FOOD AND LAND USE

BOOST SYSTEMIC CHANGE TO REACH NET-ZERO EMISSIONS FROM FARM TO FORK

Current situation and challenges

- European agro-sector from farm to fork generates 430.5 $MtCO_2e$:
  - 395 $MtCO_2e$ from agriculture (10% of the total European CO_2 emissions), mainly from three sources: soils nitrification and denitrification, enteric fermentation by ruminant animals and manure management.
  - 35.5 $MtCO_2$ from food and beverage industry.
- Agriculture, food and beverage dominate today's bioeconomy workforce, representing 13.7 million jobs.
- Major turnover is generated by the food and beverage industries, with €236 billion (20% of total turnover) generated by the meat sector.

> *“We should take a holistic approach to deliver biodiversity and productivity through a series of pathways. Technology solutions must be incentivized for us to deliver the Farm to Fork vision.“*
>
> **Alexandra Brand,** Chief Sustainability Officer, Syngenta

The main challenges are:

- Reducing the environmental impact of the whole agricultural value chain from farm to fork to cut down emissions by -20% in 2030 and -50% in 2050[1].
- Creating alternative sources of proteins to reduce our dependency on livestock production.
- Maintaining agricultural jobs thanks to changes in agricultural practices (for example conservation agriculture) and creating new ones to replace the losses triggered by technological development (for example synthetic meat, Agriculture 4.0)

> *“We need to accelerate the whole agri-food bioeconomy, moving away from prototypes and front-runners, to a broad adoption of Agriculture 4.0 by 12 million farmers in Europe.“*
>
> **Dr. George Beers,** Project Manager at Wageningen University

Solutions, projects and scale-up

Proposed projects will initiate sustainable changes to scale up in each part of the value chain to ensure the reach of overall net-zero objectives:

- Support the development of a sustainable agriculture:
  - Contribute to CO_2 reduction targets with actions both on soil fertilization to reduce the need for inputs such as nitrogenous ones (i.e., microbial fertilizer and bio-stimulants) and on global agricultural practices (i.e., conservation agriculture and Agriculture 4.0).
  - Scale up insect production to provide an alternative of fast-grow feedstock proteins while creating a new promising agricultural sector generating jobs, revenues and CO_2 savings.
  - Innovate to capture diffuse methane from cattle on-site as it is being done for CO_2 capture in industry.
- Change the dietary habits of Europeans by reaching respectively 20% and 10% market share for plant-based and cell-based meat products in 2030 while investing in synthetic milk technology development. Achieving this target will save up to 51 $MtCO_2$, while generating €40 billion turnover and supporting 596,000 jobs.

The first phase from 2021 to 2025 will be dedicated to innovation, launching of pilots and scale-up preparation:

- Carry out feasibility studies for breakthrough technologies and launch R&D projects and pilots for bio-stimulant and fertilizers, conservation agriculture and Agriculture 4.0.
- Scale up conservation agriculture and innovative livestock farming to 10,000 pilot sites for each technique.
- Launch regulatory discussions about an EU carbon credit program.

The second phase will prioritize new technologies from phase 1 and scale up to reach a 25% reduction of the emissions of the sector in 2030 compared to today's level.

- Multiply scope and scale and create bridgeheads in all European regions for new technologies.
- Scale up the pilots from 2021 to 2025 which have demonstrated the best technological and economic potential.
- Finalize the regulatory scheme for an EU carbon credit program.

Impacts

- **€66 billion total market (turnover + investments) per year in 2030.**
- **1.0 million permanent jobs in 2030.**
- **119 $MtCO_2$ avoided per year in 2030.**

Regional approach

Europe can lever:

- A strong agricultural R&D in Western Europe.
- A large variety of land across Europe, giving the opportunity to test innovations and regional specificities at European level.
- The Common Agricultural Policy frameworks and discussion groups must be involved to ensure consistency with current regulatory schemes.

