GARDEN

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Report on food chain logistic challenges, electric and biofuel mobility solutions in public policies



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Greener AgRo-fooD logistics in the Mediterranean area (GARDEN)

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ABSTRACT

This study examines the critical role of logistics in short and local food supply chains (SFSCs), with a focus on the last-mile delivery stage in urban contexts. High fragmentation, small delivery volumes, and complex routes render logistics both a cost driver and a significant source of environmental impact. Findings underscore the necessity of scaling commercial flows before implementing sophisticated logistics solutions such as consolidation hubs or shared platforms. Intermediaries emerge as valuable partners in pooling volumes and improving cost-efficiency, while close collaboration among producers, buyers, logistics operators, and public authorities is essential. On the technological front, electromobility and biofuel-based transport, combined with retrofitting strategies, offer viable pathways to reduce carbon emissions. However, these advances rely on robust infrastructure, digital tools for data-driven route planning, and regulatory support in the form of Sustainable Urban Mobility Plans (SUMPs), Sustainable Energy and Climate Action Plans (SECAPs), and Low Emission Zones (LEZs). Ultimately, study finds that the transition to sustainable SFSC logistics hinges on context-sensitive strategies that integrate organizational innovation, stakeholder collaboration, technological adoption, and supportive policy frameworks. As consumer awareness grows, aligning production, distribution, and consumption patterns will promote more resilient, low-impact local food systems capable of meeting environmental objectives and ensuring economic viability.



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3. PURPOSE OF THE DOCUMENT AND GENERAL INTRODUCTION

This document serves as a comprehensive analysis of the challenges and opportunities within urban short food supply chains (SFSCs), with a focus on achieving sustainability, decarbonization, and scalability. SFSCs represent a promising pathway toward creating more resilient and environmentally friendly food systems by fostering closer connections between producers and consumers while reducing the carbon footprint of transportation. However, these systems face significant logistical challenges, particularly in urban settings where last-mile delivery emerges as a critical bottleneck.

The study draws on insights from prior European projects, international case studies, and stakeholder experiences to illuminate the multifaceted dynamics of SFSC logistics. A primary goal is to identify critical barriers faced by key stakeholders—producers, logistics providers, buyers, and local authorities—and to propose innovative, targeted solutions that align with the unique demands of urban and peri-urban contexts. By integrating findings from field research and real-world practices, the document outlines practical strategies for overcoming inefficiencies, scaling operations, and fostering collaboration across the supply chain.

Central to this analysis is the exploration of technological innovations and their transformative potential. Digital tools and platforms emerge as pivotal enablers for optimizing operations, consolidating commercial flows, and connecting stakeholders in meaningful ways. Similarly, advancements in clean vehicles, biofuels, and electromobility technologies offer tangible pathways for decarbonizing food logistics, particularly in densely populated urban areas. By showcasing examples of successful implementations, the document highlights practical approaches to reducing the environmental impact of food supply chains.

Beyond the technological and logistical dimensions, this study examines the critical role of public policy and regulatory frameworks in driving sustainable logistics. European initiatives such as the European Green Deal and regional policies like Sustainable Urban Mobility Plans (SUMPs) and Low Emission Zones (LEZs) provide vital context for understanding how governance can support the transition to greener, more efficient food systems. By leveraging such policies, public authorities can catalyze infrastructure investment, incentivize sustainable practices, and foster low-carbon mobility solutions.

Ultimately, this document aims to provide a strategic foundation for addressing inefficiencies in last-mile logistics, accelerating the development of scalable and collaborative models, and promoting resilient local food ecosystems. Through its synthesis of research, case studies, and actionable recommendations, the study seeks to empower stakeholders to achieve broader sustainability objectives while ensuring economic viability and social inclusivity. By advancing sustainable urban food logistics, the document aspires to contribute meaningfully to the global agenda of environmental and societal resilience.

4. ASSESSMENTS DELIVERED BY PAST AND ONGOING EUROPEAN PROJECTS

This assessment explores a range of past European projects dedicated to advancing sustainable mobility, energy efficiency, and innovative logistics solutions. The initiatives—such as Bin2Grid's promotion of biomethane production from food waste, EnerNETMob's development of electromobility networks, and DECARBOMILE's efforts to decarbonize last-mile logistics—offer valuable insights into how urban mobility and supply chains can become more environmentally friendly from a holistic perspective. By examining their objectives, methodologies, and outcomes, we aim to understand the impact of these projects on promoting renewable energy, enhancing electromobility infrastructure, biofuel mobility solutions, and fostering collaborative approaches to sustainable transport across Europe, therefore, indicating valuable lessons learned, while also building a repository of past European project dedicated to achieving sustainable mobility.

Bin2Grid project [1] (full title: Turning unexploited food waste into biomethane supplied through local filling stations network). aims to promote the segregation and collection of food waste as an energy source, its conversion to biogas, upgrading to biomethane, and utilization in a network of filling stations to support renewable energy production and sustainable waste management. Technical requirements for usage of biomethane in local filling stations was assessed, with particular focus to transportation sector (e.g. waste management trucks). Bin2Grid project supported 4 European cities in production and distirbution of biomethane as a biofuel based solution in transport sector; Zagreb, Skopje, Malaga, and Paris. Project implemented activities across the whole Food Waste to Biofuel (FWtB) concept in target cities, including supply (waste producers, waste management, and biofuel production), and demand (biofuel distribution through filling stations networks). Results include the creation of technology library on biogas/biomethane production, development of concept of filling stations network in target cities, benchmark tool for waste to biomethane concept, and development of national biomethane strategies on biomethane grid injection among others. Project indicated several challenges regarding the current state in project countries including limited number of refuelling stations, their lack of interoperability, limited car buying options, and higher maintenance cost.

They concluded that new partnerships between stakeholders to better balance supply and demand – along with other measures such as a favourable tax regime – could considerably boost the sector.

EnerNETMob project [2] (full title: Mediterranean Interregional Electromobility Networks for intermodal and interurban low carbon transport systems) EnerNETMob aims to draft, test and improve “Sustainable Electromobility Plans” according to common standards and low carbon policies, in order to set an “Interregional Electromobility Network” crossing cities of all the Interreg MED area. The project promotes shared mobility and land-sea intermodality using electric transport systems, by implementing interurban and interregional pilot networks of Electric Vehicles Supply Equipment (EVSE) also co-powered by Renewable Energy Sources. EnerNETMob created an "Interregional lectromobility Network" alongside an ICT Platform to manage monitor charging infrastructures, interconnect local "Small-Scale Infrastructure Network" within a transnational “Inter-regional Electromobility Network”, Interconnects and test “Small-Scale Infrastructure Networks”, as well as allow users to tackle longer travels at the transnational and interurban level thaks to the mapping of electrical charging points. The project also produced a number of useful documents for the development of electromobility in Europe, such as best practices in different countries in diferent areas of electromobility themes, policy recommendations to address existing barriers and foster the uptake of electromobility in Mediterranean regions, a report of electro-mobility and energy supply state of the art in partner states, EU policy and regulation framework of electromobility, guidelines to develop "sustainable electro-mobility plans", and finally a hand book "the resaons to choose the elctric transport".

DECARBOMILE project [3] (full title: Five pillars to DECARBOnize the last MILE logistics) aims to trigger an unprecedented improvement of the green last mile logistics in Europe. To reach that goal, DECARBOMILE relies on a strong experience of decarbonating urban logistics through European initiatives such as CIVITAS. Partners will build upon all previous results to develop improved delivery methods, tools and methodologies, and implement them across Europe. The solutions developed in DECARBOMILE will demonstrate the full potential of decarbonised last mile logistics in four living labs (in Logrono - Spain, Nantes - France, Hamburg - Germany and Istanbul - Turkey) and 4 satellites (Tallinn - Estonia, Getafe - Spain, Ghent - Belgium and Sarajevo - Bosnia and Herzegovina) will be involved at a smaller scale to test and study the solution in their own local contexts.

DECARBOMILE will rely on developed methodologies to implement the new solutions and delivery methods in collaboration with all relevant local stakeholders, based on their needs and behaviours. The relation with and between stakeholders will be facilitated by the creation of a collaborative urban consolidation logistics framework that will include a digital platform, methodologies for collaboration, and ICT and IoT tools. This common framework, along with tailored innovative business models and recommendations on local policies, will allow for a strong collaboration during the project, allow to learn more about the end-users' needs and behaviours. The delivery methods will be strongly improved with urban consolidation centres, micro urban consolidation centres including smart lockers, innovations on cargo bikes and how they can be used with load pooling for instance, electric barge and more. The goal is to use and improve existing solutions and allow their interoperability and modularity to improve their efficiency and use their complementarity.

GREEN-LOG project [4] (full name: Cooperative and Interconnected Green delivery solutions towards an era of optimized zero emission last-mile Logistics) accelerates systemic changes in last mile delivery ecosystems for economically, environmentally and socially sustainable city logistics. The project establishes city platforms comprising of inclusive stakeholder Urban Living Labs for nurturing social innovation, designing and deploying innovative delivery solutions while allowing the most effective exchange of ideas, the development of robust, harmonized regulatory and policy frameworks, and cooperative business models that build upon effective public/private-sector collaboration and joint investments. The GreenLog approach provides an innovative simulation environment for scenario building combining different solutions that allow the integration of last-mile delivery interventions with the highest possible impact on environmental sustainability and traffic reduction, while considering their financial viability. On the operational level, GreenLog provides cargo-bike based innovations for sustainable micro-consolidation design and deployments, multimodal parcel deliveries integrating public transportation, Logistic as a Service platforms for interconnected city logistics and automated delivery concepts with the use of autonomous vehicles and delivery droids. The solutions are supported by interconnected city logistics dataspaces that feed dynamic services for proactive optimization of the ecosystem, respecting the interests of consumers, businesses and city stakeholders. The approach is deployed and validated in five cities and areas: Athens, Barcelona, Flanders, Oxfordshire and Ispra.

Special focus is given on the transferability of the proposed innovation, starting from three follower cities with high interests in tailoring and replicating the GreeLog solutions, and continuing with a pan-European outreach with intensive transfearability accelaration actions, setting the ground for the establishment of multiple city logistics Urban Living Labs. No deliverables have been published yet.

BioDieNEt project [5] (full title: Developing a network of actors to stimulate demand for locally produced biodiesel from used cooking oils) has the objective of promotion of localised biodiesel production for transportation purposes, by means of the active involvement of local Energy Agencies in more than 10 European countries. The action will establish a working network of Energy Agencies, working closely with their associated local municipalities and regional governments and other market actors across Europe who are engaged in or planning to be engaged in the supply of locally-produced biodiesel from used cooking oils. The network will provide specific, practical information, education, dedicated tools and support to help set up and maintain projects which result in greater uptake of locally-produced biodiesel by public and private vehicle fleets as well as individual vehicle owners. Through the involvement of Energy Agencies traditional barriers of centralized biodiesel structures are addressed to enable easier introduction in higher concentrations (20-100%), reduce high risks involved for potential biodiesel producers, and create localized supply chains. The main objective of the BioDieNet project was the development of a network integrated by different agents to stimulate the demand for biodiesel created from used vegetable oils, in order to reduce greenhouse gas emissions, the environmental impact of cooking oil spills, and, at the same time, generate jobs. CRIB contributed with experience gained from the "La Ribera en Biodiesel" local project, which was launched in 2003. La Ribera en Biodiesel project performed the collection of used vegetable oils for their transformation into biodiesel.

DEMETER project [6] (full title: Building an Interoperable, Data-Driven, Innovative and Sustainable European Agri-Food Sector) aimed to enhance digital solutions for farmers through:

- A human-in-the-loop model combining human expertise with digital information.
- Prioritizing interoperability across data, services, platforms, M2M communication, and human knowledge, connecting farmers, advisors, and ICT solution providers.

- Transforming agriculture with digital technologies such as IoT, Earth Observation, Big Data, AI, and promoting cooperation, mobility, and open innovation practices.

The DEMETER Project achieved significant advancements in smart farming and IoT integration, demonstrating interoperability between IoT technologies through the Agricultural Information Model (AIM). This model integrates diverse data sources, enhancing data accessibility and usability across the agricultural sector (Demeter - EMPOWERING FARMERS) (CORDIS EU). The project executed 20 pilots across 18 countries, showcasing innovations in herbicide use, pesticide management, water and soil management, harvest optimization, and energy management. These pilots improved operational efficiency and sustainability for 6,000 farmers and 38,000 devices (Demeter - EMPOWERING FARMERS) (DEMETER Project). Additionally, the project fostered new business opportunities, creating a secure European IoT ecosystem (Demeter - EMPOWERING FARMERS), and focused on standardization to ensure scalability and reduce implementation costs (Demeter - EMPOWERING FARMERS).

FoodDecide project [7] (full title: Digital Technologies for Food Safety Decision Support) aims to enhance food supply-chain models by incorporating time-based information, such as seasonality, to better reflect demand variations and improve trace-back algorithm performance. This project will produce new scientific algorithms and practical decision support software. By extending the algorithmic and knowledge base, the project aims to support future trace-back solutions for food-borne outbreak investigations and benefit various supply chain applications, including agriculture, tourism, and transportation planning. The FoodDecide project aims to enhance existing food supply-chain models by integrating time-based information, particularly focusing on seasonality. This approach is expected to better reflect demand variations and improve trace-back algorithm performance. The development of realistic, time-dependent food supply-chain models is valuable not only for food safety but also for agriculture, tourism, and transportation planning. The project will produce both new scientific results (algorithms) and practical software solutions (decision support software). Scientifically, it will extend the algorithmic and knowledge base needed for future trace-back software solutions, supporting food-borne outbreak investigations. These advancements could also benefit other researchers and developers in creating tools to manage and analyze food supply chains more effectively.

aGROWchain project [8] (full title: Agrowaste supply chains for sustainable growth) aims to improve the promotion of the sustainable management of solid agricultural residues to cover thermal needs in public buildings. In the project the partners worked on the development of supply chains and business models with the Municipal Authorities. Also, the project included the implementation and demonstrative operation of 1 supply chain per country participating in the project, which allowed the control and optimization of the proposed models in real conditions. Main outputs include:

- 1 supply chain for each municipality demonstrated through a pilot action of 18 months
- 1 GIS mapping and logistics tool for agrowastes valorization
- Identification of alternative supply chains in Amyntaio and Novaci that can support future biomass installations (at least 2 per Municipality)
- 4 case studies for the exploitation of local agrowastes in 4 Municipalities in the Programme area, apart from Amyntaio and Novaci.
- 2 training seminars targeting local authorities (25 trainees and 2 days each)
- 1 operational interactive platform for biomass suppliers in the cross border area
- Development of 1 bioenergy cluster in the former Yugoslav Republic of Macedonia and 1 virtual mega-cluster across the borders.

EMOBICITY project [9] (full title: Increase Of Energy Efficiency By Electric MOBIlity In The CITY) aims to strengthen the capacities of all key-stakeholders on e-mobility, especially regarding policy making, through workshops, study visits and peer reviews, as well as to raise public awareness by open campaigns and other communication activities. EMOBICITY supports policy learning on e-mobility at a national and regional level, by the exchange of experience, between the project partners, policy and decision makers and other project stakeholders from the EU participating countries. Key outputs include:

- Workshops, study visits and other activities, bringing together all key players for discussions and brainstorming, highlighting relative good practices
- Providing action plans for the improvement of the policy instruments addressed by the partnership, proposing enrichments and amendments

CABIT project [10] (full title: E-Cargo Bike Riders Initial Training) supports moves to transfer as much as possible of the freight/goods being moved within the urban environment in Europe, from diesel and petrol vehicles to electrically powered cargo bikes.

To achieve this, the project aims to help support any municipality, business or social enterprise which uses or intends to use an e-cargo bike to deliver its operations or services. A training programme targeting specifically e-cargo bike riders, to enable them to ride, operate their vehicles, and carry out required tasks in a safe, skilled and competent manner.

TRAILS project [11] (full title: Youth for Sustainable Mobility and Inclusion) provides support for the new generation of workforce in the field of urban mobility, specifically – electromobility, by providing access to new knowledge and skills, through which young practitioners can adapt to modern technologies and business models. The project also aims to promote entrepreneurship and innovation capacity among young people and grant them access to professional development in the electric vehicle industry. Key results are:

- Solving challenges in the electric vehicle industry caused by the lack of sufficient qualifications of the incoming workforce.
- Development of new knowledge and skills, helping young people adapt to the needs of the industry.

SPOTLOG project [12] (full title: Green and Socially resPOnsible ciTy Logistics InnovaTions) main vision is to involve local communities in creating socially responsible logistics systems, based wherever possible on zero-carbon modes, through the intelligent use of all available resources and taking advantage of the digitalisation of goods and passenger transport services. By focusing on low-density communities and medium-sized cities, SPOTLOG partners aim to improve regional policy instruments toward the European goals of inclusive and carbon-neutral mobility. Main outputs include:

- Share knowledge and spot good practices regarding innovative ways of efficient logistical distribution and zero-carbon modes,
- Promoting trust between stakeholders for better inter-sector collaboration (e.g., by fostering collaboration between passenger transport and logistics companies, distributors and local commerce);
- Building professional capacity in planning and impact assessment of the various solutions and improving the adequacy of the legislative framework and sustainable mobility plans.

Table 1. Past and ongoing European projects

PROGRAMME AND PERIOD	PROJECT ACRONYM	APPLICATION AREA
H2020-EU.3.3.	Bin2Grid	Croatia, Germany, Austria, North Macedonia, Spain, France
Interreg MED	EnerNETMob	Greece, Malta, Italy, Cyprus, Albania, Croatia, Slovenia, Portugal, Montenegro, Spain, France, Austria
Horizon Europe (HORIZON-CL5-2021-D6-01-08)	DECARBOMILE	France, Spain, Denmark, Germany, Italy, Turkey, Bosnia and Herzegovina, Belgium, Estonia, Bulgaria, Poland
Horizon Europe (HORIZON-CL5-2021-D6-01-08)	GREEN-LOG	Luxembourg, Greece, Spain, Cyprus, Belgium, United Kingdom, Sweden, Estonia, Italy, Romania
Intelligent Energy Europe (IEE)	BioDieNEt	UK. Germany, Austria, Italy, Hungary and Spain
H2020-DT-2018-2	DEMETER	Italy, Luxembourg, Spain, Germany, Greece, United Kingdom, Norway, Czechia, Montenegro, Romania, Ireland, Serbia, Portugal, Poland, Georgia, Slovenia, Finland
Federal Ministry of Education and Research (Germany)	FoodDecide	Montenegro, Germany
INTERREG-IPA CBC	aGROWchain	Greece, North Macedonia
Interreg Europe	EMOBICITY	Greece, Croatia, Germany, Portugal, Romania
Erasmus +	CABIT	Austria, Italy, Greece, Bulgaria, Spain, Romania
EIT Urban Mobility	TRIALS	Bulgaria, Malta
Interreg Europe	SPOTLOG	Portugal, Italy, Poland, Latvia, Finland, Belgium, Romania

5. CHALLENGES OF FOOD CHAIN LOGISTICS

5.1 Introduction

In this section, we look at the issues involved in the downstream logistics of food supply chains for supplying towns and cities, with a particular focus on short and local circuits. The content presented draws on research, field experience, and sectoral studies from several countries. After defining the key concepts mentioned in this document, the first part explains why decarbonizing logistics is essential to reduce the environmental impact of the products transported, as well as the various levers that can be used to achieve this (matching means of transport to volume transported, optimizing delivery rounds, choosing clean vehicles). In the second section, we explain why these levers are difficult to implement, particularly in the case of short and local circuits. Thus, in this section, we address the key challenges faced by various stakeholders in the food supply chain, including producers, logistics stakeholders, distributors, final buyers, and local authorities, within short and local circuits. In the third section, we present decision-support tools, information systems, and existing digital platforms that can be used to rationalize delivery routes and/or plan vehicle replacement. We also present feedback from various countries on innovative short-food supply chain initiatives led by producers, wholesalers, logistics operators, sales platforms, shops, and reverse logistics stakeholders. In the fourth section, we list the lessons learned from these experiences considering the implementation of the GARDEN's project.

5.1.1 Definitions

Logistics: Logistics encompasses the management of all material, information, and financial flows aimed at improving the organization of production, supply, and distribution. It involves coordinating all the stakeholders, from the producer to the end customer. In short and local food supply chains, we can distinguish between:

- Upstream logistics (on the scale of the farm and its suppliers),
- Downstream logistics (which concern distribution either directly or via an intermediary),
- Reverse logistics (possible return of containers and packaging, and organic waste).

