these companies require their suppliers to comply with codes of conduct and have established emissions-reduction targets that include scope 1, 2, and 3. Solar Foods sources its carbon dioxide from Woikoski's Kokkola's road salt production plant and its own on-site direct air-capture plant.

Although it has yet to set climate targets, Solar Foods is starting to integrate strategies to reduce operational emissions in its development plan for Factory 02. The company is evaluating the potential of transferring surplus heat from the Solein ® production process back to the district heating network. This would reduce the energy consumption of the network by providing it with waste heat. The company is also aiming to address the impacts of its other feedstocks. An example of this includes installing an electrolyzer plant next to Factory 02. However, it is still in the pre-engineering stage of Factory 02, and Solar Foods has yet to establish plans for how it will address the climate and environmental impacts of its new facilities beyond regulatory and permit requirements.

Implementation Drivers

Solar Foods' operations and investments are consistent with those of a growing company, though the extent to which it can serve its target markets is contingent on external factors and internal oversight. This includes adequate financial management, positive consumer sentiment toward Solein ®, regulatory approval, and the mitigation of climate and environmental risks as production volumes increase.

Solar Foods' governance mechanism is designed to support the commercialization of a novel low-carbon food product and is commensurate with a start-up company that is scaling up. The expertise of the board of directors in sustainability matters has somewhat improved with the addition of Pasi Vainikka, former CEO of Solar Foods, and the re-election of Paula Laine, previously the CEO of the Finnish Climate Fund, at the 2025 general meeting. The remainder of the board is composed of food and industry executives. The board does not have a climate or sustainability-focused function, since it is organized in audit, nomination, and remuneration committees. That said, the company's overall strategy is to commercialize a low-carbon protein source to replace greenhouse-gas-intensive food products, which requires sustainability know-how for the product development process, as well as managerial and industry experience to achieve strategic growth.

The company does not currently generate revenue from the sale of Solein ®, and its investments and operations are entirely supported by external financing. In 2025, it submitted an application to the Business Finland/Ministry of Economic Affairs and Employment for a €66 million investment grant. According to the company, the first development phase of Factory 02, with a projected investment of €134 million, is entitled to this grant because it has been designated an important project for common European interest (IPCEI) by the European Commission. Solar Foods has been notified of an additional €110 million of IPCEI funding from the

EU, of which €44 million has already been approved as a research and development grant. To further support its future financing needs, the company was listed on the Nasdaq First North Growth Market Finland in 2024. Solar Foods is also shifting from offering only powder prototypes to customers to also sampling concepts where it will introduce finished products containing Solein ®. Solar Foods expects that these elements, combined with higher productivity, entry into new markets, and its phased capex approach for Factory 02, will enable it to reach positive cash flow and profitability in 2030.

The climate benefits of Solar Foods' product Solein ® depend on customer uptake. As a novel protein source, Solein ®'s growth potential in the food and beverage market relies on customers' willingness to shift from animal- and plant-based protein sources. This may also be influenced by how Solein ® is perceived relative to competitive plant-based and cellular protein products on the market. Should customer demand fail to meet the projected supply capacity, this could prevent the company from generating positive cash flow in 2030 as well as slow the low-carbon transition of food systems. The company has signed memorandums of understanding with two customers for 6,000 tons of Solein ® produced in Factory 02, which could become binding agreements.

Because Solein ® is a novel product, its marketability relies on regulatory approval in each of the markets Solar Foods seeks to enter. The company is currently only allowed to produce and sell its products in Singapore and the U.S., and has yet to obtain approval in the EU and the U.K. In 2024, Solar Foods made some progress in this regard by addressing inquiries from the European Food Safety Authority.

As the production of Solein ® increases, the climate and environmental lifecycle impacts will depend on Solar Foods' ability to address potential risks. Any new construction projects entail emissions from the materials (cement and steel) and equipment used. In addition, Solein® could entail transport emissions, since it will be produced in facilities located, for example, in Finland and exported to Singapore and the U.S. As sales volume grows, these risks could also increase. To date, Solar Foods has used both air and maritime freight to transport Solein ®.

Nasdaq Green Designation

Nasdaq Green Equity Designation

S&P Global Ratings confirms that Solar Foods Oy meets the requirements for Nasdaq Green Equity Designation, set out in the Nasdaq Green Equity Principles.

In 2024, 100% of Solar Foods' turnover came from assets with some Shade of Green, exceeding the 50% threshold for green activities for company turnover. The sum of opex and capex allocated a Shade of Green is 100%. This exceeds the 50% threshold for investments, defined as the sum of capex and opex. In 2024, Solar Foods had no turnover derived from fossil fuel activities, meeting the threshold of less than 5% of the company's turnover being derived from fossil fuel activities.

In addition, Solar Foods meets Nasdaq's transparency requirements on EU Taxonomy alignment, as well as environmental targets and key performance indicators (KPIs). The company is not required to report on the EU Taxonomy. Solar Foods' activities do not fall under the scope of the categories listed in the EU Taxonomy. It has reported its EU Taxonomy data, environmental targets, and KPI data through the Nasdaq ESG Portal.

S&P Global Ratings' Shades of Green

Assessments	Dark green	Medium green	Light green	Yellow	Orange	Red
Description	Activities that correspond to the long-term vision of an LCCR future.	Activities that represent significant steps toward an LCCR future but will require further improvements to be long-term LCCR solutions.	Activities representing transition steps in the near-term that avoid emissions lock-in but do not represent long-term LCCR solutions.	Activities that do not have a material impact on the transition to an LCCR future, or, Activities that have some potential inconsistency with the transition to an LCCR future, albeit tempered by existing transition measures.	Activities that are not currently consistent with the transition to an LCCR future. These include activities with moderate potential for emissions lock-in and risk of stranded assets.	Activities that are inconsistent with, and likely to impede, the transition required to achieve the long-term LCCR future. These activities have the highest emissions intensity, with the most potential for emissions lock-in and risk of stranded assets.
Example projects	Solar power plants	Energy efficient buildings	Hybrid road vehicles	Health care services	Conventional steel production	New oil exploration

Note: For us to consider use of proceeds aligned with ICMA Principles for a green project, we require project categories directly funded by the financing to be assigned one of the three green Shades.

LCCR--Low-carbon climate resilient. An LCCR future is a future aligned with the Paris Agreement; where the global average temperature increase is held below 2 degrees Celsius (2 C), with efforts to limit it to 1.5 C, above pre-industrial levels, while building resilience to the adverse impact of climate change and achieving sustainable outcomes across both climate and non-climate environmental objectives. Long term and near term--For the purpose of this analysis, we consider the long term to be beyond the middle of the 21st century and the near term to be within the next decade. Emissions lock-in--Where an activity delays or prevents the transition to low-carbon alternatives by perpetuating assets or processes (often fossil fuel use and its corresponding greenhouse gas emissions) that are not aligned with, or cannot adapt to, an LCCR future. Stranded assets--Assets that have suffered from unanticipated or premature write-downs, devaluations, or conversion to liabilities (as defined by the University of Oxford).

Related Research

- Analytical Approach: Climate Transition Assessments, July 18, 2024
- Analytical Approach: Shades of Green Assessments, July 27, 2023
- FAQ: Applying Our Integrated Analytical Approach For Climate Transition Assessments, July 18, 2024

Analytical Contacts

Primary contact

Sofia Singh Digpaul
London
sofia.singh.digpaul
@spglobal.com

Secondary contacts

Kristina Alnes
Oslo
kristina.alnes
@spglobal.com

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