List of projects – FOOD & LAND USE

Transversal

#50 - TRANSFORM EUROPEAN AGRICULTURE WITH SUSTAINABLE FARMING TECHNIQUES
Experiment and develop science-based conservation agriculture and sustainable farming systems to cut farming costs and emissions

#51 - HARNESS THE POWER OF AGRICULTURE 4.0
Boost the use of digital solutions to increase productivity while lowering GHG emissions, moving from 5% front-runner farmers to a broad application

Crop

#52 - REINFORCE PLANTS AND BOOST CROP RESILIENCE TO USE LESS EMISSIONS-INTENSIVE FERTILIZERS AND INPUTS
Customized microbial fertilizers production on-site and biostimulants to foster plant growth and carbon capture under abiotic stress

Livestock

#53 - TAP INTO THE POTENTIAL OF INSECTS FOR FAST-GROW FEEDSTOCK PROTEINS
Bring to commercial scale insect-protein production facilities and build routes to market

#54 - CAPTURE METHANE AND NON-CO_2 GHG EMISSIONS FROM CATTLE
Develop and test prototypes to capture methane and other gases emitted by cattle

#55 - PROMOTE TASTY, AFFORDABLE AND LOW-EMISSION ALTERNATIVES TO MEAT AND DAIRY PRODUCTS
Large scale production and receptive markets can massively cut greenhouse gas emissions associated with conventional animal products

[1] *Net-zero agriculture in 2050: how to get there: https://europeanclimate.org/content/uploads/2019/11/02-19-net-zero-agriculture-in-2050-how-to-get-there.pdf*

TRANSFORM EUROPEAN AGRICULTURE WITH SUSTAINABLE FARMING TECHNIQUES

Experiment and develop science-based conservation agriculture and sustainable farming systems to cut farming costs and emissions

FOOD & LAND USE

Transversal

IN A NUTSHELL...

- **Issue:** Systemic approaches to lower GHG emissions from farms have proven efficient but are still not widespread across European farms
- **Solution :** Massively extend these practices while supporting continuous research will enable to reach 20% emissions abatement with no new inventions required
- **Key impacts :** 25.9 $MtCO_2e$ avoided, €9.4 billion turnover, 140,000 jobs in 2030

Innovation bet

Acceleration and scale-up

Drive to market scale

Project opportunity and ambition

Project type 1: Obtain quantified evidence on the economic and environmental benefits of Conservation Agriculture using 10,000 pilot projects across the EU

- Involve crop input manufacturers, researchers and local farmers in a five-year initiative.
- Evaluate solutions aiming to reduce soil disturbance, maintain vegetative cover on soils, increase pollinating species population, utilize appropriate rotations of diversified crops.
- Develop suitable measurement technologies for soil, crops, flora and wildlife indicators to justify and scale studied solutions supported by reliable data.
- Projects that inspired this analysis: Cross-country initiatives between Syngenta, farmers and researchers.

Project type 2: Test and extend innovative livestock farming systems in 10,000 farms to reduce emissions from meat and dairy industries

- Involve researchers, farmers and meat and dairy associations to assess the impact of several livestock farming techniques to reduce GHG emissions in 10,000 beef farms over a four-year period.
- Areas to test include cattle management, feed management, manure and land use, techniques to reduce fuel oil, electricity and water consumption.
- The goal is to sustainably transform livestock management in these farms, especially in countries where such practices are less widespread, e.g. Central and Eastern Europe.
- Projects that inspired this analysis: Life Beef Carbon, Life Greensheep.

Project type 3: Create an EU carbon credit program and other incentives to scale up sustainable crop and livestock farming systems

- Develop a common EU methodology to give certified carbon credits to farmers that reduce GHG emissions using sustainable farming techniques, thus enabling them to fund deep reductions below baseline.
- Encourage local farmers to adopt sustainable farming models by contributing to their initial investments (e.g. through loans or tax credit) or public finance.
- Test a set of incentives allowing farmers to adopt low-emission techniques while ensuring their financial security and business resilience.
- Projects that inspired this analysis: French CarbonAGRI methodology, certified under the Label “Bas Carbone” from the government, to issue tradeable carbon credits to incentivize GHG emission reduction.

Why this technology and project are needed to reach net-zero

These projects are necessary to respond to the three key challenges to ensure a sustainable food future, identified by the WRI report on global food[1]: the food gap, the land gap and the GHG mitigation gap. Closing these gaps will be required to manage the increase of world population (from 7 billion in 2010 to 9.8 billion in 2050), of food demand (to rise by 50%) and of the animal-based food demand (to increase by 70%).