An optimized logistics could be described as follows: the right product, in the right place, at the right time, at the right cost. This document proposes a comprehensive view of the logistics concept and defines logistics to encompass transportation, warehousing, and inventory management, in accordance with established definitions in the literature.

The logistics of short and local circuits are not the same as those of long circuits on a smaller scale. It requires specific organizations to be set up and tools to be adapted because of:

1. the fragmentation of flows (small volumes, from a multitude of producers to a multitude of sales outlets),
2. the diversity of products,
3. the lack of logistics expertise on the part of producers and their limited capacity to invest or pay for external services.

It is more complex and generally more costly than in the case of long distribution channels because it is less easy to massify flows [13].
The last mile supply chain generally refers to the last delivery of transport into the city town. It needs a complex organization, involving producers, food hub platforms, intermediaries, professional transporters specialized in the last mile supply chain, a food solidarity organization, etc. It's a key challenge in the process of decarbonizing food logistics with the development of low-emission zones. It's also a food democracy challenge to give access to fresh and quality food in urban areas.

Reverse logistics: If we reason in terms of urban metabolism, logistics for urban food supply in the south of Europe has, finally, every interest in taking into account the export of waste generated by inhabitants and companies (packaging, containers, unsold goods, etc.), which can be a real problem in certain cities, particularly on the coast, to reduce the environmental impact of the products. This is how our project intends to experiment with the implementation of different approaches to meet the challenges of energy transition, food resilience of the Mediterranean territories, and circular economy. Even though reverse logistics is relatively common in a variety of industries, it is still not adequately implemented in the food industry [14].

Short food supply chain (SFSC): The EU regulation recently formulated an official definition of short supply chain: "*A short supply chain means 'a supply chain involving a limited number of economic operators, committed to cooperation, local economic development, and close geographical and social relations*

between producers, processors and consumers" (Article 2 of Regulation (EU) No 1305/2013 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD).
The frame of the EU regarding the short supply chains is specified as follows: "*Support for the establishment and development of short supply chains … shall cover only supply chains involving no more than one intermediary between farmer and consumer*".

(Article 11 of European Commission Delegated Regulation (EU) No 807/2014 supplementing the Rural Development Regulation).

Source: Short food supply chains and local food systems in the EU [15]

Local food system: "a food system in which foods are produced, processed and retailed within a defined geographical area" (depending on the sources, within a 20 to 100 km radius approximately). The notion of "local" food is subjective and depends on the context of the local area: the density of population, accessibility, and urban or rural character. "The term 'local' can also refer to the closeness of the relationship between producers and consumers, based on mutual trust and cooperation".

Sources: Short food supply chains and Local Food Systems in the EU, A State of Play of their Socio-Economic Characteristics [16], Short food supply chains and local food systems in the EU [15]

5.1.2 Content

- Decarbonizing logistics to reduce the environmental impact of food products: a complex necessity

In this section we talk about (1) the product Life Cycle Analysis (LCA) - as logistics can have a major impact on the environmental global impact of food products, (2) the need to optimize short and proximity supply chains logistics and the levers to achieve this objective (taking into account the specific features and the complexity of those supply chains), and (3) the challenges facing by the city of the future, which will have repercussions on supply chain stakeholders (Low emission zone, etc.).

- Pooling, optimizing, monitoring, investing…: the challenges facing supply chain stakeholders, particularly in the case of short and local food circuits

In this second section, we describe the challenges from the point of view of producers, wholesalers, logistics operators, sales platforms, shops, and stakeholders of the circular economy, underlying the challenge of communication (information flow).

- Innovating in food supply chains: tools and feedback to be developed at the level of the Euro-MED cooperation area

In this section, we analyze existing tools supporting the stakeholders in their logistics decision-making (e.g. Logicout, Verdir ma Flotte), sales platforms that try to facilitate the massification of flows (e.g. CoopCircuits), tech operators using algorithms to connect supply chain stakeholders and allow polling strategies (e.g. La Charrette, Agriflux).
We also collected feedback from producers, wholesalers, logistics platforms, grocery shops, and reverse logistics companies who built organizations meeting some of the challenges outlined above. In each case, we highlight the solution developed, the users, the finance resources, and the results (successes, failures, analysis).

- Summary: main lessons for designing the pilots of the GARDEN project:

Based on the previous section, we highlight the main lessons learned to improve logistics organizational models and to support stakeholders in finding an effective functioning logistics system.

6. DECARBONISING LOGISTICS TO REDUCE THE ENVIRONMENTAL IMPACT OF FOOD PRODUCTS LIFE CYCLE: A COMPLEX NECESSITY

6.1 Logistics of food supply chain

Food logistics is a vital element of the food supply chain [17]. It is an important aspect of fulfilling consumer demands by providing the right product and quantity at low cost and on-time delivery with minimum or no food waste since the majority of food products have a very short shelf-life [18]. It includes both cold and ambient logistics involving precise planning, execution, and efficient monitoring to effectively manage the movement of food products from farm to fork with minimum resources and wastage while at the same time satisfying consumer needs.

According to Mittal, A. et al. [19] efficient logistics management must consider three key aspects:

1. **transportation** (movement of inventory from point to point in a supply chain);
2. **warehousing** (activities involving the physical locations where inventory is stored, retrieved, assembled, and packed for distribution);
3. **inventory management** (monitoring and deciding how much inventory to store, what is in stock, and how inventory should be stored).

As stated in the paper of Bloemhof, J. M. et al. [20] food chain logistics comprises organizations that are responsible for the production and distribution of vegetable or animal-based products. In general, these chains may comprise growers, auctions, wholesalers, importers and exporters, retailers, and specialty shops and their input and service suppliers (Figure 1).

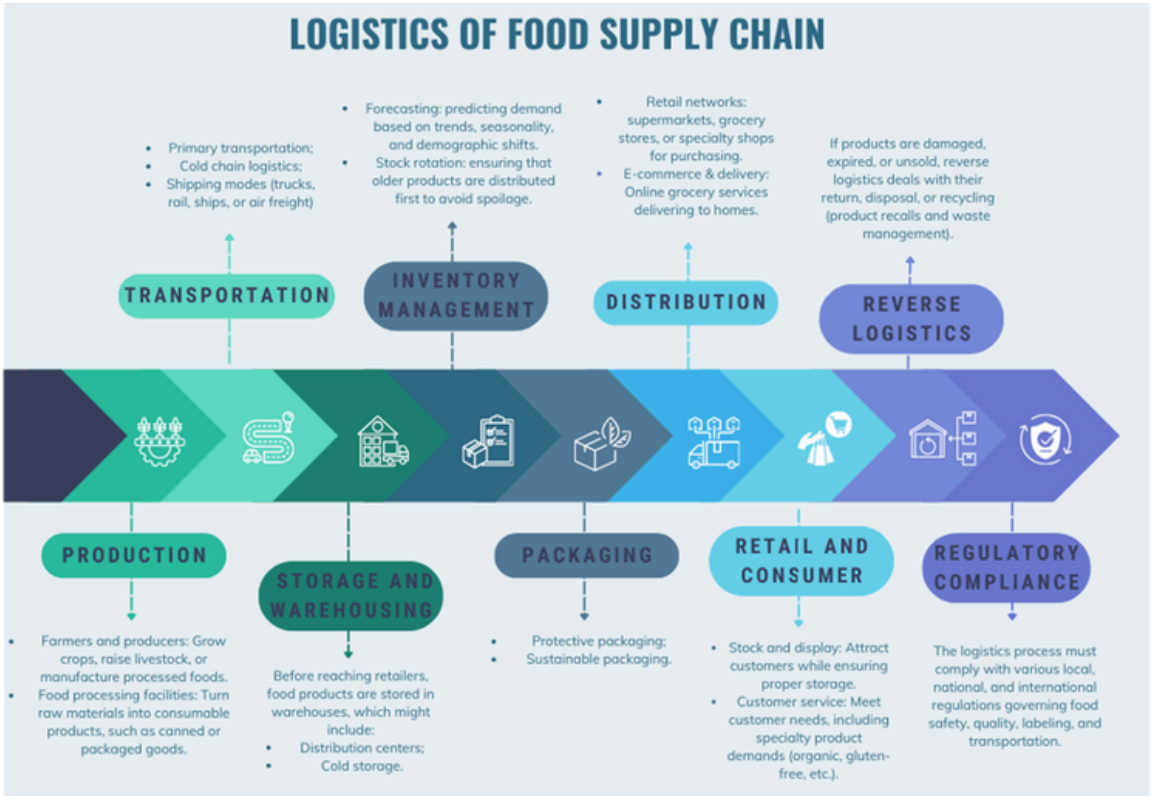


Figure 1. Steps of logistics in food supply chain [20]

In long chains, there is not only one type of logistic organization, as it can vary according to the supply mode, to the destination of the product (exchanges within or between areas, international exchanges) and its purpose (sale to customers, catering industry, eating outside of home, or food processing) [21]. However, a global pattern emerges from the analysis of the fruit and vegetable industry, as illustrated in the Figure below.

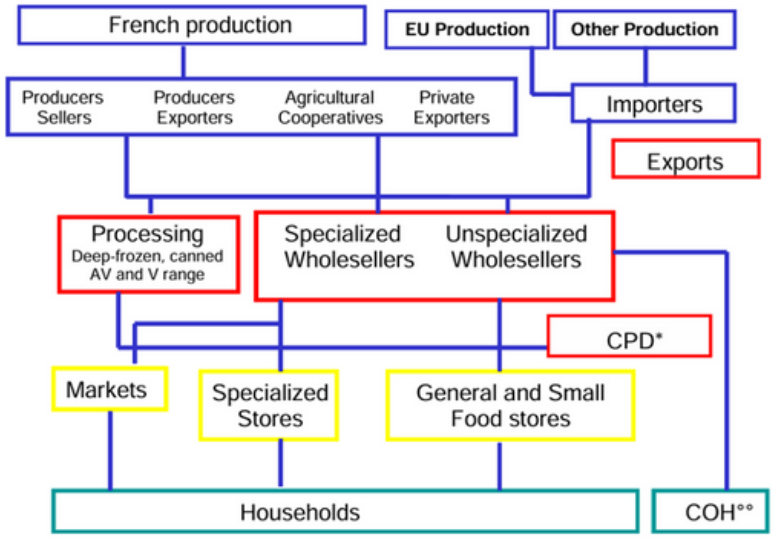


*Figure 2. Long food chain organization (*Central Purchasing Department, **Catering industry and eating outside of the home) [22]*

The graph highlights the significant role of intermediaries in the supply chain: traders, central purchasing departments of large retailers, and/or logistics service providers. Producers lack control over the flow of goods and information. To gain better control over their supplies, large retailers and local authorities have established their own purchasing structures, reducing reliance on dedicated intermediaries. Consequently, traders have diminished in importance, with only 2,112 companies and 26,105 employees in 2006 [22], while the sector had been in decline since the start of the decade. Additionally, the global fruit and vegetable market is projected to grow significantly, with trends indicating a 50–150% increase in production by 2050 to meet dietary needs. Innovations in cold chain logistics, precision agriculture, and packaging play a crucial role in supporting this growth, leading to new market dynamics that may further reduce the reliance on traditional intermediaries.

Food logistics businesses have embraced information technology in their daily operations to manage both road and food safety compliances, road conditions, including congestions, service level (on-time in-full delivery), and to improve environmental performance [18]. Additionally, the food logistics market has grown increasingly saturated over the past few decades, with rising customer demands adding more complexity and pressure to the systems. Factors like product shelf life, globalization, demographic shifts, fluctuating demand for specialized food products (such as gluten-free, low-sugar, low-salt, and low-calorie options), and the need to meet ethical and sustainable standards have further intensified this pressure.

As reported by Yacamán Ochoa, C. et al. [23] when using a cooperative approach to make the logistics of regional food supply efficient, the following key areas need to be considered:

- improve the efficiency of the whole supply chain through the shared use of vehicles and by creating shorter routes between the production zones and the local consumption points.
- strengthen the relationships in the supply chain, mainly with institutions to encourage public purchasing and small-scale commerce.
- optimize logistics to cope with efficiency on a regional level through the aggregation of multiple small-scale farms to improve efficiency and reduce costs.
- carry out, wherever possible, joint planning between several small-scale farmers for a range of diversified products, ensuring year-round supply.

- secure finance to invest in new technology (e-commerce and GIS tools).

6.1.1 *Logistics of short and local food supply chain (SFSC)*

Since the early 2000s, short food supply chains (SFSCs) have expanded significantly across Europe, driven by rising consumer concerns about food sustainability, transparency, and the environmental impacts of long, industrialized supply chains. Key motivations behind this shift include the desire for local products, improved food safety, and support for rural economies. The literature shows that the demand for local food is growing [24] and impacts farmers, restaurants, and other food services [25]. It's considered the most important food trend [26]. Consumers perceive local foods as providing a wide range of benefits such as environmental sustainability [27], various food quality attributes [28], food security [29] , social justice [30],and support for the local farming economy [31].

Several EU projects, such as Strength2Food [32] and SMARTCHAIN [33], have explored the impact of SFSCs on economic, social, and environmental sustainability. For example, SFSCs, like farmers' markets and local cooperatives, have been shown to foster stronger relationships between consumers and producers, increasing consumer trust and transparency regarding food origins. SFSCs also provide economic benefits for producers by allowing them more autonomy and better resource utilization. However, challenges such as higher costs (last mile logistics for SFSC can represent 45% of the total cost of a product) and limited availability compared to conventional supply chains remain barriers to wider adoption, as we will see in the following sections.

6.2 The last-mile logistics impact in the life cycle analysis of food products

Food production is responsible for about 30% of global energy consumption when including a full lifecycle of products for agriculture, food processing, distribution, and consumption. Furthermore, the food system is the largest user of land on the planet, with vineyards alone occupying about 7.5 million hectares of land, and cereals cultivated across 700 million hectares of land [34] - twice the geographic size of India. The production and delivery of food necessitates a continuous and considerable supply of energy and natural resources, including not only fossil fuels but also crops, soils, biomass, plastic, steel, and minerals.

One life cycle assessment calculated that for every 1 J delivered in a final food product consumed by a household, typical energy and resource requirements needed to make and deliver that food reached about 10 J [35]. Every year, about 9,800-16,900 metric tons of carbon dioxide (CO_2) are created via the food supply chain, with this figure expected to climb to 30% by 2050. Methane (CH_4)emissions are primarily caused by animal-origin meat and dairy products, as well as rice production, but nitrous oxide (N_2O) emissions are caused by food products from other crops. Carbon dioxide is also generated during the manufacture and delivery of food goods.

The Life Cycle Assessment (LCA) is a standardized framework (ISO 14040 and 14044) that allows assessing the environmental impact of a product or system over its entire life cycle, from the extraction of raw materials to end-of-life or recycling. LCA makes it possible to quantify environmental impacts to identify eco-design or improvement options and to compare, from an environmental point of view, systems with the same function, for the same quantity of service provided. LCA is one of the major environmental assessment approaches used to shed light on the major issues facing society. It provides a methodological framework for thinking about, defining, and quantifying the environmental consequences of human activities. The approach is systemic (taking into account the entire life cycle of a product to describe value chains as a whole), and multi-criteria, to address issues relating to human health, ecosystems, and resources. The LCA makes it possible to assess the impact of the delivery logistics on the global environmental impact of the food supply chain.

6.2.1 *Impact of logistics in SFSC : example with a life cycle analysis of 4 food product*

Between 2017 and 2020, as part of an action research project, FAB'LIM (partner of the project Euro-Med GARDEN) led participatory eco-design initiatives on 4 products from short, local organic farming channels in the south of France (bread, tinned tomato sauce, bottles of wine, and bottles of beer). The analyses show that, in organic farming, the choice of product containers and the optimization of distribution logistics are among the most significant aspects to be taken into account in reducing environmental impact. This last point is confirmed by the work of ADEME (the French Agency for Energy Transition). In a June 2017 report [36] on the environmental impact of short and local food supply chains, ADEME points out that more proximity does not necessarily mean fewer greenhouse gas emissions per kg of product transported if the transport used is

unsuitable, if logistics are insufficiently optimized or if consumers have to travel further because of the dispersal of distribution points.

The idea that local food systems' small travel distances are enough to make them environmentally friendly and that SFSC creates less CO2 than traditional food systems is incorrect: the proximity between producers and consumers does not automatically indicate a reduction in emissions [37].

Conversely, it is possible to find out conditions and factors whereby local distribution systems have a greater impact than long sales chains (see e.g. [38], [39], [40]).

Hence the importance of supporting initiatives led by local stakeholders: producers, food processors, citizens' groups, local authorities, businesses, and/or associations, by sharing best practices and promoting the levers for optimizing logistics and the associated environmental gains. If logistics are optimized (matching the kind of transport to the volume transported, optimizing the delivery route, filling the lorry, using a clean vehicle, etc.), short, local food supply chains can be highly efficient from the point of view of transport.

7. POOLING, OPTIMIZING, MONITORING, INVESTING: THE NEW CHALLENGES FACED BY FOOD SUPPLY CHAIN STAKEHOLDERS, ESPECIALLY IN SHORT AND LOCAL FOOD CIRCUITS

7.1 Producers / processors

7.1.1 Producers in long food supply chain (LFSC)

Long Food Supply Chains (LFSCs) involve numerous intermediaries between producers and consumers, posing several challenges for producers. While these chains enable the global availability of food, they often make it difficult for producers to achieve fair earnings and sustainable operations. The key challenges faced by producers in LFSCs are limited transparency, price fluctuations, logistical costs, and the impact on product quality and the environment.

- **Unfair trading practices (UTPs) in LFSCs**

One of the most significant challenges faced by small farmers, cooperatives, and small food processors in LFSCs is unfair trading practices (UTPs). Smaller producers often rely on large buyers, like supermarkets and major food processors, as their primary or sole access to the market. These large buyers can exert considerable pressure on prices, often pushing smaller suppliers into unfavourable conditions, at times forcing them to sell at a loss to maintain market access. This undermines the economic sustainability of small farmers and cooperatives, making it difficult for them to compete in a market dominated by larger players.

In June 2016, the European Parliament urged the European Commission to propose measures against UTPs to ensure fair earnings for farmers and a better choice for consumers. In response, the EU adopted legislation in 2019 specifically aimed at reducing UTPs, especially in the agricultural sector. This legislation prohibits practices like late payments, last-minute cancellations, and unilateral contract changes, all of which disproportionately impact smaller producers. By curbing these unfair practices, the EU seeks to create fairer trade conditions and improve market

access for small-scale producers, promoting a more balanced food supply chain for all participants.

- **Limited transparency in LFSCs**

Due to the length and complexity of these supply chains, it becomes increasingly difficult for producers to have clear visibility over the journey of their products once they leave the farm or production facility. Producers often struggle to trace where their products are being sold and how they are handled at various stages of the supply chain. Without proper insight into how their goods are stored, transported, or processed, producers may face quality control issues or risks of spoilage, which can damage their reputation. Pricing along the supply chain becomes opaque, making it challenging for producers to understand how their products are valued and how much of the final retail price they actually receive. Middlemen and larger entities in the supply chain may take significant portions of the profits, leaving producers with smaller margins and limited negotiating power. Limited transparency affects producers' ability to gauge consumer perceptions. Without direct feedback or interaction with the end consumers, producers have a harder time understanding market trends, consumer preferences, and how their products are perceived in terms of quality and price. This disconnect can hinder their ability to adapt and innovate, further reducing their competitiveness in the market.

- **Logistics and transportation costs**

Logistics and transportation costs present a major challenge for producers in LFSCs. Since products must often travel significant distances to reach markets, the costs associated with transportation, storage, and distribution increase considerably. This is especially problematic for small producers, who typically lack the resources and economies of scale that larger producers or corporations can leverage. For smaller producers, high transportation costs can significantly erode already thin profit margins. The expenses related to fuel, packaging, and cold storage—particularly for perishable goods—can quickly accumulate, leaving little room for profitability. Furthermore, longer transportation times increase the risk of spoilage or quality degradation, leading to additional losses for producers who may already be struggling to compete. The logistics complexities of LFSCs also extend beyond cost. Coordinating the movement of goods across multiple stages of the supply chain, often involving numerous intermediaries, can lead to inefficiencies such as delays or miscommunication. These challenges can disrupt delivery schedules, affect the freshness of products, and increase the likelihood of wastage. For small producers, who often operate on tighter schedules and budgets, any disruptions in logistics can have significant consequences.

- **Dependency on intermediaries**

Producers in LFSCs often rely on intermediaries like distributors, wholesalers, and retailers to reach consumers. Lack of direct contact with consumers prevents producers from gathering insights into preferences, trends, and feedback. Without this connection, producers struggle to adapt their products and build brand loyalty, as larger retailers often promote their own branding over small producers' labels. Relying on intermediaries limits producers' control over pricing, marketing, and product placement. These middlemen may prioritize their own goals, leaving producers with little influence over how their products are represented.

- **Perishability of Products**

Fresh produce has a short shelf life, and the longer it takes to reach consumers, the more likely it is to lose freshness and market appeal. However, products often go through multiple stages such as transportation, storage and distribution, each of which adds time and potential exposure to spoilage factors such as temperature fluctuations and improper handling. The extended transportation and storage times increase the risk of spoilage, quality deterioration, and food waste, leading to financial losses for producers. For smaller producers, these challenges are intensified due to limited access to cold chain infrastructure. The costs of temperature-controlled logistics are high, leading to increased wastage and reduced profit margins. Spoilage of products not only impacts producers financially but also contributes to food waste, a significant environmental issue. Solutions for improving this challenge require substantial investment, making perishability a persistent challenge for smaller producers in LFSCs.

7.1.2 Producers in short food supply chain (SFSC)

In the last report of the European parliament about short supply chains, 15% of the farmers were selling more than 50% of their product in a SFSC (definition above): direct sales by individuals (e.g. local food market), collective direct sales (e.g. farm shop) and partnerships (e.g. community-supported agriculture). The SFSC are interesting for both producers and consumers as they ensure a higher share of the final sale price for the first ones and an unbeatable value for the second ones. Nevertheless, short food supply chains cannot always meet the demand from larger customers as “they have limited ability to expand due to higher costs of production, processing and transport, and to their location, which confines them to small, local markets” (Short food supply chains and local food systems in the EU. [15]), the logistics flows are more complex and need a lot of relationships (except for direct sale).

- **The difficulty to meet a high demand**

SFSCs typically involve producers with limited production and logistics capacities. By participating in SFSCs, they find suitable marketing channels that enable them to become entrepreneurs [41]. Moreover, producers who decide to distribute their products through SFSCs are usually small and medium-scale farmers with limited production and logistics capacities because of the lack of availability of resources (infrastructure, skills, capital etc). Yacamán Ochoa, C. et al. [23] noticed the lack of interest in increasing direct sales to restaurants and small shops, despite being territories with an important tourist weight, where they are an essential economic sector. This lack of engagement is also evident in the public food procurement sector. This is linked to the producers' inability to meet the high demand for daily distribution of a diverse range of products, often due to small-scale production and limited resources. Small farms frequently lack the infrastructure and labor force to efficiently handle large orders or offer variety, which results in difficulties scaling up operations. Moreover, small shops and restaurants often prefer not to use SFSCs for this reason, as they rely on consistency and volume, which small producers struggle to deliver. The underutilization of online sales and e-commerce further complicates the situation, despite these being strategies with growing potential to streamline processes. When considering the potential for boosting sales through wholesale and distribution channels, both regions express a similarly low valuation due to their limited negotiating power on prices. Notably, in Malaga, there is a preference for selling tropical crops to distribution companies that typically export the produce elsewhere, highlighting an ongoing challenge in maximizing local sales and distribution efficiency.

- **The cost of logistics for producers in SFSC**

Logistics, in particular, is one of the most important obstacles of short food supply chains. The OLICO-Seine project (2016-2018, 180 surveys in Normandy and the Paris region) calculated an average of 8 hours a week spent by farmers on logistics (for an average of 16 sales outlets). The results of the project also underlines that few of them have already calculated their logistics costs (50% have not done so, and 25% have only done so approximately). This explains why logistics costs are not well included in the price of the product (ALLOCIRCO project, 2015 [42]). Researchers estimate that this cost represents an average of 23% of producers' turnover [43], whereas it is estimated that an optimized logistics organization should represent less than 20% of turnover. Actually, it appears that many farmers in short supply chains frequently do unprofitable delivery rounds.

Regarding legal issues, producers in short supply chains who want to deliver the food for themselves and other producers suffer a mismatch with the standards adapted to long the supply chain (too expensive, too complex): the regulations on the transport of goods, communication, traceability (barcodes, etc.) and packaging.

- **The environmental impact of SFSC logistics**

As mentioned above regarding the life cycle of food products from local food chains, the transport for distribution to customers, both individuals and professionals, generates a huge environmental impact because of the difficulty in massifying flows, the farmers' lack of logistics ability to optimize their rounds, the type of vehicles used and their limited capacity to invest or use external services [13]. As a result, transport and the associated logistics represent both a big environmental impact and a significant cost for producers. Producers wishing to develop their sales through short distribution channels are therefore faced with a number of difficulties, some of which can only be resolved through logistics. Their main challenge is to diversify sales outlets - particularly in towns - while reducing the environmental impact of deliveries and without compromising the viability of the business model.

- **The lack of infrastructure and organization for SFSC**

Chiffoleau Y. et al. [44] highlight that one of the primary challenges for SFSCs is the lack of infrastructure and organizational support necessary for their growth. For example, many small producers lack access to logistics platforms (such as the FoodHub platform) that could enhance their competitiveness and enable more efficient distribution. Additionally, many producers rely on limited distribution channels, like local markets and direct sales, which restricts their market reach. Expanding into additional channels, such as partnerships with wholesalers or online platforms, could help broaden consumer access but remains an underutilized option.

Producers also face organizational and resource constraints that hinder growth. Many believe that collective approaches through SFSC platforms could improve their negotiating power and increase supply chain efficiency. However, they are often challenged by the extensive administrative paperwork required by public administrations, coupled with limited human and financial resources, which restrict their ability to focus on business organization, marketing, and expansion.

- **Market competition from larger retailers**

As highlighted in the research by Vittersø G. et al. [45] one of the primary challenges for small-scale producers is the competition posed by larger retailers. While interviews with both producers and retailers revealed few negative comments about cooperation among local producers, the relationship between small producers and larger retail chains is more complex. Large retailers benefit from economies of scale, allowing them to offer a broader range of products at lower prices, which small producers find difficult to match. Additionally, these retailers provide consumers with the convenience of one-stop shopping, even offering local and organic products, traditionally the domain of small producers. Larger retailers also enjoy superior brand recognition and marketing power, which draws more customers and makes it difficult for small producers to compete on visibility. Moreover, large chains have significant negotiating power, enabling them to secure lower prices from suppliers, a leverage that small producers cannot achieve. Lastly, the sophisticated logistics and distribution networks of larger retailers ensure product consistency and availability, further complicating small producers' efforts to maintain a competitive edge in the market.

- **The lack of information and awareness about SFSC**

Among producers looking to sell their products in SFSC, Agiado-Gragera, C. et al. [46] conducted a study in Spain employing a participatory approach, utilizing focus groups composed of food producers and consumers. Producers were selected based on their criteria to distribute their products either entirely or partially through these channels. Out of the total number of producers in the country, a total of 24 participated in the research. In this study, one of the primary issues highlighted by the producers is the lack of awareness and information regarding SFSCs. Producers attribute this lack of awareness to insufficient advertising, both internally among producers themselves and externally by public administrations. A significant challenge identified by 28% of respondents is the need for producers to enhance training and advertising of SFSCs, both within the sector and through public administrations. This lack of promotion contributes to consumer unawareness about SFSCs, including their types and locations. In connection with these challenges, the producers called for more active involvement from public administrations in promoting these channels, suggesting that a more coordinated effort in terms of advertising, education, and logistical support could greatly enhance the visibility and appeal of SFSCs, ultimately benefiting local economies and fostering more sustainable food systems. GARDEN's partners have confirmed that this issue is not only relevant in Spain but also in the other south-Europe countries.

- **Bureaucratic barriers**

In the study by Agiado-Gragera, C. et al. [46] the role of public administrators emerged as a significant challenge, noted in 44% of producers' responses. Producers highlighted the need for clearer, more streamlined regulations for products sold through SFSCs, as current regulations are often vague or overly complex, adding unnecessary difficulty to the commercialization process. Additionally, there is a strong call for public administrations to provide greater financial support through grants, subsidies, or low-interest loans. A notable 6% of responses specifically cited the need to reduce bureaucratic barriers. Small-scale producers, who typically lack dedicated administrative staff, are often overwhelmed by the extensive paperwork required for health certifications, tax compliance, and other permits. These administrative demands disproportionately impact smaller producers, slowing their ability to bring products to market efficiently.

Furthermore, producers feel that the rigid application of regulatory standards, designed primarily for large industrial producers, does not consider the unique scale and resources of SFSC operations. This lack of regulatory flexibility increases costs and delays, hindering SFSC producers' competitiveness relative to those in traditional large-scale distribution channels.

- **Cooperation and technological solutions**

Among the possible levers mentioned in the literature are (1) the pooling of delivery rounds between several farmers in a group, via sales intermediaries or subcontractors, and (2) the use of “neutral” or low-emission vehicles, provided that the economic and organizational model and the information system between the various operators are secure [47].

Researchers see multi-actor solutions and digital technology as the two keys to improving short supply chain logistics [13]. A number of digital tools have been developed to support short supply chain stakeholders in their logistics management (Agriflux, La Charrette), while innovative organizations are being set up to guarantee a complete short-distance supply chain, taking into account the constraints and needs of producers (Echanges Paysans, Coolivri). We describe some of these tools and innovative organizations in later sections.

7.2 Logistics stakeholders

7.2.1 Transporters

In this part, we focus on professional transporters, excluding food producers delivering shops or selling points by themselves (Producer challenges are detailed in Section 2, Part a.). The companies that operate the last mile delivery of food products in towns and cities are generally highly specialized as it is considered the most complex, polluting and inefficient segment of the food supply chain [48]. Regarding pollution, Garnett, T. [49] emphasized that food transportation contributes significantly to overall emissions in the food chain, but these emissions can vary depending on the distance travelled, the mode of transport, and the efficiency of the vehicles used.

Last-mile food supply has a number of characteristics that are challenging professional transporters: limited maximum vehicle weight, compliance with low-emission zones, heavy traffic and limited parking, multiple delivery points, etc. We made a list of the key challenges faced by transporters of the food last mile delivery, taken in the literature and from various interviews with professionals and experts involved in the GARDEN's pilot sites.

- **Access to storage platforms on the outskirts of towns**

Accessing storage platforms, food hubs and micro-hubs is a key challenge to better the food logistics and the mobility in general in cities in the future. As an example of this lack of platform in the mediterranean cities, experts consider that the Occitanie region (where Montpellier is located) is well below the national average in terms of the amount of land dedicated to logistics platforms: "this represents an average of 1 m^2 per inhabitant in France and 0.5 m^2 per inhabitant in Occitanie" (François de Bertier, TenLOG). An additional 85,000 m^2 should be dedicated to logistics platforms to adapt the region to demographic change, according to those experts.

Some city authorities have already started to address this problem by developing innovative solutions. CityPorto in Padua, Italy, addresses the challenge of delivering goods to congested city centres by using an urban consolidation centre located two miles from the city. This hub allows large freight vehicles to drop off shipments, which are then distributed to city centre businesses using low-emission vehicles. The initiative helps reduce congestion and improve air quality in the low-carbon zone of the city. Initially supported with a public subsidy of €360,000, CityPorto has operated independently since 2007, handling 100,000 deliveries annually by 2015. Bologna adopted Sustainable urban logistics plans that include the creation of micro-hubs ("locakers") downtown, centralizing the last mile delivery in a specific place in each neighborhood, as part of the Horizon Europe project ''URBAN'' [50].

- **Renewing the vehicle fleet or adopting the long-term leasing model**

To gain access to the low-emission zones introduced in certain cities (in France and Bulgaria, for example) and to meet the sustainable development targets set internally, transport operators are being encouraged to renew their vehicles (retrofit or purchase) to make their fleets greener. An alternative is to lease vehicles on a long-term basis rather than buy them. The development of low-carbon energy infrastructures and the structuring of local supply chains go hand in hand with this transition. In its REPOS plan (positive energy region) [51], the Occitanie region (France), for example, plans to achieve green energy self-sufficiency by 2050, notably by doubling the number of electric charging stations.

- **Complexities of the vehicle routing problem in food distribution networks**

The Vehicle Routing Problem (VRP) is one of the most significant challenges in distribution management, especially within food supply chains. VRP involves determining the most efficient routes for vehicles assigned to serve a set of customers. The complexity of this problem increases as various factors such as fuel costs, delivery time windows, and vehicle capacities come into play. Figure 3 illustrates a typical VRP framework where a set of customers is supplied from a single depot. Effective solutions to VRP are crucial for reducing operational costs, improving customer satisfaction, and enhancing overall distribution efficiency.

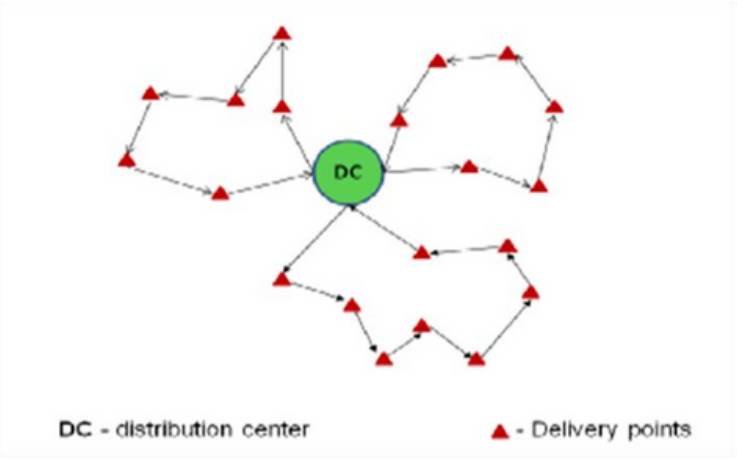


Figure 3. Schematic illustration of typical VRP framework with single-stage and multiple vehicles (Note: The solid arrows indicate that the vehicle routes are starting and ending at DC.) [52]

Several critical issues must be considered when modelling VRP. These include the number of stages in the distribution process (e.g., whether it involves just delivery or both delivery and pickup), fleet size (single or multiple vehicles), vehicle capacity, delivery time windows, and the nature of supply and demand, which can be either deterministic or stochastic [53]. Each of these factors adds layers of complexity to the routing problem, making it challenging to find optimal solutions that maximize efficiency and minimize costs.

VRP models are further shaped by location data, such as depot and customer locations, and vehicle characteristics like speed and capacity. Additionally, the conditions of paths between locations (e.g., main roads, secondary roads, gradients, and weight or speed limits) influence the routing strategy [54]. Optimal routing solutions must balance direct costs, like fuel consumption, with practical road and vehicle constraints, ensuring timely, cost-effective deliveries despite logistical challenges.

- **Connecting transport operators with the rest of the supply chain**

Connecting transport operators with producers, food processors and buyers is necessary to avoid miss deliveries, food losses, but also optimize the fill rate of the vehicles and the delivery rounds. Some tools have been developed to optimize the flows of logistics information. La Charrette, in France, allows producers, transporters, retailers of SFSC to meet and organize the logistics in a more efficient way. or the physical flows. Agriflux, in France, connects the transporters and producers to optimize the vehicle fill rate on existing delivery rounds. Some transporters choose to cooperate, for example by sharing a base at a food hub platform on the outskirts of town (e.g. Transporteurs du quai mutualisé in Montpellier).

Numerous horizontal and vertical collaboration ideas among transporters can be imagined to optimize the food logistics and ensure a viable business model for those companies [19].

- **Envisioning the future of urban logistics transport**

Last-mile supply raises many questions and has given rise to initiatives aimed at minimizing its environmental impact. Cargo bikes are one of these initiatives, which have been widely developed as an alternative to light commercial vehicles in city centres, offering interesting flexibility in congested urban areas [48]. These players are now part of the landscape and will have to be taken into account by incumbent carriers. Thus, the county of Bentheim in Lower Saxony, Germany, offers an example for the future of urban logistics transport. After establishing over 1,000 km of cycle paths and achieving a 33% cycling traffic share, the region, known as the "most bicycle-friendly district in Lower Saxony," turned its attention to sustainable commercial transport solutions. They introduced the ‘Graftschafter Lastenrad’ scheme, which provides a €500 subsidy for businesses to purchase cargo bikes, with the condition that they are used for at least four years in commercial operations.

Other initiatives are emerging, such as the “Tramway-cargo”, planned in Montpellier, or freight by barge in Toulouse. These are embryonic solutions that could one day, if not supplant, at least have a major impact on the traditional haulage business model.

7.2.2 Food Hub logistics platform and other “facilitators”

We are focusing on “facilitators” and logistics platforms which are not just storage facilities on the outskirts of towns, but also play a role in the local food system by bringing together supply (producers, processors), demand (distributors, retailers) and intermediaries (wholesalers). Is it important to specify here that some “facilitators” are not food platforms (cf : GRAP - Coolivri in part 3), but the “platform model” is usually the objective to reach for a facilitator to scale up the short food supply chain in an urban context. These structures, closed to “wholesale markets”, played a particularly important role in France's major conurbations after the Second World War. In the 1960s, 17 “markets of national interest” (MIN) were created (1965 in Montpellier) with the aim of structuring urban food supplies by curbing the negotiating power of wholesalers in order to guarantee fair remuneration for producers and controlled prices for consumers [55]. The most emblematic “MIN” is Rungis (Paris), which is considered as the largest wholesale market in the world and through which 40% of the fruit and vegetables consumed in the Île-de-France region pass. Today, despite the success of Rungis, the “MIN” model powered by public authorities has lost its appeal, for a number of reasons that we will discuss below. Researchers who have studied the issue believe that this type of logistics platform plays an essential role in structuring food supplies at low logistics costs and controlled prices for consumers (Sebbane, 2024) and could represent powerful transformation tools for local authorities with ambitious food policies. Generally located on the outskirts of towns and cities and at the entrance of low-emission zones (where these exist), the platforms enable the wholesalers to store products and the producers to process, sell or organize the transport of their products to the town centre. Positioned as a third way, between direct sales (virtuous but which seems to have reached its glass ceiling) and the supermarket model (dominant but inefficient from a social and environmental point of view), wholesale market-type platforms are considered to be one of the key elements in the development and democratization of local short distribution channels by several researchers specializing in this field in France [13], Here we look back at the various issues encountered by these organizations in their attempt to propose a viable, desirable and sustainable third way of supplying food in towns and cities.

Platforms challenged by changes in the food system and the new strategies of logistics stakeholders.
Today's the food distribution system is characterized by three models:

1. The dominant 'cash and carry' model of the GMS (large-scale distribution), characterized by long circuits and distribution outside towns via storage platforms managed by the big companies in the sector (e.g. Métro).
2. The alternative model of direct sales without intermediaries (e.g. AMAP in France), which concerns around 5% of the population in France.
3. The "MIN" model, which integrates short and long distribution channels.

The phenomena of urbanization and gentrification have led to strong competition over the use of land. Peri-urban logistics platforms, which centralize wholesale and retail activities in a single location, are no longer a priority for urban development. Large out-of-town hubs are emerging that are conducive to an agri-food model of mass production and consumption [56]. MINs have failed to anticipate urban development on the one hand and changing consumption patterns on the other: they have been "bypassed by the supermarket model and short-circuited by the direct-sales model" (R. Vincent, 2024) [57]. As a result, logistics platforms have lost their appeal to producers, who prefer models a) or b), in the first case despite supply quality and without price transparency, in the second despite the high cost and environmental impact of logistics. Furthermore, the trend towards wholesaler concentration (for economic profitability reasons) is leading to quasi-monopolies with strong bargaining power - undermining the food hub's desire to guarantee controlled prices [55].

The food hub "MIN" model could, however, offer a hybrid model that integrates long and short circuits in a beneficial coexistence (sharing resources, equipment and know-how). Managing the last mile - which is the most complex, costly (30% of supply costs), polluting and inefficient [48] - is precisely an area where long and short supply chains can work together to optimize flows (reducing costs and their environmental footprint).