Traditional farming techniques are not always optimized with regards to their climate impacts. For instance, only recently has it been realized that tilling soil is an emissions-intensive activity, as it was previously considered beneficial for crops. Avoiding it can reduce farming emissions by 20%[2].

Advanced farming models based on comprehensive approaches can unlock substantial reductions of GHG emissions from agricultural activities. Both crops and livestock management need to be considered.

Conservation Agriculture

CA is one of the pillars of the 4 per 100 global initiative launched at COP21 in Paris (along with other techniques such as Agroforestry)[3]. It focuses on minimum soil disturbance for establishing crops, maintaining vegetative cover on soils and utilizing rotations of diversified crops.

In Europe, successful cross-country projects are showing their benefits, with up to 50% decrease in GHG emissions and costs along with increased fauna population like birds and worms.

Sustainable livestock management

The Life Beef Carbon EU project promotes livestock farming techniques in France, Spain, Italy and Ireland (countries accounting for over 30% cattle emissions in Europe) which can lead to -15% GHG emissions. In addition, Life Greensheep, which is a similar project, is about to be launched.

It is crucial to study, test and spread sustainable agriculture techniques across Europe based on strong collaboration between researchers, industrials, producers and farmers. Once validated, sustainable farming techniques can be implemented in all EU countries, with support from public institutions. EU regulation and aligning subsidies are also important catalysts to promote sustainable farming across Europe.

Some countries, such as those in Southern Europe, would particularly benefit. These countries have a major need for soil restoration solutions due to a rapidly changing climate and high soil erosion together with considerable livestock numbers. Eastern countries like Poland or Romania are also starting to take interest resulting from the positive deployment of these techniques in Western Europe. Consequently, this is a trend to accelerate and promote.

Impacts

	2030	2050
CLIMATE IMPACT	**25.9 $MtCO_2e$ avoided**	**60.5 $MtCO_2e$ avoided**
ECONOMIC IMPACT	**€9.4 billion turnover**	**€21.8 billion turnover**
JOBS	**140,000 total jobs**	**328,000 total jobs**

#50 [1]https://research.wri.org/sites/default/files/2019-07/creating-sustainable-food-future_2_5.pdf
[2]https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3975454/
[3]https://www.4p1000.org/

HARNESS THE POWER OF AGRICULTURE 4.0

Boost the use of digital solutions to increase productivity while lowering GHG emissions, moving from 5% front-runner farmers to broad application

FOOD & LAND USE

Transversal

IN A NUTSHELL...

- **Issue:** Innovative instruments such as robotics, IOT, satellites, AI offer great, yet under-exploited potential in the agricultural sector
- **Solution:** The accelerated development and uptake of these tools will help deliver more environmentally friendly practices
- **Key impacts:** 18.4 $MtCO_2e$ avoided, €4.4 billion total market, 67,000 jobs in 2030

Innovation bet

Acceleration and scale-up

Drive to market scale

Project opportunity and ambition

Inspired by the "Smart Agri Hubs" and "IoF2020" initiatives, this project is designed to push collaboration between key players (see “Major stakeholders”) to bridge the gaps in digital innovation for the agri-food sector.

The project will:

- Identify the gaps between real needs on the ground, ongoing projects and existing tools in the field (in terms of geographies, technologies, methodologies, integration needs, interfaces with other sectors such as transport and logistics).
- Derive 100 concrete experimentations to bridge this gap, based on real use cases and considering all existing learning.
- Conduct these experiments over four years and assess and optimize the impact of all digital components relevant for the agri-food sector (see below the list of technology areas).
- Build a unified reference network, that gathers dispersed initiatives across Europe to apply through local hubs and multiply their benefits.

It will deliver a portfolio of 100 use cases with details on:

- Technology and innovations tested, experiment protocol, involved stakeholders and geographies covered
- Results of the experiment with analysis on how to increase economic viability and market share of the technologies.
- Potential for replication across Europe, including proposed levers to increase end-user and farm adoption.

The project will cover the following areas of developing Agri 4.0 technology:

- Satellite images and their exploitation.
- Robotics, IoT and sensors.
- AI and Blockchain.
- Digital platforms.
- Transversal enablers, such as integration (authentication, fireware, connection and others), 5G infrastructures, standardization requirements.

Main stakeholders: Farmers, digital-based agrotech startups and SMEs, IT companies, telecom operators, universities, EU professional associations; The project will cover: fruit, vegetables, arable crops, livestock (meat and dairy), aquaculture, forest and other land use, as well as interfaces with other sectors: health, mobility, logistics, and education.