- **Optimizing warehouse location and distribution networks for sustainable food supply chains**

Location decision is one of the critical elements in strategic planning for firms, particularly in the context of general distribution within the food supply chain. When deciding on warehouse locations, key factors such as the nature of the facility, the surrounding environment, the customer base, and the distance or time between the facility and its customers must be considered. Suárez-Vega, R. et al. [58] emphasize that Geographic Information Systems (GIS) play an essential

role in modern location analysis, helping decision-makers optimize distribution networks. Through GIS, firms can better analyze spatial data to enhance goods distribution efficiency, which can lead to fewer vehicles, shorter transport distances and times, and, consequently, reduced greenhouse gas (GHG) emissions [59] and lower distribution costs [60]. However, as McKinnon, A. [61] notes, the shortest routes do not always equate to lower emissions, as they may include minor or congested roads. Therefore, optimizing routes and locations involves balancing distance, time, and environmental impact.

- **Food platform: the need for a viable economic model open to local players**

Food hub logistics platforms (such as the "Markets of national interest") are currently specialized in pure food logistics activities (organization of wholesale markets for professionals, rental of storage space). In order to make their business model more viable and to take advantage of potential synergies, some food hubs are looking forward to diversifying by developing delivery activities (organizing or carrying out last-mile transport) or integrating non-food products. The development of last-mile delivery services, in particular, is a crucial issue, as we have seen, both to reduce its environmental impact [62] and to optimize flows and make town centers accessible to small local producers.

- **The need for support from public authorities and urban planning stakeholders**

Investment, both financial and moral, by local public authorities is one of the keys to the development of MIN-type food hubs. This involves financing infrastructure (construction, renovation of platforms, food processing plants, low carbon energy infrastructure, etc.), giving access to urban land and integrating the food hub tool into local food policy (roadmap, charter, etc.). The issue of land access is a special matter for public decision-makers in charge of urban planning. Researchers stress the need to network urban areas with "logistics hotels" (small urban platforms) coordinated by the food hub to facilitate last-mile supply (Sebbane, 2024). An example of micro-hubs managed by public authorities can be appreciated in Bologna (project URBAN) as those infrastructures are a key part of the Sustainable Urban logistics Plan of the city council.

7.2.3 Wholesaler / Intermediaries

Wholesalers are companies whose job it is to buy and compile a catalog of products for retail distributors, to store and sometimes transport the products to them. They are, therefore, different from "facilitators" as they become the owner

of the product at some point. Historically, wholesalers have been essential to professional food supply as they reduce the number of contacts for accessing a wide range of products: wholesalers are therefore the conduit between food manufacturers (and sometimes the producers/farmers) and foodservice operators [24]. Indeed, the lack of time to identify suppliers leads a majority of professionals (retailers, restaurateurs, hotels, contract caterers) to turn to specialized players capable of providing them with a catalog of products of great variety, at advantageous prices and with expertise on specific products [63]. However, the development of the GMS agri-food system, characterized by the "platformization" phenomenon (big GMS companies build their own platform and internalize the role of wholesaler), have strongly reduced the role of the wholesalers in the food supply system [64]. On the other hand, the position of wholesalers is out of kilter when it comes to short distribution channels, which by definition tend to keep intermediaries to a minimum. However, wholesalers seem to be showing a growing interest in short distribution channels and are playing a role in local sourcing for catering professionals and retailers [24]. These intermediaries, who centralize product and information flows and possess specific resources (know-how, infrastructure, etc.), take on distribution functions that enable them to help create proximity between players [65]. Very little scientific literature has examined the relationship and possible development opportunities between wholesalers and players wishing to work in short distribution channels [25]. Yet, wholesalers and new stakeholders close to traditional wholesalers but who define themselves as 'intermediaries', are involved in the development of short or local food distribution channels. In this section, we describe the main issues facing wholesalers (intermediaries) in setting up those short or local distribution channels.

- **A stakeholder marginalized by the GMS agri-food system**

The dominance of the supermarket model has led to the role of wholesalers being marginalized, with large supermarket companies gradually internalizing the tasks associated with wholesalers (developing their own platforms, etc.). Despite this context, wholesalers have managed to maintain their position by supplying both independent retailers and supermarkets with products that are difficult to manage (perishable goods such as fruit and vegetables) [66]. In addition, wholesalers can call on specific resources and skills (interpersonal skills, knowledge of what is on offer in a given area, product knowledge, etc.) that enable them to justify their value-creating intermediation activity.
The future of wholesalers may lie in the relocation of food supply chains, in support of local and short distribution channels - as some researchers think [65].

But this collaboration is not self-evident, as wholesalers are often seen as incompatible with the very principle of short distribution channels (without intermediaries) and suffer from a poor image among producers.

- **A stakeholder usually ignored by short supply chains**

As explained above, the wholesaler's position seems to conflict with the very principle of the short distribution channel, which aims to eliminate all intermediaries (one intermediary at most). Models with more than one intermediary are no longer considered “short” food supply chains, but they can still be considered as local food supply chains, which is also interesting in the evolution of the food system. This tension between the two models can be seen when we talk to the players responsible for promoting short distribution channels. The “Market of national interest” of Montpellier, for example, is regularly accused of competing with wholesalers by developing a farmers' market. This “competition spirit” is underlined by the trend towards concentration among wholesalers [57]. which strengthens their bargaining power. Despite this, some believe that wholesalers have a complementary role to play and that Food Hub-type structures do not compete with wholesalers because they position themselves in a segment that is not covered by wholesalers (structuring organic and local supply). Wholesalers are complementary when it comes to supplying foreign fruit and vegetables in winter, for example. But should wholesalers be excluded from the development of short distribution channels? The answer is no. As mentioned in the introduction, many food professionals rely on wholesalers to supply them with local produce (restaurants, retailers, institutional catering). Below, we list the difficulties encountered by wholesalers in adapting to short distribution channels and meeting their customers' demand. Wholesalers can play an important role in supporting short supply chains, scaling up the market by aggregating the offer and optimizing the logistics to the clients. This is not easy and wholesalers face some difficulties when turning to short food supply chains.

- **Difficulties in sourcing local producers, restrictive legal issues and business model challenges**

In the scientific literature, there are a few articles on the difficulties faced by wholesalers in sourcing local products [67], [68]. However, compared to the GMS, wholesalers should have less problems connecting with local producers as they can usually develop local relationships [66]. There is also mention of the difficulties wholesalers have in complying with the health regulations in force, which producers operating in short local circuits do not necessarily respect.

Wholesalers can require farmers to comply with food safety protocols or carry liability insurance to protect them against economic loss from food-borne illness associated with the products delivered [69]. Also, wholesalers working with short and local food supply chains frequently face difficulties in setting up their business model, as they can't have a huge margin selling local products [64]. Despite those constraints, new kinds of wholesalers or "intermediaries" appear and work to support the development of short food supply chains with collective catering, food shops and restaurants. For example, in France, "Mangé Bio" network, is a wholesaler allowing school canteens accessing a wide range of local and bio products.

- **Wholesaler's strategy to support short food supply chain and emergence of short food distribution intermediaries**

As mentioned above, wholesalers and other intermediaries can play a role in the relocation of the food system and the development of short or local supply chains. While some producers do find it advantageous to deliver directly to consumers - that represents between 5 and 10% of the total food consumption in France for example [70]. -, the support of an intermediary is generally the surest way of building a local supply in which all the players - producers included - benefit. This intermediary can take different forms : a structure set up at the initiative of a group of consumers (e.g. 'Échanges Paysans', France) or a cooperative involving all the stakeholders (e.g. "Mangé Bio" network). Intermediaries can bring real added value to short distribution channels when they not only provide a logistical solution for producers, but also facilitate their commercial development (prospecting for new outlets) - which is the main issue of short and local food producers. As said above, wholesalers have the required resources and expertise to make the offer meet the demand (regarding commercial and logistics considerations).

A strategy set up by wholesalers to support short and local food supply chains is the creation of local certification. For example, the wholesaler Creno developed a certification "Les jardins d'ici" ("gardens from here") for producers selling within a 150 km radius [64].

As a conclusion, short and/or local circuits need intermediaries to change scale, reach a wider audience and become sustainable over time. These intermediaries can take the form of wholesalers / intermediaries (who own the products) or other stakeholders (facilitators - as mentioned in part 2) who propose to aggregate the offer to create a complete catalog and open development prospects for producers.

7.2.4 Alternative local food system : direct-to-consumer sales and marketplaces

Short food supply chains are frequently understood as direct sales models, even if short food supply chains can accept one intermediary. Direct-to-consumer sales represents between 5 and 10% of the total food consumption in France for example [70]. The development of direct sales (different from short distribution channels), which grew rapidly during the COVID period in some European countries [71]. was accompanied by the emergence of numerous marketplaces designed to bring supply and demand closer together by relieving producers of some of their commercial and logistical work (prospecting, order management, etc.). These digital tools, which vary widely in response to the heterogeneity of the contexts, have the merit, when they are functional, of enabling a change of scale in the development of short distribution channels, optimizing commercial and even logistical management for the producer and, in some cases, increasing the participation of all the players involved in the governance of the supply system. According to a study compiling 75 consumer surveys, 50% of French people have already bought food online and between 50 and 70% would like local retailers to sell online [72]. According to a study conducted by NielsenIQ [73], 45% of Spanish consumers have purchased food online, while more than 60% expressed interest in buying local products through digital channels. Similarly, in Italy over 70% of consumers showed interest in purchasing food online from local producers [74]. However, these tools still need to meet a number of challenges if they are to provide an ideal solution for producers, particularly when it comes to integrating logistics issues.

7.2.4.1 The impact of the COVID-19 on the development of marketplaces

A scientific research lead in 13 different countries shows that the COVID-19 pandemic crisis is behind a significant increase of the demand for alternative local food systems among citizens (direct farm sales, food boxes). This situation is due to the fear of food shortage, an increase of the time spent in cooking and a new awareness about food quality. In France the COVID-19 crisis generated a growth by a factor of three to ten in the demand for fresh food products coming from alternative local food systems near cities. “In Italy, almost 50% of the population prioritized health and well-being when making food purchases, raising demand for ‘Made in Italy’ products, and even more so for ALFS products”. This growing interest for ALFS made them possible to scale up, which was their most important constraint till now.

Technology and social innovation allowed this scaling up : “Due to the closure or suspension of outdoor markets and catering, many small producers survived by turning to online sales, home delivery, pickup points, or drive-through markets, thereby developing new skills, platforms and channels, or repurposing old ones”. During the COVID-19 the number of marketplace and more simple online tools (facebook website, excel sheet) has grown in France. Additionally, an increasing number of small local producers in Spain began leveraging digital platforms to reach their consumers, offering easy access to fresh, locally-sourced products directly from farms. Similarly, in Italy, the COVID-19 accelerated this trend, with many small-scale farmers starting to market their products through online marketplaces and digital platforms.

7.2.4.2 The difficulty to choose among the diversity of platforms

There are many "marketplaces" and e-commerce sites dedicated to the sale of short-run food products, and they have received a major boost from the closure of physical markets during the COVID-19 containment periods. There are several different types, depending on the service offered (creation of a personalized online shop or market place), the customer they are aimed at (private individuals, retailers, caterers) and the additional services offered (logistics planning tool, invoicing service). This great diversity of platforms offers a wide choice for producers wishing to find new distribution channels for short distribution channels, but the sheer number of offers makes the choice difficult. For example, a survey carried out in France by the RMT alimentation locale (local food research network) identified 58 digital short channel sales tools. A number of decision-support tools have also been developed (e.g. OAD Vente en ligne, France [75]). These tools are very welcome, given the lack of clarity in the digital offering: ‘rapid growth, many failures, few surveys’ [13].

7.2.4.3 The need for interoperability with digital logistics tools

Interoperability, in a digital context, refers to the ability of several digital tools to be connected (information centralized). For example, it enables a producer to market his products via several channels using the same tool, or to connect the purely commercial site with the invoicing management tool and the logistics planning tool. In this sense, it is a key factor in the development of short and local distribution channels [13]. In a recent study driven in France, out of 31 platforms questioned as part of a survey of managers of short channel sales tools, only 12 offer or require an integrated logistics solution [72].

Some digital platforms specialized in short-distance sales, like Coopcircuit (France), are already working on the interoperability of the various marketing, invoicing and logistics tools (see the presentation of Coopcircuit in following sections).

7.3 Distributors

7.3.1 The short food supply chain distribution

SFSCs are typically linked to direct, face-to-face distribution methods, connecting producers directly with consumers, as seen in direct farm sales and farmers' markets. They are often confused with 'local food systems,' where food is distributed and sold within a short distance from its production site, within the same geographic area or locality, regardless of how many intermediaries are involved.

As stated in the study of Vittersø, G. et al. [45], the role of SFSCs in food distribution differs greatly across European countries. Augère-Granier [15] noticed that direct sales have minor importance in Malta, Austria and Spain, with more than 90% of food retail occurring in the large supermarket chains, while in other countries direct sales, traditional specialty shops and food markets have prevailed and account for a significant share of the market. For instance, the share of farms involved in direct sales is nearly 25% in Greece, 19% in Slovakia and around 18% in Hungary, Romania and Estonia [15]. As noted by Augère-Graniert [15] at EU level, direct sales between farmers and consumers represent only 2% of the fresh food market. Food is mostly distributed in supermarkets, hypermarkets, and discounters, which account for 54% of total edible grocery sales in the EU. In 2014, the share of the top five retailers exceeded 60% in 13 Member States. In 2011, four retailers controlled 85% of the food market in Germany, and three retailers controlled 90% of the Portuguese food market. Such concentration of power can result in unfair trading practices, undermining the livelihood of small farmers and producers.

- **Impact of large multinationals on local food distribution and development**

The current markets, dominated by large multinationals, shape the operation and structure of food distribution and supply, presenting significant challenges in food chain logistics for general distribution. This system does not recognize the differential features of each territory, and it brings losses to producers as well as being detrimental to local development [76] (Mendez-Gutierrez del Valle, R. et al., 2017).

In many regions, such as Montenegro, recent years have seen significant changes in the retail sector, marked by the privatization of retail chains by larger corporate groups. This shift has led to larger retail chains dominating the market, outcompeting smaller retail outlets. Consequently, consumers are increasingly drawn to larger shopping centres that offer a wider variety of high-quality goods at competitive prices. This trend not only threatens the survival of small local markets and producers but also leads to a reduction in the diversity of food products available to consumers. The dominance of large multinationals in the food distribution chain has created a system that prioritizes efficiency and uniformity over local specificity and diversity. This results in the marginalization of local producers who struggle to compete with the scale and pricing strategies of these larger entities, ultimately impacting the socio-economic fabric of local communities.

- **Vulnerability of urban agri-food systems due to limited diversification and long supply chains**

The configuration of an agri-food system within each city is heavily influenced by a diverse set of territorial factors [77]. A significant challenge arises for cities that are particularly susceptible to supply problems due to their limited diversification of value chains and supply channels. These cities often face a high or exclusive dependence on food imports, making them vulnerable to disruptions in the supply chain. Another aspect contributing to this vulnerability is the presence of long and complex supply chains. These chains are inherently fragile and can be easily affected by sudden shocks, whether these shocks are of social, political, economic, or natural origin [78]. The complexity and length of these supply chains increase the risk of delays, shortages, and increased costs, which can directly impact the availability and affordability of food for urban populations. Such a configuration makes urban agri-food systems highly susceptible to a variety of disruptions.

- **Building resilient distribution networks in urban agri-food systems**

Political instability, economic downturns, or natural disasters can lead to immediate and significant impacts on the distribution of food supplies. This situation underscores the importance of developing more resilient and diversified distribution networks within urban food systems. To improve food security, cities need to address the overreliance on imports and the complexity of existing supply chains. By creating more localized and simplified distribution channels, urban areas can reduce their vulnerability to sudden shocks and disruptions. A more resilient distribution network ensures that food can be effectively and efficiently delivered to consumers even in times of crisis, helping to maintain

stability in the urban food supply.

- **Pricing complexity and consumer perception in alternative food distribution networks**

In the study conducted by Vittersø, G. et al. [45] pricing issues in general distribution were examined, revealing the intricate balance between economic efficiency and ethical fairness. Surveys and interviews with producers, retailers, and consumers highlighted that higher prices in some cases were associated with solidarity initiatives among producers and consumers, such as those seen in Italian Solidarity Groups and the Norwegian Consumer Cooperative. Pricing challenges directly affect the Norwegian Consumer Cooperative's capacity to assist local farmers. Larger organic farms benefit from economies of scale, allowing them to offer lower prices and provide more vegetables per bag to consumers. This creates a price disparity that can be confusing for consumers, who may not understand why the quantity of vegetables varies while the price remains the same.

Communicating these pricing differences is an ongoing challenge for organizers of these alternative food networks. They must navigate the complexities of explaining the relationship between price, quantity, and the support of local farmers. This issue underscores a deeper conflict within the food distribution system: balancing economic efficiency with ethical considerations and fairness.

- **Optimizing last-mile logistics and energy efficiency in local food distribution**

The logistics problem presents a significant bottleneck in the local food system due to uncoordinated and suboptimal food transport systems, which are often not energy efficient [79]. There is considerable potential to improve energy efficiency in food transport within LFSCs by rethinking how food delivery systems are organized. Potential strategies include using more energy-efficient vehicles, introducing regional biofuel production [80], increasing vehicle capacity utilization [81], and planning optimal distribution routes [82].
A critical challenge within this context is last-mile logistics, especially the transportation of perishable goods in congested urban areas. These operations have yet to reach their full efficiency potential. Unlike non-food delivery networks, local food business models often lack consolidation, which limits efficiency gains. Additionally, local food distribution typically relies on small trucks and vans. These vehicles consume substantial amounts of fossil fuel and contribute to higher levels of pollutant emissions.

The complexity of designing last-mile logistics for food products is further increased by the high operational costs and environmental impacts associated with cold chain transportation and warehousing [83]. Cold chains are crucial for maintaining the quality and safety of perishable goods but are energy-intensive, adding to the overall environmental footprint of the food supply chain.

- **Combating mislabelling and fraud in the supply chain**

Mislabelling and fraud present significant issues in the fish distribution chain, where products are sometimes sold under different names to command higher prices. For example, some studies, including the EU Project Food Integrity, have shown that over 30% of fish in restaurants may be mislabelled, raising serious concerns about transparency and trust in the supply chain. Addressing this problem requires stricter regulations, better monitoring, and increased transparency to ensure consumers receive the product they are paying for. This issue highlights the importance of establishing trust and authenticity in the market, particularly for small-scale fisheries that rely on their reputation for quality and local sourcing.

- **Policy bias and limited market access for small-scale producers**

Small-scale producers across various industries often face challenges due to policy biases that tend to favour larger, more established enterprises. This bias can be attributed to the lobbying power of large corporations and the limited visibility of smaller producers. Such policies can restrict operational capacities and market access for small-scale producers, limiting their ability to compete. For example, in the fisheries sector, small-scale fishermen experience these challenges in both fishing operations and the marketing of their catches. The FAO Volunteer Guidelines for Securing Sustainable Small-Scale Fisheries emphasize the importance of policy support in ensuring food security and reducing poverty, highlighting the broader need for fair and inclusive market access.

- **Barriers to direct marketing and traditional selling patterns**

Recently, increasing restrictions have been placed on the direct marketing of small-scale fisheries catches in many European regions, affecting traditional selling patterns that often involve members of fishing households, particularly women [84]. These barriers prevent small-scale fishermen from directly engaging with consumers, making it difficult to maintain traditional market practices. Regulations in several EU nations, such as Spain and Portugal, may require catches to be sold through local auctions, excluding direct consumer participation.

This leads to a decline in traditional market outlets, further marginalizing small-scale fisheries.

- **Competition with global markets and supermarket chains**

The influx of fish from global markets poses a significant challenge for local small-scale fisheries, as traditional marketing methods struggle to adapt to the changing landscape. Supermarket chains and large corporations now dominate most fish markets, often favouring aquaculture or imported products over locally sourced fish. This competition makes it increasingly difficult for small-scale fishermen to sell their catches through traditional channels, even in regions where there is a strong demand for fresh local fish.

- **Complex regulations and decline of traditional market outlets**

Complex regulations present additional hurdles for small-scale fishermen trying to sell their products directly to consumers. Even though European laws may support small-scale direct sales, implementing these regulations at the national level can be complicated and is not always guaranteed. Street vending is often prohibited, and strict marketing standards can create barriers to entry for small-scale fisheries. This regulatory complexity contributes to the decline of fishmongers and traditional market outlets, creating serious obstacles for the distribution and sale of small-scale fishery products. Together, these challenges highlight the need for more supportive policies, streamlined regulations, and efforts to maintain traditional market channels to ensure the viability and sustainability of small-scale fisheries in Europe.