Regional Clusters: aim for EU27 balance, however the 400 targeted regional clusters of smart Agri hubs will be taken as a reference, to not create unnecessary inefficiencies.

Why this technology and project are needed to reach net-zero

Agriculture 4.0, in comparison to Industry 4.0, stands for the integrated internal and external networking of farming operations, relying on digital information, electronic communication, automated data transmission, processing and analysis[4]. It encompasses precision farming, smart farming and digital farming. Typical applications involve robotics, sensors, IoT, satellites, data analytics and decision support, digital apps and platforms.

These tools enable substantial savings on inputs (water, fertilizers, pesticide and others)[5], reduction of farm-related CO_2 emissions, soil compaction, optimized yields and quality in agricultural production.

Yet, according to the European Agricultural Machinery Association (CEMA), "Uptake of these technologies is currently lagging behind the pace of digital technology uptake in other sectors, due to agricultural product margin constraints and associated investment capability"[6]. Therefore, Europe must accelerate the development and deployment of these technologies, in order to consolidate a leading position in the digital area, and at the same time contribute to the attractiveness of the sector for younger generations of farmers.

Key challenges include the integration of solutions, standardization skills and attractiveness of rural territories to make business cases work for telcos, reconciliation of projects and funding levels (EU, national, regional). The exploitation of European satellite data is also a key challenge, as Copernicus satellites provide free and open data, based on which non-European firms (e.g. Google) can also provide services, with higher development means and better marketing. The EU must therefore strongly support promotion and development of usages in this field, e.g. through the DIAS (Data and Information Access Services)[7]. Agriculture is one of the most promising fields of application of Copernicus data[8].

Impacts

	2030	2050
CLIMATE IMPACT	**18.4 $MtCO_2e$ avoided**	**18.4 $MtCO_2e$ avoided**
ECONOMIC IMPACT	**€4.4 billion total market** €8.1 billion investment by 2030, €813 million yearly average (2020-2030) €3.6 billion turnover in 2030	**€9.8 billion total market** €20.3 billion investment by 2050, €680 million yearly average (2020-2050) €9.1 billion turnover in 2050
JOBS	**67,000 total jobs**	**146,000 total jobs**

#51 *[4]https://www.cema-agri.org/images/publications/position-papers/CEMA_Digital_Farming_-_Agriculture_4.0__13_02_2017_0.pdf*
[5]Example of PepsiCo: -26% water input in http://breakthrough.unglobalcompact.org/disruptive-technologies/digital-agriculture/; example of Greece: -19% consumption of water, fertilizers and pesticides, and +10% production through Earth Observation-based smart farming services: https://www.copernicus.eu/sites/default/files/PwC_Copernicus_Market_Report_2019.pdf
[6]https://www.cema-agri.org/images/publications/position-papers/2019_CEMA_Agritech_2030_web.pdf
[7]https://www.copernicus.eu/en/access-data/dias
[8]https://www.copernicus.eu/sites/default/files/PwC_Copernicus_Market_Report_2019.pdf

REINFORCE PLANTS AND BOOST CROP RESILIENCE TO USE LESS EMISSIONS-INTENSIVE FERTILIZERS AND INPUTS

Customized microbial fertilizers production on-site and biostimulants to foster plant growth and carbon capture under abiotic stress

FOOD & LAND USE

Crop

IN A NUTSHELL...

- **Issue:** Ammonia-based fertilizers rely on an energy-intensive production and environmentally harmful operations, and reduce soil quality
- **Solution:** Microbial fertilizers, combined with a better use of mineral fertilizers, offer a desirable alternative that can be rapidly developed and deployed at farm scale. In addition, biostimulants strengthen plants and allow for lower use of fertilizers
- **Key impacts:** 6.6 $MtCO_2e$ avoided, €1.4 billion total market, 20,000 jobs in 2030

Innovation bet

Acceleration and scale-up

Drive to market scale

Project opportunity and ambition

Test and commercialize solutions for on-site production of microbial fertilizers on 50 farms.