7.4 Final buyers / consumers

7.4.1 Citizens

Increased consumer knowledge of the food system's impact on climate and health plays a significant role in influencing the adoption of SFSCs. The increased consciousness of sustainability among consumers translates into a rising desire for more sustainable food items, including local, seasonal, organic, and fair-trade food. From studies focused on consumers' perspectives and preferences emerged some interesting results:

- Increasingly, customers place higher importance on sustainability, local sourcing, and transparency when making food decisions [85].

- Consumer demand for products with lower environmental footprints and enhanced traceability fosters the demand for SFSCs [86].
- Consumers consider SFSCs as an opportunity to strengthen local economies, maintain traditional knowledge, and support healthier and more sustainable dietary practices [87].
- Participation in SFSCs is encouraged by the preference of consumers for immediate proximity and a more intimate relationship with food suppliers [88].
- The growing interest of customers in the social and environmental aspects of sustainability presents favourable conditions for SFSCs to prosper [89].

Nevertheless, despite consumers' growing demand for sustainable food sources, several authors have documented an attitude-behaviour gap: a discrepancy between customers' preferences and their actual purchasing choices or their readiness to pay for sustainable products and services. Consumers who have a higher level of awareness and openness towards sustainability-related issues may not necessarily engage in more sustainable behaviour and purchasing patterns. This phenomenon is due to the fact that, while the rise of SFSCs has brought numerous benefits, it has also introduced new challenges for consumers. In the following, the main challenges from the consumers perspective that have been identified.

- **Accessibility**

One of the primary challenges facing consumers in short food supply chains is accessibility [90], particularly in urban areas or regions that are not rich in agricultural production. Consumers in urban centres often have limited access to local food producers, which can make it difficult to find a consistent supply of fresh, locally sourced food. Furthermore, SFSCs are often more prevalent in rural or agriculturally rich regions, leaving urban consumers to rely on traditional long supply chains that may not prioritize local or sustainable products. Accessibility also poses a challenge in terms of the variety of products available. Certain regions may specialize in specific types of produce or agricultural products, meaning that consumers are limited to seasonal and regionally specific goods.

- **Affordability**

Affordability is another significant challenge for consumers in SFSCs [91]. While direct relationships with producers can sometimes reduce costs by eliminating intermediaries, locally sourced products are often more expensive than those found in conventional food supply chains. This is partly because small-scale farmers in SFSCs do not benefit from the economies of scale enjoyed by large

agribusinesses, which can lead to higher production costs. Furthermore, the infrastructure required to maintain SFSCs, such as local markets or distribution networks, can also increase costs, which are ultimately passed on to the consumer.

- **Food Availability and quality**

Consumers in SFSCs also encounter the difficulty of restricted availability and uniformity in product supply [41]. Moreover, small-scale farmers may have limited means to store or preserve food for long durations, therefore worsening the instability in supply. The presence of seasonal fluctuations and limited production and storage capacities introduces an unpredictable supply for consumers, therefore complicating the task of meal planning and keeping a constant diet. In contrast to bigger food supply chains, which often have stringent criteria and certifications to guarantee food safety, small-scale manufacturers may lack the same degree of supervision and may lack the necessary finances or expertise to adopt the same food safety principles as their bigger counterparts [92]. Insufficient uniformity in this matter might result in disparities in quality among different producers and can expose customers to risks such as bacterial contamination or inadequate handling procedures. Intermediary organizations can assist in ensuring reliable availability, facilitating communication, ensuring food safety, and effectively managing quality control concerns [93].

- **Logistical Challenges**

Logistics pose another challenge for consumers in SFSCs. In conventional food supply chains, large-scale distribution networks and sophisticated logistics systems ensure that food products are delivered efficiently and consistently. However, SFSCs often lack this infrastructure, meaning that consumers may need to put in more effort to obtain their food. For example, consumers may need to travel to farmers' markets, participate in community-supported agriculture (CSA) programs, or even visit farms directly to purchase their food. This can be time-consuming and inconvenient, particularly for individuals with busy schedules or those who live far from local producers. Summarizing, the logistics structure of SFSC is strongly in contrast with the Highly time-oriented buying habits of consumers [41]. Although online platforms and direct-to-consumer delivery services have arisen as possible answers to these logistical issues, the infrastructure for online sales and delivery is still in the process of being developed in many places [47].

- **Consumer Education and Awareness**

One of the less tangible but equally important challenges facing consumers in SFSCs is the need for greater education and awareness. The purchasing behavior of consumers towards SFSCs may be guided by higher-level motivations that are rooted in a mindful mindset and align with the principles of sustainable consumption [94]. Participating in SFSCs often requires consumers to have more knowledge about where their food comes from, how it was produced, and the environmental and ethical implications of their choices. This requires both time and effort, and not all consumers may be willing or able to invest the necessary resources to make informed decisions. This is a stark contrast to the convenience of conventional supply chains, where food products are readily available without much thought required on the part of the consumer.

Actions and policies aimed at enhancing the spread and significance of Short Food Supply Chains should be based on a thorough examination of the requirements and attributes of all the consumers engaged and their features [95]. Analysing consumers and the elements that impact consumer behaviour in SFSCs is crucial. To investigate cultural aspects, societal conventions, and consumer views, future research should utilize anthropological methodologies. Furthermore, it is necessary to investigate the effects of communication methods on customers' food preferences, as well as the impact of external elements like pricing, competition, and government regulations on consumer behaviour [96].

7.4.2 Ho.Re.Ca. (hotel-restaurant-café)

A multitude of research indicates that consumers hold a favourable disposition towards the inclusion of locally sourced food in restaurants [97]. Consumers acknowledge that the decision of restaurateurs to use locally farmed ingredients has several significant advantages, including environmental sustainability, proximity to local farmers, premium quality, freshness, and taste, as well as transparency about the food source. In response to the increasing consumer concern for their health and environmental preservation, the use of organic or locally sourced products has emerged as a prominent trend that meets the demands of customers seeking healthy choices. Initiatives have arisen to enhance the farm-to-restaurant network by establishing specific agreements between farms and chefs for materials [98].

Notwithstanding the acknowledged advantages of direct farm-restaurant links and the chefs' and local farmers' desire to collaborate, many obstacles to an effective supply system network design persist.

- **Logistics Complexity**

Local food circuits often involve small-scale producers, which may lack the distribution infrastructure of larger suppliers. This can lead to irregular deliveries, difficulties in scaling, and increased transportation costs as products may need to be sourced from multiple small farms rather than a single, large distributor. Ho.Re.Ca operators can meet difficulty in sourcing a wide variety of products from multiple suppliers. In particular, Businesses in urban areas or regions without strong local agriculture may find it harder to access fresh, local produce, increasing the complexity of sourcing. In order to achieve a beneficial environmental outcome, it is necessary to give particular consideration to the logistical requirements of the local system during its design and to organize it according to a defined framework [97].

- **Availability and Consistency**

The local food circuits frequently rely on small-scale farmers and producers, resulting in an unpredictable supply. Local products are available according to the seasons. This can limit menu options during certain times of the year and Ho.Re.Ca. businesses may need to adapt their menus or find alternative sources. In addition to the problem of seasonality, the use of local products implies other issues: a small number of local suppliers, the vulnerability to weather conditions, and production capacity deficiencies [99]. Local farms may not be able to consistently produce the quantity and variety of ingredients that Ho.Re.Ca. businesses require. These circumstances pose challenges for hotels and restaurants in maintaining a reliable supply of specific products, which might affect the stability of their menus and the satisfaction of their customers.

- **Cost Management**

Although local food circuits can reduce the carbon footprint, Local produce can be more expensive than conventionally sourced ingredients, especially out of season. Due to smaller production volumes and more labour-intensive methods, local food frequently commands higher prices in comparison to imported or mass-produced alternatives. Further, buying food from small producers often comes with higher operational costs. Fragmented sourcing means more frequent, smaller deliveries, which can increase transportation and labour expenses. This can strain profit margins for Ho.Re.Ca. businesses and the higher

costs can be difficult to absorb [100], especially for smaller Ho.Re.Ca. establishments.

- **Regulatory and Food Safety Concerns**

Compliance with food safety standards becomes more challenging in local circuits, where producers may not always have the same protocols as larger suppliers [101]. Not all local producers may adhere to the same health, safety, and quality standards, complicating procurement for businesses. Ensuring consistent quality and traceability requires additional oversight from stakeholders in the Ho.Re.Ca. sector and may need to invest in quality control measures. Further, HoReCa businesses that emphasize sustainability, or organic sourcing may face difficulties ensuring that local suppliers meet strict certification standards, such as organic or fair-trade certifications.

- **Communication and Collaboration**

From the farmer perspective, small-scale producers interested in SFSC must understand the unique significance of social connections and the necessity to maintain them appropriately [102]. Concurrently, Ho.Re.Ca. Businesses need to manage complex negotiations and to effectively communicate their needs and collaborate with producers. Dealing with multiple small-scale producers can require more time and effort compared to working with large distributors, increasing the complexity of procurement management. Building relationships with local producers takes time and effort.

These challenges necessitate the development of new strategies for logistical coordination, closer collaborations with local producers, and innovative cost management approaches to successfully integrate short and local food circuits into the Ho.Re.Ca. Industry. Scientific literature and case studies identified logistics coordination and food hubs as solutions for most of the presented challenges [103]. Partnering with or supporting the establishment of local food hubs—centralized facilities that aggregate, store, and distribute food from local producers—can simplify sourcing and improve access to a wider variety of products. Effective collaboration, coordination, and effective communication among actors in the supply chain are widely recognized as a fundamental approach for enhancing performance [104].

7.4.3 Collective catering, kindergarten

Collective kitchens and kindergartens play a crucial role in SFSCs by directly connecting with local producers to source fresh, sustainable, and nutritious food.

Despite the benefits, these consumers face several challenges that can impact the efficiency, reliability, and sustainability of SFSCs. Below are four key challenges faced by these final consumers:

- **Limited Availability and Seasonality:**

One of the primary challenges for collective kitchens and kindergartens is the limited availability of local produce, which often varies with the season. Unlike conventional supply chains that can source out-of-season or non-local products year-round, SFSCs are heavily dependent on what is locally available at any given time. This seasonality can create gaps in supply, forcing kitchens to frequently adjust menus or find alternative suppliers. For example, if certain fruits or vegetables are not in season, kitchens may need to either exclude them from the menu or pay higher prices to obtain them, leading to inconsistencies in meal planning and nutritional offerings [105]. The reliance on seasonal produce requires careful planning and flexibility, which can be challenging for institutions with fixed budgets and menu requirements.

- **Higher Costs and Financial Constraints**

Short food supply chains often involve higher costs compared to traditional, large-scale supply chains. The direct purchase from local farmers, while beneficial for supporting local economies, can result in higher prices due to the smaller scale of production and lack of economies of scale. For collective kitchens and kindergartens, which typically operate on tight budgets, these higher costs can be a significant burden. Limited financial resources may restrict the ability to consistently source high-quality, locally-produced food, leading to compromises in meal quality or quantity [106]. Moreover, the absence of bulk purchasing discounts and the higher costs of organic or sustainably produced food can further strain financial sustainability, making it challenging for these institutions to maintain their commitment to SFSCs.

- **Logistical and Storage Challenges**

Managing logistics and storage for fresh, perishable goods is a complex task for collective kitchens and kindergartens. SFSCs typically involve frequent, smaller deliveries to maintain freshness and reduce food waste. However, this requires efficient logistical arrangements and adequate storage facilities, which may not always be available. Many kindergartens and small kitchens lack the infrastructure for proper cold storage or inventory management, increasing the risk of food spoilage and waste. Additionally, the need for multiple deliveries can complicate scheduling and increase transportation costs, further straining resources [106].

Efficient logistics and adequate storage capacity are essential for maintaining the integrity and safety of food, yet achieving this can be a significant challenge for final consumers in SFSCs.

- **Consistency and Reliability of Supply**

Ensuring a consistent and reliable supply of food is critical for collective kitchens and kindergartens to meet their daily operational needs. However, SFSCs are often more vulnerable to disruptions compared to conventional supply chains. Factors such as weather conditions, pests, or unexpected changes in demand can significantly affect local production, leading to supply shortages [107]. For example, a poor harvest season due to adverse weather can limit the availability of certain crops, making it difficult for kitchens to source the ingredients needed for planned meals. Additionally, reliance on a small number of local producers without sufficient contingency plans can exacerbate supply issues [105]. These disruptions can result in menu changes, increased costs, or even the inability to provide certain meals, highlighting the need for robust supply chain management and diversification strategies.

7.4.4 Food solidarity, social kitchen

Food insecurity is not a new phenomenon especially in zones affected by years of conflict, which is a major driver of hunger [108]. Recent data collected by the WFP estimates up to 811 million people 'do not have enough food' among which 45 million are at risk of famine, the most extreme form of hunger where death is highly likely. In response to these crises, solidarity kitchens, powered by volunteer efforts, play a crucial role in supporting vulnerable communities, providing essential nourishment during times of acute need. These initiatives aim to provide meals to those in need, relying on local resources, volunteer labour, and donations. They usually face several significant challenges that affect their operation and sustainability.

- **Infrastructure and Logistical Limitations**

Volunteer-based solidarity kitchens often struggle with inadequate infrastructure, such as insufficient kitchen space, storage facilities, and cooking equipment. These limitations hinder their ability to operate efficiently and safely, particularly when preparing large quantities of food. For instance, in many urban areas, these kitchens operate in temporary or borrowed spaces without proper cold storage, compromising food safety. Additionally, logistical issues, including the transportation of food donations from various locations, exacerbate these challenges [109].

Coordinating volunteer schedules and managing inconsistent food supplies further complicate operations.

- **Rising number of undernourished people**

The global increase in the number of undernourished individuals, particularly in regions affected by conflict, environmental stress, and weak governance, exacerbates the demand for humanitarian food assistance. An alarming number of people continue to face food insecurity and malnutrition, as global hunger levels have plateaued over the past three years, with estimates of 713 to 757 million people undernourished in 2023—approximately 152 million more than in 2019, based on the mid-range estimate of 733 million [110]. Fragile settings struggle to provide adequate access to nutritious food, highlighting the limitations of current food solidarity efforts in these areas. Despite the professionalization of humanitarian response systems over the past two decades, they remain severely underfunded and structurally inadequate to address the growing need.

- **Financial Constraints**

Operating on limited budgets, solidarity kitchens depend heavily on donations and volunteer contributions. This financial precarity makes it difficult to invest in necessary resources, such as high-quality ingredients, durable kitchen equipment, or even rent for a dedicated space [111]. The lack of consistent funding sources often forces these initiatives to rely on ad-hoc fundraising efforts or sporadic donations, which may not cover their ongoing needs. Furthermore, the absence of financial stability can limit the kitchen's ability to expand its services or reach more beneficiaries. Examples like Haley House's Dudley Dough, which closed in 2017 due to financial struggles despite paying living wages and using local organic ingredients, demonstrate the difficulty of remaining economically viable in the face of limited access to conventional funding. Many solidarity businesses, like CERO and Dorchester Food Co-op, rely on grants, self-financing, or public offerings for startup capital, but ongoing financing remains tough, especially with limited access to conventional funding.

- **Competition and supply chain gaps**

According to the Loh and Agyeman [112], solidarity businesses often struggle to balance their mission with the need to remain economically viable. These businesses often struggle to balance their mission of sustainability and ethical practices with the need to remain economically viable. For example, Commonwealth Kitchen (CWK) faced difficulties in selling tomato sauce made from surplus crops to universities.

The university's food service contractor was only willing to pay half the cost and would only make purchases when they needed the product, rather than when it was seasonally available. This illustrates a broader issue: solidarity businesses must compete not just on price but also on convenience and market demand, which often favours large-scale, conventional suppliers.

- **Tension between solidarity principles and market realities**

There is a conflict between the principles of the solidarity economy and the conventional market dynamics that commodify food, land, and labour. This tension makes it challenging for solidarity initiatives to pay fair wages, adopt ecologically sustainable practices, and retain wealth within local communities, as they often have to compete with large-scale, conventional suppliers. This is one of the primary challenges in Boston, where food, land, and labour are treated as commodities [112]. This conflict makes it difficult for solidarity initiatives to pay fair wages, adopt ecologically sustainable practices, and keep wealth circulating within local communities.

- **Coordination and Volunteer Management**

Effective coordination is crucial for the smooth functioning of solidarity kitchens, yet it is often a challenge due to the voluntary nature of the workforce. Ensuring consistency and reliability can be difficult with volunteers coming from diverse backgrounds and having varying levels of commitment [109]. The lack of a formal structure or dedicated management team can lead to inefficiencies, such as miscommunication, duplication of efforts, or gaps in service. Additionally, maintaining volunteer motivation over time is a challenge, especially when faced with high-stress situations or burnout.

- **Community Engagement and Support**

The success of solidarity kitchens largely depends on the support and engagement of the local community. However, raising awareness and encouraging participation can be challenging, particularly in communities with low social cohesion or trust. In some areas, there may be a stigma associated with receiving food aid, which can deter potential beneficiaries from seeking help [111]. Moreover, without strong community ties, these kitchens may struggle to secure the necessary volunteer support or food donations, limiting their impact.

- **Affordability of nutritious food**

Currently, an estimated 3 billion people cannot afford a healthy diet, particularly in regions like sub-Saharan Africa. The high cost of fruits, vegetables, and other nutrient-rich foods makes it difficult for these initiatives to provide balanced,

nutritious meals to those in need. Another challenge is the prevalence of unhealthy food choices, driven by the relative prices of processed foods, marketing campaigns, and the demand for convenience. Efforts to promote healthier diets through food solidarity initiatives are also hampered by broader systemic issues. The global food system is not structured to prioritize access to healthy, nutrient-dense foods, and there is a need for innovations in food production and processing to make these foods more affordable.

- **Inclusivity issues**

A significant challenge for food solidarity initiatives and social kitchens is their lack of inclusivity, as many food aid programs fail to reach all individuals in need, leaving marginalized groups without adequate support [113], [114], [115]. This lack of inclusivity highlights a significant gap in current food solidarity initiatives, which struggle to provide comprehensive assistance to all vulnerable populations.

- **Sustainability and Resilience**

While solidarity kitchens play a critical role during emergencies, their sustainability over the long term is often uncertain. Many of these initiatives are reactive, springing up in response to immediate needs but lacking a long-term strategy or plan for resilience. This reactive nature makes them vulnerable to fluctuations in volunteer availability, food donations, and funding. Building a more resilient model requires strategic planning, stronger community partnerships, and exploring alternative funding sources to ensure continuity and the ability to respond to future crises effectively [111]. By focusing on short-term solutions, social kitchens may inadvertently divert attention from more sustainable strategies needed to create lasting change. Without tackling these root causes, social kitchens remain temporary fixes rather than long-term solutions to food insecurity [113], [116].

7.5 Local authorities

7.5.1 State-owned kitchens

State-owned kitchens, which serve as a critical component of public welfare systems, play an essential role in providing meals to vulnerable populations. These kitchens are integral to short food supply chains (SFSCs), which emphasize proximity, transparency, and sustainability. However, state-owned kitchens face multiple challenges that hinder their effectiveness and sustainability:

- **Infrastructure and Logistical Challenges**

State-owned kitchens often operate in facilities lacking adequate infrastructure, compromising food quality and safety. Many kitchens, especially in urban areas, struggle with insufficient cold storage and food processing facilities, making it difficult to manage perishable goods like fruits and vegetables effectively. Outdated and inefficient equipment leads to significant financial losses and resource wastage. Additionally, a shortage of transportation vehicles and drivers exacerbates logistical inefficiencies, making it challenging to serve large populations while maintaining food freshness and safety [105]. The need for frequent small deliveries due to limited storage capacity increases operational costs and can lead to food waste if not managed properly. These issues highlight the necessity for investment in modernizing infrastructure and optimizing logistical frameworks to enhance efficiency.

- **Financial Sustainability**

Operating state-owned kitchens poses significant financial challenges. These kitchens often rely on limited budgets provided by government agencies, which may be insufficient to cover the costs of modernizing facilities or sourcing high-quality ingredients. High operational costs, including those for labor, utilities, and food procurement, can strain these budgets, risking the consistency and quality of service delivery. Inadequate financial support may lead to service interruptions or a decline in meal quality, compromising the welfare of vulnerable populations [117]. Securing sustainable funding sources and exploring public-private partnerships can be vital strategies to ensure the financial viability and resilience of state-owned kitchens. Furthermore, supportive government policies, financial incentives, and regulatory frameworks are crucial to providing the necessary backing for these kitchens to thrive.

- **Coordination Among Stakeholders**

Effective collaboration between various stakeholders—including government bodies, suppliers, and community organizations—is essential for the smooth operation of state-owned kitchens. Poor coordination can result in fragmented efforts, inefficiencies, and missed opportunities for resource optimization. For example, unclear communication channels between local governments and kitchen operators may delay the implementation of necessary improvements or the procurement of essential supplies. Establishing clear roles, responsibilities, and communication protocols can enhance stakeholder coordination, improve operational efficiency, and maximize the impact of state-owned kitchens. Leveraging technology, such as digital platforms for better communication and logistics coordination, can further strengthen these collaborative efforts.

- **Cultural and Social Engagement**

State-owned kitchens often face challenges related to social and cultural acceptance. In some communities, there may be a stigma associated with receiving meals from a state-run facility, which can discourage participation among those who need these services the most. Additionally, resistance to menu changes or the introduction of healthier food options may arise due to conflicts with local food preferences and habits. Moreover, inadequate dissemination of information about available services and complex enrollment criteria can further limit access. Engaging the community through education and outreach initiatives is crucial to overcoming these barriers, promoting cultural acceptance, and encouraging greater utilization of state-owned kitchen services [118]. Incorporating local food preferences and educating the community on the benefits of healthier options can also enhance acceptance and participation.

- **Scalability and Resilience**

Scaling up state-owned kitchens to meet increasing demand, especially during crises such as natural disasters or economic downturns, presents a significant challenge. Maintaining service quality and operational integrity while expanding is difficult, particularly when resources are already stretched thin. State-owned kitchens often rely on a limited number of suppliers and may lack contingency plans, making them vulnerable to supply chain disruptions. For instance, during the COVID-19 pandemic, many social kitchens faced severe challenges in sourcing and distributing food due to sudden logistical disruptions and shifts in demand. To build resilience, these systems need diversified sourcing strategies, improved logistical frameworks, and the capacity to adapt quickly to changing circumstances [117]. Exploring innovative models such as local food hubs and digital platforms for direct sales and logistics coordination, can help enhance scalability and resilience.

- **Policy Support and Regulatory Frameworks**

The role of government policies is critical in supporting the sustainability and efficiency of state-owned kitchens. This includes creating supportive regulatory environments that allow for flexibility in sourcing and menu planning, providing financial incentives for modernization, and establishing guidelines that promote transparency and accountability. Public-private partnerships can also be a key avenue for funding and innovation, enabling state-owned kitchens to access private sector expertise and resources while maintaining their public welfare mission [117].

- **Technology and Innovation**

The integration of technological solutions is vital for improving the efficiency, scalability, and responsiveness of state-owned kitchens. Digital platforms can streamline communication and coordination among stakeholders, while data analytics can help optimize supply chain management and predict demand more accurately. Smart logistics solutions, such as real-time tracking of deliveries and automated inventory management, can reduce waste and enhance operational efficiency [119]. Investing in technology not only modernizes state-owned kitchens but also aligns them with the evolving needs of the communities they serve.

- **Environmental Sustainability**

Incorporating environmentally sustainable practices is increasingly important for state-owned kitchens. Reducing food waste through efficient inventory management and using local, seasonal produce can minimize the environmental footprint. Additionally, implementing energy-efficient equipment and sustainable waste management practices can further align these kitchens with broader environmental goals [118]. These initiatives not only promote sustainability but can also enhance the community's acceptance and support for state-owned kitchens. In the context of short food supply chains, the inherent limitation in scale poses a unique challenge. Scaling up while maintaining core values such as proximity, transparency, and sustainability is difficult, particularly for food solidarity initiatives. Although digital platforms have facilitated scaling in some regions, these cases are rare, and many SFSCs struggle to balance expansion with their ethical and operational principles. The COVID-19 pandemic underscored the vulnerability of SFSCs to disruptions, highlighting the need for more resilient models that can withstand future challenges. Strategies such as establishing local food hubs, fostering stronger community partnerships, and diversifying supply chains are crucial for building more robust and adaptable food systems that can better support state-owned kitchens and the vulnerable populations they serve.

8. INNOVATING IN FOOD SUPPLY CHAINS: TOOLS AND FEEDBACK TO GET INSPIRED AT THE LEVEL OF THE EURO-MED COOPERATION AREA

8.1 Decision-support tools: optimizing the logistics model and the vehicles used

- **Tool n°1 - Logicoût**

Rethinking its logistics organization model to optimize costs and reduce the associated carbon footprint

Logicoût [120] is a french application that calculates the cost and carbon impact of a short delivery round. This tool was developed by CEREMA in partnership with a number of other players as part of two projects aiming at optimizing short food supply chain logistics organizations (OLICO-Seine and ALLOCIRCO). Logicoût has been available free of charge since 2018, and 27,435 simulations have already been carried out.

To run a simulation, the farmer describes the type of vehicle he uses (engine, size and year in service), his delivery route (mileage and journey time, time spent at delivery points), the time spent on logistics activities, the cost he wishes to retain for the hour worked and other costs (such as tolls or parking). Other information can be specified to deepen the analysis (vehicle price, delivery time, GPS points, etc.).
The simulation not only enables the cost and carbon footprint of the delivery route to be calculated, it is also an essential starting point for modeling different scenarios for more efficient logistics organizations. Logicoût is therefore a diagnostic and decision-making tool. It can be used to calculate sales prices that are consistent with the actual cost of delivery, to optimize delivery rounds, to assess the viability of different outlets, etc.

- **Tool n°2 - “Verdir ma flotte”**

Identify "neutral" or low-emission vehicles suited to a specific use

“Verdir ma flotte” [121] is a tool that has been freely available since 2022 to calculate a vehicle's TCO (total annual cost of ownership) and carbon footprint.

"Verdir ma flotte" [121] is a tool that has been freely available since 2022 to calculate a vehicle's TCO (total annual cost of ownership) and carbon footprint. The calculator compares different fuels and technologies, namely biofuels (B100, HVO and bioGNC) and hybrid and all-electric powertrain technologies. Once again, this is a decision-making tool that can be adapted to different contexts and uses. It allows anyone to choose the best solution based on ecological efficiency and the cost for a specific use. The example below shows the recommendation of the tool when asking for the best low-carbon energy for operating last-mile delivery rounds with a 7.5 tons truck.

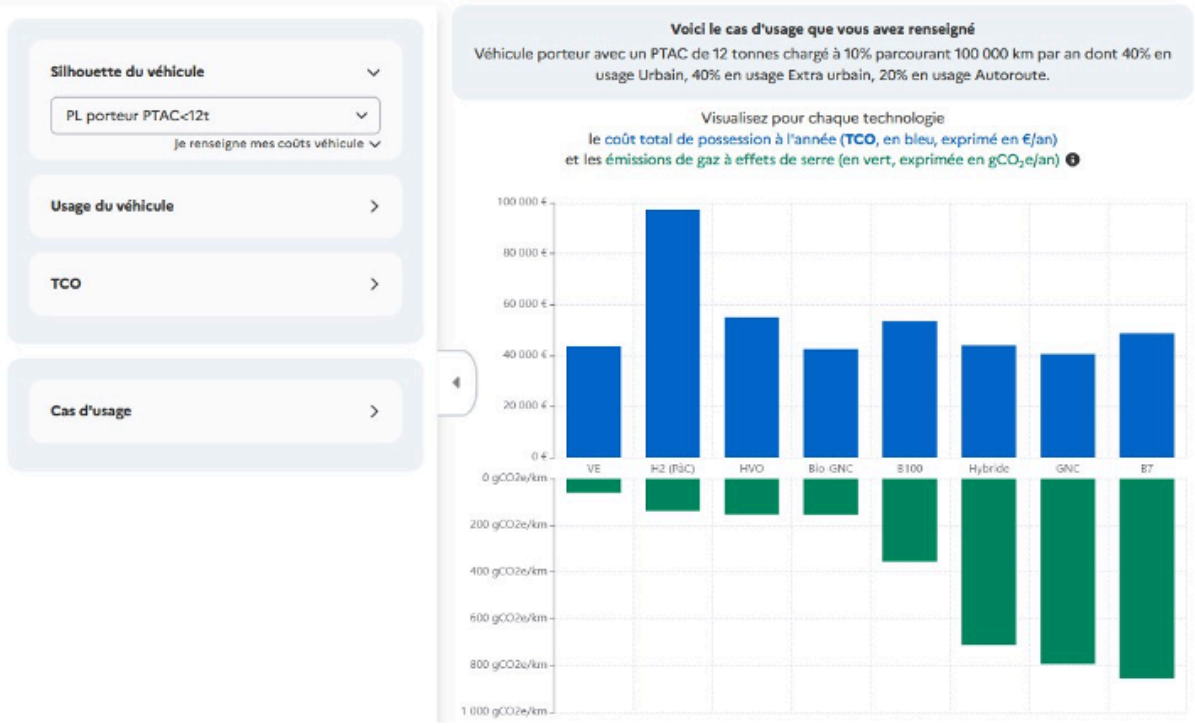


Figure 4. Screenshot of the low-carbon mobility assessment tool "Verdir ma flotte".

- **Tool n°3 - Climact 2050 Pathways Explorer**

Calculate your CO2 emissions by making different scenarios.

"Climact 2050 Pathways Explorer" [122] is a comprehensive, open-source tool designed to assist policymakers, experts, and stakeholders in exploring low-carbon scenarios and energy transitions. This dynamic platform covers all energy sectors and greenhouse gas (GHG) emissions, providing insights through a real-time web interface.

Unlike traditional forecasting models, the Pathways Explorer doesn't predict future outcomes or attach specific probabilities to scenarios. It also doesn't include macro-economic analysis or cost optimization, with costs calculated retrospectively.

Built on extensive expert consultations and engagements, the platform supports the development of ambitious low-carbon pathways, from projections of historical trends to transformational scenarios requiring breakthrough technologies and societal shifts. Users can leverage the tool to align national or regional targets with EU sources, track GHG reduction progress, and assess the broader implications of various pathways, including costs, air pollution, and resource use. By offering detailed sectoral interactions and synergies across multiple countries, the Climact Pathways Explorer is a vital resource for shaping effective, data-driven climate strategies.

- **Tool n°4 - Free parking places for city logistics**

In the city center of Helsinki, 40 % of light lorry drivers report that they have difficulties finding a place for loading and unloading, which causes costs, emissions and problems with air quality. In 21 % cases, drivers have to park on the sidewalk, which causes disturbance and insecurity for pedestrians. Parking issues are often a large ineffective factor in business operation.

The City of Helsinki, Forum Virium and 10 logistics companies have together developed an app for finding free parking places for city logistics. The aim is to find ways to enhance distribution. In the pilot, drivers can observe 22 parking places in the city center and see if they are vacant. Parking places are equipped with cameras and status information can be shared in real-time. For reporting, the program registers every stop lasting more than 3 minutes, and drivers are able to report causes for stopping. So the pilot also provides statistical data on distribution and traffic problems and generates a timeline showing temporal distribution of deliveries (day, month). A time reserving system is part of this pilot.

The pilot has increased fluency and efficiency in logistics and deliveries. Costs have been lowered by savings in fuel, emissions decreased, air quality and road safety improved. It provides information for city planning about the need for parking space and its utilization at different times. One goal is to keep the city center lively and the services nearby for residents, while also building an attractive city for businesses. Companies found private-public development of city logistics important.

8.2 Digital logistics platform and networks: connecting stakeholders and consolidating flows

- **Initiative n°1 - La Charrette**

A social network to connect local food stakeholders.



Figure 5. Brewery part of a La Charrette network [123]

La Charrette [124] is a social economy organization founded in 2017 in Haute-Savoie (France) by two entrepreneurs. After testing a number of digital tools designed to help producers find a logistical solution for food short supply deliveries, the founders of La Charrette turned their attention to developing a social network for all organizations involved in local food, in 2022. This local food community is of interest to public authorities not only in France (local authorities) but also in Belgium and Quebec, so La Charrette is also offering support services for the structuring of a local food ecosystem (these services have enabled La Charrette to break even since 2022).

How it works? Farmers, food producers, marketplace, intermediary, transporters, grocery shop, GMS or reverse logistics companies wishing to identify local food stakeholders in their area can consult "La Charrette" community map, target and contact those offering a solution to their problem. Access to the map is free, but a premium account (50 euros per year) is required to post messages. A producer can, for example, use this network to get in touch with another producer delivering to the same sales outlet and offer to pool transport, or meet a producer with a storage site. A grocery shop can find a local supplier for a given product o a professional transporter to be delivered: the possibilities are endless.

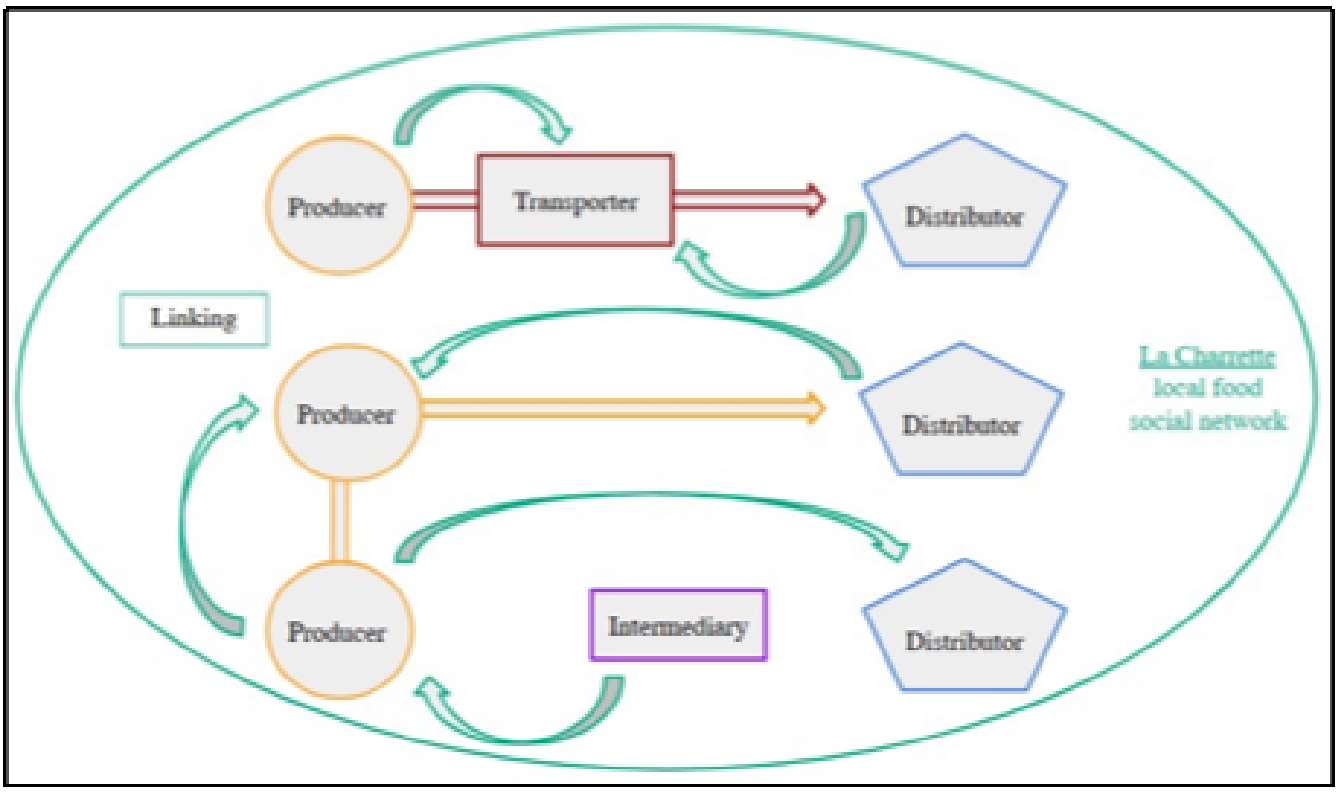


Figure 6 How "La Charrette" social network of local food stakeholders works: an example of how stakeholders can get in touch with each other.

Analysis: To date, 12,000 local food operators are listed on the Charrette community (including 3,000 paying accounts), and the solution has also been adopted in Belgium and Quebec. The network is working well because it provides an answer not only to purely logistical problems but also to the lack of cohesion between local food operators. Indeed, since its creation in October 2023, Laura Giacherio (co-founder of La Charrette) estimates that 60% of the 45,000 messages posted or exchanged on La Charrette's social network were aimed at identifying a supplier or an outlet (and the other 40% were aimed at finding a ogistics solution). Producers who set up co-delivery circuits with other producers thanks to La Charrette's contacts said they gained between 10 and 15 new outlets as a result. The community also benefits small hauliers looking for deliveries to make, and local food intermediaries who are always on the lookout for new suppliers. In short, the strength of “La Charrette” lies in the fact that it offers a solution that pools information flows rather than physical flows - which are very difficult for short supply chains to pool, given the diversity of stakeholders and functioning. The social network framework provides sufficient flexibility for each player to meet the operator they look at and to find the solution they need.

Cost to the producer: free access, premium membership at €50 per year (to send messages).

Sources: La Charrette, le réseau social des professionnels du locavore – Marcelle [123] ; Interview of Laura Giacherio from "La Charrette" (FAB'LIM).

- **Initiative n°2 : Seljak.me**

Digital platform for direct sale of agricultural products

Figure 7. Seljak.me logo [125]

Seljak.me [125] places a strong focus on small farmers and producers from rural areas, giving them the opportunity to easily market their products and expand their reach. This reduces their dependence on traditional market channels and increases their chances for economic growth. Through the platform, consumers can obtain clear information about product origins and communicate directly with producers, enhancing trust and transparency in the supply chain. By using the Seljak.me platform, local producers can sell their products directly to end consumers, eliminating the need for intermediaries. This allows farmers to retain a larger portion of the profits, while consumers receive fresh, local products at more affordable prices.

Description of the solution context: Seljak.me is a digital platform based in Montenegro that connects local farmers and agricultural producers with consumers, facilitating direct sales of fresh, local products. It was developed to address the challenges that small farmers face when trying to reach the market, such as dependency on intermediaries, limited access to urban markets, and reduced profit margins.

How it works? Farmers on the Seljak.me platform have the opportunity to showcase their products by uploading images, providing detailed descriptions, and setting prices.

Once the products are listed, farmers maintain direct communication with customers, who can place orders through the platform. This direct interaction allows farmers to retain full control over their pricing and sales conditions. Consumers can browse the platform, choose from a variety of locally produced goods, and place orders directly with the farmers. They have the flexibility to arrange either delivery or pickup directly from the farm. After purchasing, customers are encouraged to rate the products and leave feedback, fostering transparency and helping other users make informed decisions. This system not only strengthens the relationship between farmers and consumers but also enhances trust within the supply chain.

Seljak.me modernizes the Montenegrin food supply chain, making it more efficient and sustainable by directly connecting local supply with demand, all through a user-friendly digital interface.

- **Initiative n°3 - CoopCircuits**

CoopCircuits [126] is a French société coopérative d'intérêt collectif whose mission is to support the scaling-up of short distribution channels. To this end, CoopCircuits provides organizers of short circuits (mostly food) with an online sales platform, under a free license, and offers training and personalized support for the efficient management of an online store. CoopCircuits also offers customized tool integration services (e.g., connecting an online store to an accounting or mailing tool). CoopCircuits thus builds a decentralized distribution system, reconnecting producers and consumers, made up of multiple independent distributors, diverse in nature but also linked to one another, enabling them to help and cooperate with one another. Thanks to this cooperative approach, the players in the distribution system retain control over the technologies they use, building and managing them together, and ensuring their sustainability. What's more, they share them openly so that as many people as possible can benefit from them, which is central to CoopCircuits' social project.

Economic model: The platform has been in operation since 2017. It was initially supported by the Open Food France association and operated at the time on the basis of free contributions from users and subsidies. When CoopCircuits was created, the service offering without support was financed by a free contribution, and the offering with support by a levy of 1% of the sales (excluding VAT) generated by the stores. As this rate did not enable the cooperative to follow the desired development trajectory, it was decided to increase the rates as of January 1, 2024, to a levy of 3.5% of sales (excluding VAT) generated online, with a floor of €60/year and a ceiling of €10,000/year.

Stores run by associations not subject to VAT can obtain a 20% discount on the tariff on request. To date, the cooperative is still looking for an economic model that will enable it to stabilize its offer and provide a quality service at an affordable price.