- The main ambition is to validate the feasibility of producing on-site soil specific microbial fertilizers at large scale, in 50 pilot European farms, with a robust, convenient, easy-to-use process, and at a competitive price.
- Ensure testing on several types of farms in terms of size, soil and crop.
- Results should clearly show each technology's versatility to fully commercialize and become substitutes to traditional fertilizers from 2022.
- Build and lever partnerships with large European crop input manufacturers to provide testing facilities and distribution capabilities.

In parallel, accelerate R&D in the field of biostimulants and increase the market penetration of these products through farm-scale research initiatives working on:

- Experimenting with new types of biostimulants.
- Increasing the efficiency of existing types.
- Demonstrating and quantifying the effectiveness of several biostimulants in practice.

Main stakeholders: Agritech startups, academic researchers, competence centers (like German Center for biobased solutions - CBBS), consortia such as EBIC (European Biostimulants Industry Council), major fertilizer and biostimulants manufacturers, farmers.

Regional Clusters: DACH countries (Germany, Austria, Switzerland) gather a considerable cluster of crop input companies acting as catalysts for startup-based innovations in this field.

Projects that inspired this analysis: Slovak startup Nitroterra has developed a less energy-intensive production unit for farmers to generate their own tailored biofertilizers. The project recently obtained funding to start the testing phase with a corporate partner. In the field of biostimulants, EU-funded research projects have resulted in cutting-edge companies levering on corporate and academic collaboration (e.g. Fyteko, AlgaEnergy).

Why this technology and project are needed to reach net-zero

Fertilizers

Around 1% of global GHG emissions come from the energy-intensive production of ammonia for use in fertilizers. Moreover, N_2O from inorganic fertilizer applications and end-use accounts for 50 $MtCO_2e$ emissions alone.

Biofertilizers provide a net-zero emission alternative to both issues, as they consist of natural micro-organisms. However, they are neither technically mature nor economically competitive today. To this end, it is important to upscale research in this field (only 1% of the fertilizer industry's total revenues are spent in R&D) while looking for solutions to grow production of available biofertilizers.

On-site versatile production units are critical to address these challenges. They enable the production of different microbial fertilizers at the farm, depending on climate, soil condition and crop requirements, while no longer having to rely on major distribution networks for continuous supply.

Biostimulants

Climate change and human emissions have affected European agriculture. Highly volatile weather conditions and soil erosion have led to massive crop losses, especially in Southern regions[9].

Agricultural biostimulants have diverse formulations of compounds, substances and micro-organisms that are applied to plants or soils to improve crop vigor, yields, quality and tolerance to abiotic stresses. The product is applied as a seed treatment or foliar spray and is complementary to crop nutrition and protection. Typical biostimulants include marine macroalgae extracts (such as kelp), plant extracts (such as brassinosteroids), protein hydrolysates and amino acids, or humic and fulvic acids.

While some biostimulants products have been on the market for many years, the research-based biostimulants sector has emerged recently. According to the EBIC, the impacts reach +5 to +10% in yield and +5 to +25% in nutrient use efficiency, depending on the conditions and type of crop. Higher rates can be expected from the R&D projects.

EU regulation in the field of bioeconomy needs to ensure that there will not be any breaks in the sector's development.

Impacts

	2030	2050
CLIMATE IMPACT	**6.6 $MtCO_2e$ avoided**	**26.4 $MtCO_2e$ avoided**
ECONOMIC IMPACT	**€1.4 billion total market** €5.9 billion investment by 2030, €590 million yearly average (2020-2030) €770 million turnover in 2030	**€3.3 billion total market** €23.6 billion investment by 2050, €790 million yearly average (2020-2050) €2.5 billion turnover in 2050
JOBS	**20,000 total jobs**	**49,000 total jobs**

#52 [9]See European Environment Agency report No 4/2019 "Climate change adaptation in the agriculture sector in Europe" https://www.eea.europa.eu/publications/cc-adaptation-agriculture

#53

TAP INTO THE POTENTIAL OF INSECTS FOR FAST-GROW FEEDSTOCK PROTEINS

Bring to commercial scale insect-protein production facilities and build routes to market

FOOD & LAND USE

Livestock

IN A NUTSHELL...