How the platform support logistics optimisation: CoopCircuits helps organizers of short circuits to better manage their marketing and logistics. The principle of pre-ordering (asking the consumer to order before such and such a date to be delivered on such and such a date) enables harvesting and order preparation to be fine-tuned, as well as massifying flows. What's more, the platform enables different users to connect with each other. Products in a producer's catalog can be distributed by the producer himself, but also included in the catalogs of other stores: producer groups, buying groups, grocery stores or any other initiative. Stocks and available products are synchronized to facilitate multi-distribution. In addition, the ease with which the various initiatives can cooperate makes it possible to envisage shared pick-up or delivery rounds, as well as shared distribution points.

Cooperation and network: CoopCircuits is a member of the international Open Food Network, which brings together people committed to greater food sovereignty through the development of solutions for short food supply chains. It was Open Food France that originally incubated the creation of CoopCircuits, as well as that of Data Food Consortium (of which they are members). Data Food Consortium is working to develop a common digital language (in this case, nomenclatures and an open standard) between short-circuit platforms, making it possible to pool data and connect short-circuit players and initiatives. As part of the Data Food Consortium's work, interoperability with logistics platforms will eventually enable CoopCircuits (which has access to the latest API developments) to offer a wide range of services for route optimization, co-deliveries, etc. Alongside 12 other French cooperatives, CoopCircuits is also a stakeholder in the Les Licornes association, which aims to raise the profile of member cooperatives, strengthen inter-cooperation and attract public and private institutions seeking to invest in environmental transition.

Feedback: The shared development of the technology used by CoopCircuits within the Open Food Network has enabled us to design a high-quality, stable and accessible solution. Today, CoopCircuits is recognized as a key platform, often called upon for research into short distribution channels or digital commons. On the other hand, the choice of a low-cost development strategy (no massive fund-raising to finance the start-up or the change of scale) means that we are unable

to devote a significant amount of time to running the cooperative and to business development, in a highly competitive sector.

- **Initiative n°4 - Agriflux**

A digital "control tower" for local food logistics.



Figure 8. Agriflux collects product from regional farmers [127]

Agriflux [128] is a start-up founded in 2021 that offers a service for optimizing urban food transport by linking short distribution channels to the global supply chain. The initiative was launched in response to the observation that "the market for short, local distribution channels is hampered by logistical problems. 80% of producers are left to fend for themselves" (Jean-Marc Thouy, Agriflux). The platform gives short-distance producers and distributors - who are usually excluded from the transport circuit because the quantities and value transported are too low - access to an optimized and therefore relatively inexpensive delivery service. But it also optimizes the journeys made by hauliers, who often travel empty.

How it works? hauliers register their routes and availability on the platform, while shippers (producers or distributors) book the transport that suits them best. In a way, Agriflux is a 'control tower' that coordinates supply and demand for food transport in real time. The advantage for shippers is reduced logistics costs thanks to the consolidation and optimisation of flows.

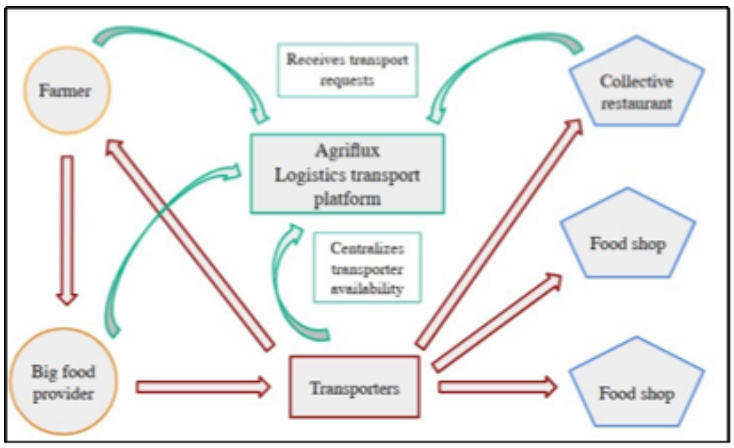


Figure 9. Functioning of the digital short supply chain transport platform developed by the start-up Agriflux

Analysis: Agriflux buys transport cheaper than if the producer contacted the haulier directly, because it manages to consolidate and optimize flows. For the hauliers, the logistical work is greatly simplified by the platform. Agriflux works with around fifty shippers, and estimates that the platform can reduce carbon emissions by 60%. The service offered by the start-up is of interest to producers who are already optimizing their deliveries, which is not always the case: "Some producers agree to deliver 2 trays of lettuce".

The challenge now for the platform is to increase the number of users, in particular by helping producers to change their practices: "Our role is to help people count", sums up Jean-Marc.

Sources: Interview with Jean-Marc Thouy d'Agriflux (FAB'LIM) ; ladepeche article [127]

- ***Initiative n°5 - FreshFlow***

Reshape the food supply chain to better stock management and avoid food waste.

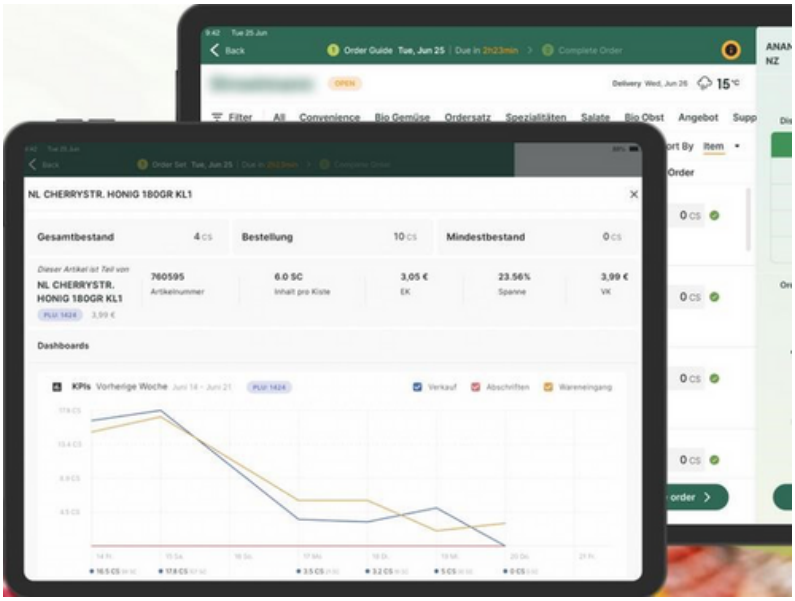


Figure 10. FreshFlow interface [129]

Headquartered in Berlin, Freshflow is leveraging Artificial Intelligence to reshape the food supply chain. Based on advanced order forecasting, replenishment, and inventory control, Freshflow significantly reduces food waste while keeping store shelves fully stocked. This not only minimizes carbon emissions but also makes fresh food more accessible and affordable, thereby increasing profits for retailers. Founded in 2021, Freshflow has secured €1.7 million by using technology to tackle global food waste and inefficiencies in the retail sector.

How it works? Freshflow's AI learns from millions of historical data points, past promotions, item-level properties (country of origin, organic status, prices, etc.), and external factors like weather, local events, and holidays. This ensures precise demand forecasting for every product in every store. Freshflow's AI tackles the complexities of fresh produce data, from automatically matching items with varying IDs to understanding PLU codes. For every order, it balances the risk of spoilage vs. the risk of stockouts, while maximizing inventory turns, shelf fullness, and freshness. The app adapts to messy and incomplete data from local suppliers, ensuring consistent, accurate ordering across all sources.

Source: Freshflow AI [129]

8.3 Innovative logistics organization model: securing supplies and optimizing logistics flows

- **Initiative n°1 - GRAP - Coolivri**

Pooling of logistics by distributors to build a diversified, ecological and viable supply network.



Figure 11. Coolivri logistics service

Coolivri is a logistics service created in 2015 by GRAP (regional groupement for local food), a cooperative founded in 2012 that brings together more than 70 grocery shops and organic food processing structures (e.g. brewers, roasters, bakers, caterers, restaurants, bars) within a 150 km radius of Lyon. GRAP members share administrative, IT, logistics and support services. Coolivri is GRAP's logistics service. Launched in 2015, it simplifies deliveries for the 150 organic producers who supply grocery shops.

How it works? (1) Several of the group's grocery shops place a group order with producers. (2) Delivery is made either to the Coolivri warehouse on the outskirts of Lyon, or to a GRAP grocery shop nearest to their place of business. (3) With the exception of a few orders delivered to the Coolivri warehouse in Lyon, the orders are prepared by the producers themselves.

(4) loaded by Coolivri drivers at the start of or during the round and redistributed to the grocery shop customers. The rounds are also used to collect returnable packaging. Grocery shops in the Rhône (Lyon department) need 2 deliveries a week because of their limited space. For the others, one delivery a week is sufficient.

Of the goods transported, 20% are fresh products and 80% dry products.

In terms of IT, Coolivri uses Odoo software to facilitate order taking and deliveries. As some shops do not have sufficient space to store all their orders, it could be envisaged, in the long term, that certain products could be stored in another warehouse on behalf of a grocery shop (but Coolivri will not be a storage platform, and this will remain exceptional). Producers will continue to deliver their products to the most convenient location for them.

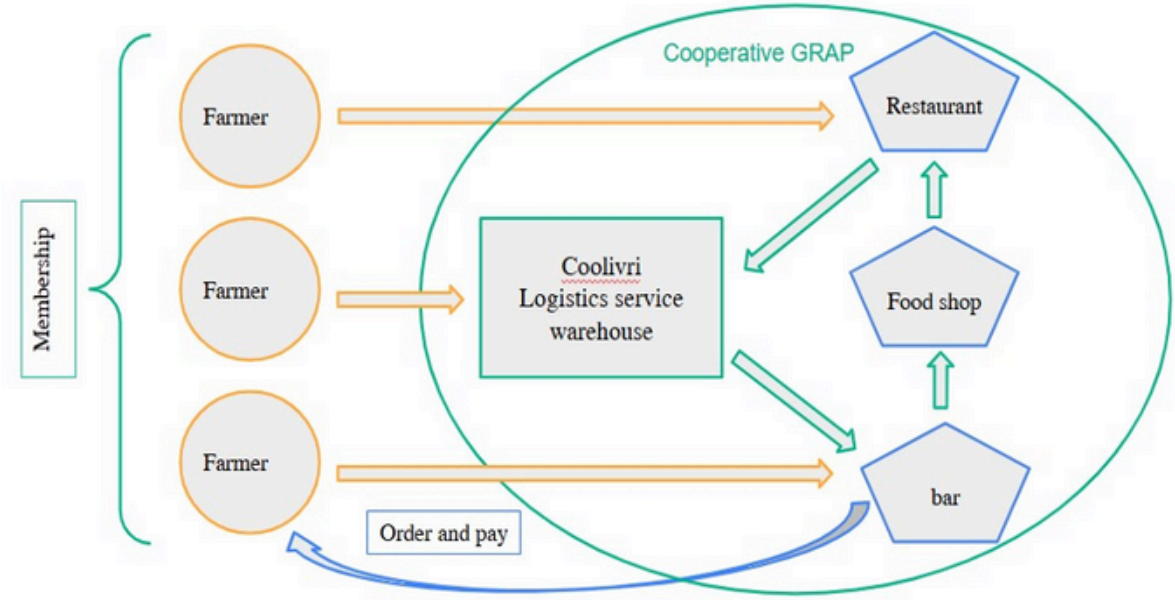


Figure 12. First version of the Coolivri logistics service set up by the cooperative GRAP. Reverse logistics are an integral part of this system.

About business model, Coolivri relies on 3 categories of resources:

1. Producers contribute 5% of sales (excluding VAT) of the products transported,
2. Grocery shops pay a subscription fee based on the level of use of the service and their turnover,
3. end-of-year discounts from wholesalers (if purchasing targets are met) go directly to Coolivri.

The benefits of Coolivri can be felt on a number of levels. The scheme supports small producers, who no longer have to deliver small quantities to multiple shops, and can boost their sales by pooling orders.

What's more, Coolivri has made it easier for grocery shops to develop their short-distance supplies. The introduction of in-house software makes it easier to take and manage orders, as well as producing a route planner for delivery staff. Coolivri's lorries run with an optimized load (it is sometimes necessary to set priorities). Rounds were expanded in 2024, and now all areas with grocery shops are served once a week.
There are plans to open a route from the Drôme to reduce the working time of delivery staff based in Lyon and ensure that the cold chain is maintained, even when there are a lot of stops and long routes. In addition, the purchase of a new, larger capacity van was necessary in the summer of 2024 for the very dynamic Lacs et Montagnes region (Savoie-Isère-Ain counties). Ultimately, as well as securing the economic model for producers and shop purchases, Coolivri helps to reduce the footprint of shop delivery rounds, as well as offering a solution for collecting returnable packaging (reverse logistics).
However, several aspects still need to be enhanced:

- the storage of products in grocery shops, particularly fresh produce (which can be complicated in the event of a large delivery from a local producer to other grocery shops in the cooperative),
- regular updating of orders by the shops (necessary in order to draw up the delivery schedules correctly),
- promoting local products and short distribution channels to consumers (via presentation sheets, inviting producers to annual seminars, etc.),
- managing the risk of overloading lorries, which for the moment only appears on the route plan and sometimes requires rapid adjustments.

Sources: Interview with Sylvie Huber (logistics coordinator of "GRAP") by FAB'LIM.

- **Initiative n°2 - Échanges Paysans**

A commercial intermediary to develop short-distance food sourcing and reduce upstream logistics costs.



Figure 13 Echanges Paysans Hautes-Alpes receives the national prize for the Social and Solidarity Economy [130]

Echanges Paysans [131] is a short food supply chain platform destined for collective and commercial catering in the Hautes-Alpes (France). The company defines its activities as "commercial mediation of public interest" between supply and demand. In other words, Echanges Paysans is a wholesaler committed to ensuring that its products are tasty, environmentally friendly and fairly priced. The association was set up in 2008 thanks to the commitment of a group of citizens, and the first deliveries were made in 2013 to the Briançon public catering sector. Today, “Échanges Paysans” has 8 employees, 700 products in its catalog and is studying the possibility of changing its status from that of an association to that of a SCIC (Société Coopérative d'Intérêt Collectif). The service is aimed primarily at producers who are in tune with these commitments and wish to develop new outlets.

How it works? Echanges Paysans commercially brings together the scattered offerings of small local producers to build up an attractive range of products aimed at the catering industry in particular. In practical terms, the SCIC canvasses for customers and, at the same time, builds up a catalog of local products. The majority of member producers deliver directly to the premises of Échanges Paysans, located in Gap (a central town in the Hautes Alpes département). The association collects products from certain producers (when they are on the delivery round), while some producers deliver directly to customers located nearby. The association makes some of the rounds to the end customers with its own truck (3.5t) and relies on a forwarding agent for large deliveries (one pallet or more). The system operates on a just-in-time basis (no stock), with delivery a maximum of one week after the order is placed, to meet the constraints of the catering industry. Customers include food shops, restaurants, hotels, the catering industry and other short distribution channels. Producers pay a membership fee of 15 euros and contribute 1% of their sales turnover (this rate is adapted for producers who carry out all the transport themselves and therefore only benefit from the commercial service). A maximum margin rate has also been set for each product category to ensure a fair distribution of added value between the producer and the intermediary (Echanges Paysans).

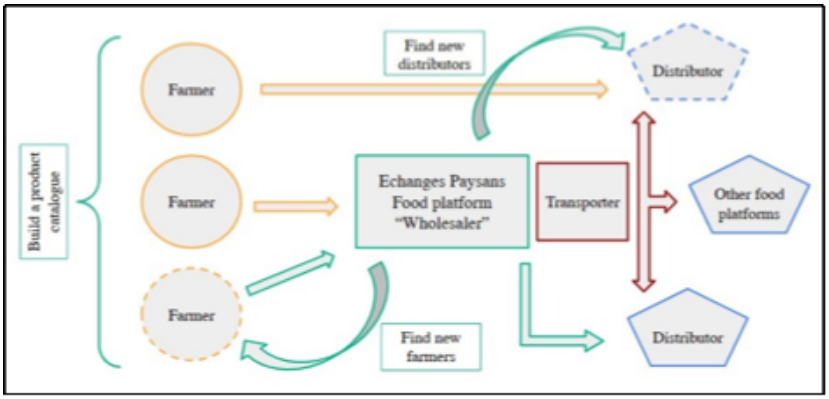


Figure 14. Functioning of the short food supply chain built and coordinated by the association Echanges Paysans.

Analysis: Echanges Paysans therefore offers a service that reduces upstream logistical costs for producers and buyers by creating a simplifying one-stop shop. Producers save time on sales work (canvassing, order management) and gain new outlets, while buyers save time by dealing with a single point of contact.
To sum up, Echanges Paysans works because it meets all the expectations placed on short distribution channels (fewer intermediaries, fair distribution of added value, price transparency, product traceability) and provides a response to the logistical problems generated by these channels (matching supply and demand, organizing deliveries, etc.).

Cost for the producer: membership fee of 15 euros and contribution of 1% of their sales turnover.

Sources: Farmers' Exchanges Hautes-Alpes [130]; Interview of Marc Lourdaux from Echanges Paysans (FAB'LIM).

- **Initiative n°3 - Livrazou**

In 2019, a number of social economy organisations in Marseille began thinking about how they could pool their logistics to manage the supply and distribution of local, short-distance food products, while at the same time reducing their impact on the environment. The LivraZou association was created in April 2021, bringing together Pain et Partage, Manger Bio Provence, Plateforme Paysanne Locale, Les Paniers Marseillais and Les Alchimistes. The shared aim is to develop a local, human-scale, integrated logistics model, optimise downstream and reverse flows to reduce the impact of urban logistics, and encourage cooperation, pooling and sharing of experience. In July 2022, LivraZou inaugurated its first urban logistics demonstrator, a 250 m² warehouse on the outskirts of the city (northern suburbs), organised as a network to cover the entire logistics chain. Fit-out: 120 sq. metres of mezzanine space for offices (€100k), 100 sq. metres of cold rooms (€80k), partitions to demarcate areas, insulation and electrical installation work (€75k), purchase of equipment: pallet racking (€7k), semi-heavy shelving (€3k), 2 stackers to lift pallets and load lorries (€8k), an electric pallet truck (€2k). LivraZou's range of services includes goods reception, dry, fresh and ultra-fresh storage, order preparation on pallets for professionals and in baskets for individuals in groups, delivery with a possible bicycle relay in the low-emission zone and management of the return of organic materials and used packaging. The medium-term challenge is to decarbonise transport, reduce waste and develop deposits, as well as building a model for integration through economic activity. To structure its business and improve responsiveness and efficiency, LivraZou is considering the introduction of software solutions for managing stocks and flows.

- **Initiative n°4 - The Market of National Interest of Montpellier**

A public-private food hub to connect the demand and the producers at the gateway to the city



Figure 15. Market of national interest of Montpellier

The status of “Market of national interest” (MIN) was created in the 1950s in response to the French government's desire to rationalize urban food supplies after the Second World War, in a context still marked by ration coupons. In the 1960s, 17 MINs were created on the basis of existing wholesale markets - 1965 in Montpellier. These were food hub platforms that centralized wholesale and retail functions (producers, wholesalers and retailers) in a single location at the entrance to conurbations, at the crossroads of available transport routes. The aim of every “MIN” was to modernize the food supply in the most important cities by guaranteeing an appropriate selling price for producers and a controlled price for consumers. These savings were to be achieved by reducing operating, transport and marketing costs, by pooling equipment and services, by controlling wholesaler margins, by creating value from basic products (processing) and by streamlining transport (in particular by connecting up to the rail network). In Montpellier, the “MIN” is managed by a semi-public company (a company with a majority public shareholding). It brings together 220 companies and generates 2,500 jobs. The city of Montpellier has made the land required for the platform available and plays a key role in the development of the MIN, which is an essential tool for achieving the objectives of the city's food policy (more local and organic produce, particularly for catering). Today, the Montpellier MIN estimates that 40% of the food products it handles are of local origin (southern France).

How it works? The Market of national interest of Montpellier is a wholesale market and logistics platform (food hub: it rents storage space to wholesalers and organizes farmers' markets three times a week. Its aim is to help producers find outlets and distributors (retailers) obtain supplies by structuring last-mile logistics from the platform. The MIN also houses a food processing centre. Producers can organize sales in advance with retailers or sell directly at the market. Some retailers have their produce delivered from the MIN by a carrier or prefer to collect it directly. The MIN's aim is to improve the city's food supply system, and efforts are being made to ensure local and organic supplies (differentiated pricing is used to distinguish between producers according to their geographical origin), as well as low-carbon logistics (less polluting vehicles and optimized delivery rounds).