- **Issue:** Insect-based feeding potential remains untapped due to limited production
- **Solution:** Scale up production supporting new sites and R&D to reduce GHG emissions in the agri-food sector
- **Key impacts:** 12.5 $MtCO_2e$ avoided, €10.5 billion total market, 158,000 jobs in 2030

Innovation bet

Acceleration and scale-up

Drive to market scale

Project opportunity and ambition

Project type 1: Invest in R&D to scale up insect breeding processes to ramp up production efficiency

- The aim of this project is to tackle industrialization challenges to make insect-fed protein production a reality.
- Main issues to be solved are managing pathogens in large-scale breeding, increase insect feeding yield and use data analytics and automation to improve processes.

Project type 2: Build ten large-scale sites to increase insect-based feed production

- The production will target livestock and fish farming in Europe and will lever industrial symbiosis with food production facilities.
- The aim of the project is to build ten sites capable of producing at least 10,000 tons per year of insect protein feed using biowastes from nearby food production facilities as input for the insect breeding process, by 2025.
- Each of these facilities will individually avoid 25,000 tCO_2e per annum combining low-emission animal-feeding production with efficient biowaste utilization.
- Partner with major biowaste producers from the agri-food industry across Europe.

Main stakeholders: Insect-based feed companies (Protix, InnovaFeed, Ynsect and others), biowaste producers, livestock and fish farmers.

Regional Clusters: France and the Netherlands host some of the leading insect feed producers in the world.

Projects that inspired this analysis: Partnership between agri-food company Tereos and insect feed producer InnovaFeed in France. The latter has recently built its biggest production site (focusing on Hermetia Illucens insects for fish food production) combining their industrial processes by using agricultural byproducts as input for insect breeding. This company expects to further deploy similar plants by 2022.

Why this technology and project are needed to reach net-zero

Livestock consumes 20% of global proteins, in direct competition with humans. As a result, insect-based protein is a promising alternative for animal feed production since it has a high protein content, can be raised with almost no water, hundreds of times less land and with far fewer environmental impacts. Fish farming is the sector that benefits the most from this solution due to positive results shown by insect-fed fish on cost and quality. FAO data shows aquaculture supplies 50% of the fish destined for consumption and it is expected to reach over 60% by 2030. This sector can easily implement insect-based feeding to enable production to increase in the coming years.

Another key factor of this technology is its potential role in the circular economy. Insect-based feeding production uses biowaste as an input for the insect breeding process and produces other waste that can be used to generate biogas, also produced directly from biowaste. As such, there is an opportunity for regulation to create better market conditions by incentivizing the biogas industry to use waste that cannot be exploited by the insect farming industry while taking advantage of the outputs of insect-based feeding production processes.

Impacts

	2030	2050
CLIMATE IMPACT	**12.5 $MtCO_2e$ avoided**	**37.5 $MtCO_2e$ avoided**
ECONOMIC IMPACT	**€10.5 billion total market** €5.6 billion cumulated investment by 2030, €0.6 billion yearly average (2020-2030) €2.1 billion turnover in 2030	**€26.5 billion total market** €75 billion investment by 2050, €2.5 billion yearly average (2020-2050) €24 billion turnover in 2050
JOBS	**158,000 total jobs**	**398,000 total jobs**

#53

CAPTURE METHANE AND NON-CO_2 GHG EMISSIONS FROM CATTLE

Develop and test prototypes to capture methane and other gases emitted by cattle

FOOD & LAND USE

Livestock

IN A NUTSHELL...

- **Issue:** Livestock produce significant amounts of methane as part of their digestive processes, which account for 40% of livestock emissions
- **Solution:** Capture CH4 and oxide to CO_2 using zeolites
- **Key impacts:** 3.7 $MtCO_2e$ avoided, €220 million total market, 3,400 jobs in 2030

Innovation bet

Acceleration and scale-up

Drive to market scale

Project opportunity and ambition

Launch five R&D projects to develop methane capture installations suited to livestock conditions:

- Test several materials and assess their efficiency and suitability to capture and transform CH_4 and N_2O. Nanoporous zeolites, as well as porous polymer networks (PPNs) are already identified and can transform CH_4 into CO_2 thanks to catalysts[11].They could also be used for nitrous oxide.
- Design installations (e.g. arrays) adapted to the spaces where livestock is the most concentrated, e.g. exhaust points of barns containing ruminant animals.
- Develop prototypes at industrial scale by 2023.
- Extend the research works to the economics of such installations, and derive recommendations in terms of carbon pricing, as well as business models.
- Propose a roadmap for the set-up of industrial production as well as deployment across Europe.

Main stakeholders: Public and private researchers, industrials and farmers to test solutions.

Regional clusters: Countries with high livestock density such as the Netherlands and Belgium can make the most out of methane capture technologies.

Projects that inspired this analysis:

- Stanford University research published in Nature.
- Similar technologies have been developed for CO_2 direct capture (e.g. Climeworks startup (CH) producing modular and scalable carbon capture units) allowing significant emission reductions at the source.

Why this technology and project are needed to reach net-zero

The agriculture sector constitutes more than 55% of non-CO_2emissions in the EU with 421.1 $MtCO_2e$/year in 2020[12]. In the 1.5TECH scenario, this total needs to go down to 276.9 $MtCO_2e$/year in 2050. These emissions come mainly from livestock, and especially ruminants, which release methane (CH_4) in the air as a result of their digestive process. Nitrous oxide (N_2O) is also released by the animal's manure. Both gases have a much higher global warming potential than CO_2: methane is 84 times more potent than CO_2 over the first 20 years and around 28 times more potent after a century. In the case of N_2O, it is 265 times more potent after a century[13].

Even after substantial efforts to reduce them, some methane emissions from meat production remain inevitable. Consequently, methane removal might counterbalance the most intractable emissions. The little research performed so far performed so far on this topic has focused not only on capturing methane but also on converting it into less harmful CO_2[14]. As methane is 200 times less concentrated in the air compared to CO_2, it is more difficult to capture. Therefore, catching it at some concentration points such as in barns where the ruminants are concentrated would enhance effectiveness.

Research is only at an early stage and shows promising results based on zeolites material. The process is said to be suitable to remove N_2O as well. Now, research needs to speed up in order to propose effective and scalable solutions which are economically viable before 2025.

The economic viability of such solutions will depend on the carbon price which will be set by European legislation.

Impacts

	2030	2050
CLIMATE IMPACT	**3.7 $MtCO_2e$ avoided**	**11.2 $MtCO_2e$ avoided**
ECONOMIC IMPACT	**€220 million total market** €370 million investment by 2030, €37 million yearly average (2020-2030) €190 million turnover in 2030	**€834 million total market** €1.6 billion investment by 2050, €50 million yearly average (2020-2050) €782 million turnover in 2050
JOBS	**3,400 total jobs**	**13,000 total jobs**

#54 [10]https://www.bloomberg.com/news/articles/2020-07-14/burger-king-s-climate-solution-is-a-limited-supply-whopper?cmpid=BBD071520_GREENDAILY&utm_medium=email&utm_source=newsletter&utm_term=200715&utm_campaign=greendaily
[11]https://www.nature.com/articles/s41893-019-0299-x
[12]Figure 12, https://ec.europa.eu/clima/sites/clima/files/strategies/2050/docs/long-term_analysis_in_depth_analysis_figures_20190722_en.pdf
[13]https://ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_1.pdf
[14]https://www.technologyreview.com/2019/05/20/960/turning-one-greenhouse-gas-into-another-could-combat-climate-change/

PROMOTE TASTY, AFFORDABLE AND LOW-EMISSION ALTERNATIVES TO MEAT AND DAIRY PRODUCTS

Large scale production and receptive markets can massively cut greenhouse gas emissions associated with conventional animal products

FOOD & LAND USE | Livestock

IN A NUTSHELL...

- **Issue:** There are still only few alternative plant-based meat products and almost no cell-based alternatives. Market shares are low and, as well as dairy alternatives, they (until recently) have mostly failed to imitate original products
- **Solution:** R&D can break down the last barriers to go-to-market and cause the acceleration of alternative meat and synthetized milk products
- **Key impacts:** 51.5 $MtCO_2e$ avoided, €39.7 billion turnover, 596,000 jobs in 2030

Innovation bet | Acceleration and scale-up | Drive to market scale

Project opportunity and ambition

Project type 1: Support mature plant-based products to achieve 20% market share by 2030

- Identify and invest in 100 promising startups that need resources to scale-up production and roll-out their plant-based products.
- Start-ups' agile nature allows them to rapidly commercialize newly-developed products.
- Alternative meat consumption will be encouraged in Europe by levering mature alternatives.
- Projects that inspired this analysis: Les Nouveaux Fermiers (FR), Vivera (NL) or Meatless (NL) have successfully started to commercialize plant-based products like steaks, sausages or nuggets.

Project type 2: Bring together industry stakeholders to launch production of low-cost cell-based meat before 2025

- Gather consortia involved in cell-based meat production across Europe (~5 pure players) to co-develop solutions.
- Identify synergies to promote research partnerships in order to boost progress and stabilize low-cost production processes.
- Make cultured meat prices competitive before 2025 and reach a market share of 10% on the meat market by 2030.
- Fund laboratories and startups to develop technologies and food producers to scale up promising solutions.
- Projects that inspired this analysis: Dutch startups Mosa Meat and Meatable have successfully developed cultured meat hamburgers.

Project type 3: Launch research to synthetize milk

- Validate the concept of casein imitation (protein found in natural milk) using a lab-grown plant-based substitute and precision fermentation techniques.
- Major Players: Besides startups, academic and private researchers for technology, food producers to scale-up production and policymakers to facilitate go-to-market and public acceptance.
- Regional clusters: The Netherlands has a startup cluster in the field of plant and cell-based meat. France and Spain are also making substantial progress in this area.
- Projects that inspired this analysis: Swedish start-up Noquo Foods has recently obtained funding to further research on a plant-based solution to produce casein. Ice cream startup Perfect day also works on this technology.

Why this technology and project are needed to reach net-zero

Livestock production produces 14.5% of all human-caused greenhouse gas emissions. Alternative sources of protein must be developed, especially replacing meat. Solutions like plant-based products or cultured meat can reach conversion rates of plant calories of 70-75%, compared to just 25% with conventional meat and will lead to significantly reduced deforestation.

Plant-based meat alternatives are already available but still need to ramp-up quality and production in Europe. These products are gradually increasing their market presence in some countries.

Cultured meat is the most innovative solution but has economic barriers to overcome before being competitive. Research can overcome the last barriers and develop European patented processes for affordable cell-based meat. Rapid progress in this field suggests that cell-based burgers will be sold for €10 in 2021.

Being able to synthesize milk in labs would enable creation of products with a similar taste as traditional milk. Solid proteins (casein and whey) account for 3.3% of the overall composition of milk and are the challenging ingredients to replicate. Synthesized milk could first be incorporated in products containing milk as an ingredient, such as desserts.

All these technologies will encounter issues with market acceptance to some degree. EU regulation and policymakers can play a critical role to help consumers get acquainted with ecological food alternatives.

Impacts

	2030	2050
CLIMATE IMPACT	**Project type 1 (plant-based): 22 $MtCO_2e$ avoided** **Project type 2 (cell-based): 11.3 $MtCO_2e$ avoided** **Project type 3 (dairy): 18.1 $MtCO_2e$ avoided**	**Project type 1 (plant-based): 44.1 $MtCO_2e$ avoided** **Project type 2 (cell-based): 22.6 $MtCO_2e$ avoided** **Project type 3 (dairy): 36.3 $MtCO_2e$ avoided**
ECONOMIC IMPACT	**Project type 1 (plant-based): €19.5 billion turnover in 2030** **Project type 2 (cell-based): €9.8 billion turnover in 2030** **Project type 3 (dairy): €10.4 billion turnover in 2030**	**Project type 1 (plant-based): €39.1 billion turnover in 2050** **Project type 2 (cell-based): €19.5 billion turnover in 2030** **Project type 3 (dairy): €20.8 billion turnover in 2030**
JOBS	**Project type 1 (plant-based): 293,000 total jobs** **Project type 2 (cell-based): 146,000 total jobs** **Project type 3 (dairy): 156,000 total jobs**	**Project type 1 (plant-based): 586,000 jobs** **Project type 2 (cell-based): 293,000 total jobs** **Project type 3 (dairy): 312,000 total jobs**

#55 [15]Europe has three major actors in cell-based meat in Europe (Meatable, Mosameat, Cubiq Foods) against eight in the USA (https://www.gfi.org/non-cms-pages/splash-sites/soi-reports/files/SOI-Report-Cell-Based.pdf)
[16]ATKearney study: https://pdfs.semanticscholar.org/a9a1/016f0eb1074257f1418ab0d8f3078e6b76a3.pdf?_ga=2.224159707.1380060643.1594894475-1928829873.1594894475