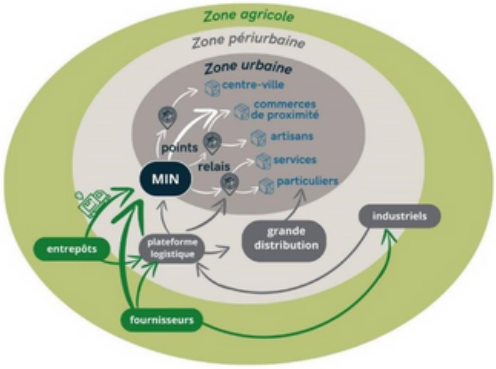


Figure 16. The "MIN" food hub's role in urban food logistics

Analysis: The MINs, and particularly the Montpellier MIN, are positioned as a third way between the dominant supermarket food supply model and the marginal model of direct channels (e.g. AMAPs in France), as mentioned in part 2 (on the subject of Food Hub logistic platforms). Ideally, its model is based on a balance between short and long distribution channels, where each benefits from the pooling of infrastructure and logistical know-how - particularly in the last mile: "*if the two distribution channels don't work with the same source of supply, they have to work together. However, they both have to deal with the problem of transport in urban areas*" (Vincent R. 2024) [57] . Making the most of the possible synergies between these players is one of the challenges facing the Montpellier MIN if it is to regain its place at the heart of the city's food supply. Today, the Montpellier MIN is "*bypassed by supermarkets and short-circuited by direct sales*" (R. Vincent 2024) [57]. Its aim is to become the public service of Montpellier's food supply, starting with the catering sector (kitchen garden). The objectives in terms of organic and local food are set out in a roadmap drawn up with the city of Montpellier. In addition, the greening of the fleet of vehicles used for last-mile logistics from the MIN and the installation of appropriate infrastructure (electric terminals, biofuel station) should be a priority in the years to come. All of the ambitions summarized here cannot be achieved without the support of the public authorities (funding, political backing) and the integration of these issues into the wider sphere of urban planning.

The choice facing urban areas like Montpellier can be expressed in these terms: devote part of the urban land to reconnecting the city with those who feed it or relegate food issues to the outskirts of large cities.

Sources: Interview of Marion Mazel from MIN of Montpellier (FAB'LIM), Internship report of R. Vincent [57]

8.4 Reverse logistics: facing the food waste challenge by optimizing the logistics

- **Initiative n°1 - Les Alchimistes**

Collecting and composting waste to close the agri-food cycle



Figure 17. Les Alchimistes collection unit [132]

Les Alchimistes [132] is a network of organisations specialised in raising awareness of sorting, collecting, managing and composting food waste from businesses and households. All are accredited as socially responsible enterprises. Operating in around twenty French conurbations (including Marseille and Montpellier), they offer waste collection services to professionals (local authorities, collective caterers, hotels and restaurants, event organisers, hospitals, schools, supermarkets, food processing industries) and households, via public contracts with local authorities. The waste is then composted on industrial platforms. By 2024, Les Alchimistes was collecting waste from more than 3,000 establishments throughout France, diverting 24,000 tonnes a year from incineration or landfill. It should be noted that in France, since 1er January 2024, any structure producing waste must implement source separation and a recovery solution, regardless of the volume of waste produced (AGEC law). Les Alchimistes helps its customers to comply with these regulations. The Alchimistes business model is based on the sale of waste collection and treatment services. Compost sales account for less than 5% of turnover.

In Marseille, empty bins are delivered and full bins collected by lorry with tailgate (by employees) and by bicycle (by a service provider). Routes are optimised using software. Collection logistics are the biggest item of expenditure, accounting for around 60% of costs. The trucks used are electric and diesel, all with Crit'Air 0, 1 or 2 (European Ecological Vignette). Because of health risks and space requirements, the Alchimistes' routes cannot be shared with those of the food industry.

Sources: Les Alchimistes aise €10 million to turn compost into green gold [133]

- **Initiative n°3 - L'incassable**

"L'Incassable" is a French association based in Marseille and created in July 2020. It is developing a channel for reusing glass bottles in the Marseille region to reduce the production of waste linked to single-use packaging. Its approach meets the objectives of the AGEC law (anti-waste for a circular economy), which aims to phase out single-use plastic and encourage the reuse of packaging in line with the hierarchy of waste treatment methods set out in the Environment Code (Article L541-1). The law sets the minimum proportion of reused packaging to be put on the market annually at 10% by 2027, i.e. 2 billion items of packaging per year. "L'Incassable" supports producers, distributors and local authorities in meeting this challenge by setting up a bottle collection, washing and reuse service, and by raising awareness to encourage changes in consumption patterns (reusable glass packaging is more environmentally advantageous than single-use glass packaging from the second use).

In France, bottles eligible for re-use can be identified by a national pictogram found on the labels of partner producers. This pictogram guarantees that the bottles are eligible for reuse and can be washed and reused. "L'Incassable" also affixes a yellow sticker specifying "Je suis consignée" (I'm returnable) to the bottles. A €0.50 deposit is paid by the end consumer, which is returned when the empty bottles are returned to the shop.

In November 2022, "l'Incassable" opened a bottle-sorting platform in Vitrolles (around twenty kilometers from Marseille), which the association shares with Soofût, a company that reuses barrels. The bottles are sorted by format, and any that do not comply are discarded. L'Incassable does not have a washing unit for the time being (until it has sufficient volumes). Once sorted, the bottles are sent for washing to either "Ma bouteille s'appelle Reviens" (My bottle is called "Come back") in Valence (Drôme) or "Oc Consigne" in Montpellier (Hérault). "L'Incassable" subcontracts the collection of bottles from shops in Marseille city center to a cyclo-logistics company (Agilenville).

The minimum collection requirement is 16 crates of 12 bottles per shop. The cyclo-logistician assembles the collected crates at its consolidation site in Marseille and assembles them on pallets. The transport company “Main Forte” then picks up the pallets and transports them to the sorting center in Vitrolles. Transport partnerships have been set up in other towns in the region. Collection thresholds depend on the routes and collection formats (pallets or mini-pallets). In October 2024, L'Incassable had 77 partner collection points and had collected more than 150,000 bottles.

Optimizing logistics is a key factor in the business model of “L’Incassable”. What works well are in-store collections on optimized, predictable, timed rounds and large volumes. However, not everything is optimal yet, and the model is building it up as we go along : “We need to further consolidate flows” (Camille Chanson, director of “L’Incassable”). Pooling has been considered with the food industry to reduce transport costs, but it is difficult to envisage fresh produce and soiled packaging living side by side. Other partnerships are being considered with packaging manufacturers (e.g. cardboard boxes), distributors and drinks wholesalers. Behaviors are also slow to change. In European countries where deposits have never been abandoned, the practice has remained part of everyday life. In France, however, deposits were virtually abandoned in the 1980s, and a major effort is now needed to raise awareness among both professionals and the general public. This explains why the deposit market is not yet fully mature.
The business model of “L'Incassable” is based on public subsidies from local public authorities (Région Sud, Aix-Marseille Métropole, Mairie de Marseille) as part of their waste prevention plans, as well as support services for drinks producers to bring their production sites into compliance and bottles for reuse. In addition, the partner producers pay an annual contribution to an eco-organisation approved by the public authorities (Citeo) to benefit from the collection of their bottles and access to the offer of re-used bottles. This will enable financial aid to be released from 2024 to support the development of the deposit model (by organizations such as “L’Incassable”), as well as the introduction of pilot areas in 2025.

Sources: interview of Camille Chanson (director of “L’incassable” by FAB’LIM).

9. MAIN LEARNING FROM THE STUDY CASES TO SET UP GARDEN'S PILOTS

9.1 Initial assessment about food logistics in short and local supply chains

- **The importance of Last-Mile Logistics in reducing the environmental impact of food supply chain:** The last-mile delivery in urban areas remains a major environmental and financial bottleneck. Reducing emissions in this stage through innovative methods like cargo bikes, urban logistics hubs, and cleaner vehicles can significantly enhance the sustainability of food supply chains.
- **Logistics as a key cost factor in SFSC:** Logistics in short food supply chains is a major cost element, often consuming up to 23% of producers' turnover. Optimizing logistics through better planning, pooling of delivery rounds, and investment in transport infrastructure can reduce costs and increase the profitability of small-scale producers.
- **The complex logistical coordination in SFSCs:** Stakeholders in short food supply chains face significant logistical challenges due to fragmented product flows, diverse product types, and limited logistics expertise. Producers, especially smaller ones, often lack the financial and organizational resources to invest in optimized logistics, making it difficult to achieve cost-efficiency. Additionally, a lack of shared logistics infrastructure further complicates coordination between producers and buyers, which leads to high transportation costs and inefficiencies.

9.2 Main findings about last mile Logistics challenges faced by SFSC stakeholders

- **The role of digital tools and collaboration in Direct-to-consumer models (D2C):** One way to develop a SFSC business through logistics solutions is by implementing direct-to-consumer (D2C) models (without intermediaries), such as farmers' markets, subscription boxes, and online sales. These D2C models offer valuable growth opportunities for small and medium-sized producers by allowing them to bypass intermediaries and retain a larger share of the retail price.

They also foster direct relationships with consumers, enabling producers to tailor their offerings to meet market demand. However, many producers underutilize D2C channels due to logistical challenges like transportation, order fulfillment, and last-mile delivery, especially without digital infrastructure. By addressing these logistical barriers and utilizing digital tools and collaboration, D2C models can become a sustainable, scalable solution that strengthens local food systems. However, is it difficult to scale up the commercial flows (and therefore the logistics one) in a direct-to-consumer context.

- **The importance of scaling up commercial flows before the logistic ones in SFSC:** Many SFSCs encounter significant challenges in achieving scalability, primarily due to limited production and logistical capacities. Producers often struggle to expand their operations to meet the growing demands of larger buyers, such as retailers and restaurants. These challenges stem from resource constraints, including inadequate infrastructure, skills, and capital, as well as logistical inefficiencies. To overcome these obstacles, it is essential to explore innovative approaches to scaling SFSCs, such as collaborative planning and shared infrastructure, which can enhance operational efficiency and support sustainable growth. Another way is to rely on an intermediary. The scalability of the logistics flows comes after the scalability of business flows. Logistics solutions are attractive for producers when they allow them not only to downsize the cost and environmental impact of the transport but also to develop their business and find new clients. This is especially true for short food supply chains, where producers, distributors and consumers are not yet well connected. Then, it's necessary to follow the steps when setting up a logistics organization. The logistics model needs to evolve as it scales up, with the food logistics platform (food hub) as a possible last step. This last step (the optimal situation a priori) can't usually be implemented directly, as it requires a big amount of commercial flows to be viable from an economic point of view.
- **The role of the intermediaries and facilitators to scale up the logistics model:** Intermediaries (wholesalers) and facilitator (food, retailers association, marketplace, etc.) play a key role in consolidating trade flows, optimizing the logistics of short distribution circuits over the last kilometer and developing the supply of local products at affordable prices in towns and cities. They have the ressource, the knowledge and the network to make the offer meet the demand. Having intermediaries in SFSC is frequently considered as contradictory even if the definition of SFSC allows one intermediary. In any case, we can talk about local food supply chains.

- **The need of cooperation with all stakeholders in SFSC models (especially buyers):** Reducing the environmental impact and optimizing the last-mile logistics of CACPs depends directly on the ability of the stakeholders in the supply chain to cooperate, which is only possible if they see an interest in this approach for the development of their business (commercial consolidation for producers, securing and diversifying supplies for distributors). Buyers especially must be included in discussion as it is the condition to optimize the logistics (for example choosing a common delivery day).
- **The importance of the context to find the best logistics organizational model:** The case studies presented emphasize that SFSCs have multiple implementation possibilities in very different contexts and that there are many solutions to operationalise the SFSC concept. Further, recent SFSC initiatives frequently involve inadequately experienced practitioners and a deficiency in a well-established culture of scientific management and optimisation, leading to inadequate results and hindering their scalability (Bayir et al., 2022). These two elements lead to highlight the importance and necessity of a preliminary phase of context analysis prior to the development or re-engineering of a supply chain model. Indeed, the context analysis will make it possible to identify the operational and strategic choices best suited to the specific context, thus reducing the risks of failure of the project itself.
- **The necessity of support from public authorities to develop the required infrastructures and food policy:** Local authorities must play a proactive role in supporting food supply chain logistics. This includes providing financial support for low-carbon infrastructures, reducing regulatory burdens for small-scale producers, and developing urban food policies that integrate logistics hubs and micro-hubs platforms to facilitate access to local food.
- **The need of adaptation to changing urban and consumer landscapes:** As cities grow and consumer preferences shift towards more sustainable and locally sourced products, supply chain stakeholders need to adapt. This includes rethinking traditional distribution models and embracing flexible, innovative solutions such as direct sales, digital platforms, urban logistics centers, micro-hubs, new public transport services, low carbon mobility infrastructure, etc. The development of sustainable urban logistics plans is a good answer to address this challenge.
- **The need for investment in digital tools and of removing technological barriers to improve SFSC:** The growing complexity of short food supply chains requires innovative digital solutions. Tools like La Charrette and CoopCircuits, which optimize logistics and facilitate connections between supply chain actors, can greatly enhance efficiency.

More emphasis should be placed on developing interoperable systems that integrate sales, logistics, and financial management to streamline operations. Additionally the integration of digital tools and platforms for managing logistics, distribution, and sales. While the implementation of digital solutions, such as e-commerce platforms, logistics management systems, and cooperative networks, has the potential to significantly streamline processes, the scalability of these efforts is hindered by a lack of platform interoperability and limited technological infrastructure.

10. SOLUTIONS TO REPLACE FOSSIL FUELS IN TRANSPORT

Greenhouse gas (GHG) emissions from the transportation sector have increased significantly over the past decades, presenting a pressing challenge to climate neutrality goals. Freight transport, which includes the movement of agricultural products, has become a major contributor to these emissions as urban areas expand and logistical demands grow. The EU has identified transportation as a critical sector in its climate and energy policies, recognizing the need to address its dependence on fossil fuels, which accounted for nearly 93% of energy use in road and rail transport in 2021. This dependency highlights the urgency of adopting sustainable alternatives, such as electromobility and biofuels, to mitigate the environmental impact of freight and logistics systems.
Electromobility, driven by advancements in technologies such as battery electric vehicles (BEVs), hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and fuel cell electric vehicles (FCEVs), is central to achieving a transition to low-carbon transportation. These vehicles offer significant advantages in reducing GHG emissions across their lifecycle, aligning with the EU's stringent climate targets, including CO2 reduction mandates set for 2025 and beyond. Furthermore, electrification in freight systems, particularly through innovations such as retrofitting, battery swapping and the expansion of charging infrastructure, addresses logistical challenges while supporting climate objectives.

Biofuels complement electromobility by providing renewable alternatives to fossil fuels, thereby enhancing energy security and reducing emissions. Derived from various biomass sources, biofuels such as bioethanol, biodiesel, biogas, and biomethane are increasingly integrated into transportation systems. Current biofuel technologies range from first-generation fuels, which utilize food crops, to advanced biofuels produced from waste and residues. The EU's Renewable Energy Directive (RED II) provides a framework for categorizing biofuels based on their sustainability and raw material sources, driving the development and adoption of these fuels in the transport sector.

This text explores the combined potential of electromobility and biofuels to transform the transportation sector, with a specific focus on their application in agri-food logistics.

By integrating electric vehicles and renewable energy carriers into the supply chain, it is possible to reduce operational costs, enhance efficiency, and meet the rising demand for greener logistics solutions. As technologies mature and supportive infrastructure expands, the adoption of these innovations represents a pivotal step toward a sustainable and competitive transportation future.

11. ELECTROMOBILITY

With the growth of urban areas themselves and increased transport demands, freight transport, in which agricultural products play a significant role, has also increased. This inevitable intensification of flows also leads to increased effects on air quality and the environment. The forecast for the overall transportation sector according to which the transport will increase by 42% by 2050, compared to the 2016 baseline, [134] in which agro-food logistics is inherently included, presents a significant challenge for the sector. If transport growth is inevitable, it is urgent for national and local authorities, and general public itself, to find a way to reduce the sector's negative impact on climate and environment. As it is, the transport sector is among the greatest contributors to EU GHG emissions. At the core of this challenge, a promising solution is the conversion of current propulsion systems to greener ones. Currently, the most developed option is adopting the Electric Vehicles (EV) encompassing the entire sector, from public transport to private and logistics use. Electromobility is crucial to achieving the EU's climate neutrality objectives and meeting the goals of the Paris Agreement and the European Green Deal, as Electric Vehicles are from a lifecycle perspective more competitive in terms of GHG emissions than conventional vehicles. Also, due to stricter EU regulations being applied from 2025 onwards, according to EU Regulation 2019/631, new EU-wide CO2 fleet targets will be imposed: a 15% reduction by 2025 for both cars and vans, and from 2030, a 50% reduction target for vans and a 55% reduction target for cars, relative to 2021 baseline. Additionally, a zero-CO2 emission target for new vans and cars is set from 2035 onwards.[135] These goals inherently imply a major uptake in the adoption of EVs, as the most advanced form of alternative fuel vehicles.

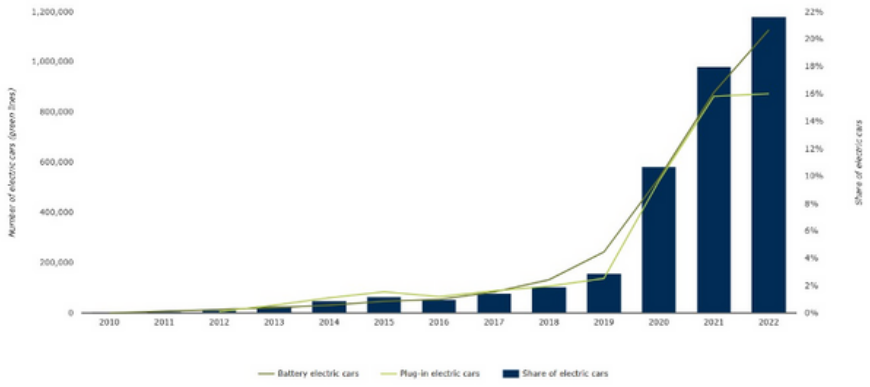


Figure 18. New registrations of electric cars, EU-27 [136]

11.1 Technologies

The development of a competitive and emission-free mobility system is essential for achieving climate neutrality. While the transition to climate-neutral mobility has already begun, the pace of this transition must accelerate. Future efforts should focus on improving system efficiency, developing batteries and energy sources for all modes of transport, and disseminating low- and zero-emission vehicles, including those powered by batteries and fuel cells. Additionally, the implementation of appropriate infrastructure is crucial. A systemic approach is required for the successful development of zero-emission mobility [137].

Electric vehicles have a great opportunity in the sector of food logistics and supply chain systems to reduce cost factor, and increase efficiency by reducing fuel and maintenance cost of the various vehicles and carriers that are used for delivery and supply. Moreover, these vehicles do not harm the environment, which is always a significant advantage when using electric vehicles [138].

Although significant advancements have been made primarily in the passenger car sector, eco-friendly options are increasingly being developed for buses and trucks. The agri-food chain is one area where electromobility vehicles can be widely applied, from agricultural machinery and warehouse vehicles to transportation between central warehouses and urban shopping centres. The development of electric vehicles (EVs) follows several directions, including battery electric vehicles (BEVs), hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and fuel cell electric vehicles (FCEVs). Electrification of public and freight transport systems is crucial for meeting climate action goals.
The successful implementation of electromobility relies heavily on the availability and accessibility of a dependable charging network infrastructure. Installing charging stations is essential to advancing electromobility, especially in countries with well-established land and marine transportation systems. One of the primary challenges in developing electromobility is the insufficient charging infrastructure.

The number of charging outlets and high-speed charging stations is currently inadequate to meet the demand for EV charging. This lack of infrastructure deters potential users due to the limited availability of charging stations. Therefore, expanding the charging infrastructure network to support the widespread adoption of electromobility must be incorporated into national development plans [139].

The transition to a competitive and emission-free mobility system is a key component of achieving climate neutrality. By focusing on system efficiency, developing batteries, disseminating low- and zero-emission vehicles, and implementing necessary infrastructure, a systemic approach can drive the successful development of zero-emission mobility. Electromobility, particularly through the adoption of innovative charging technologies and the expansion of charging infrastructure, plays a pivotal role in this transition.

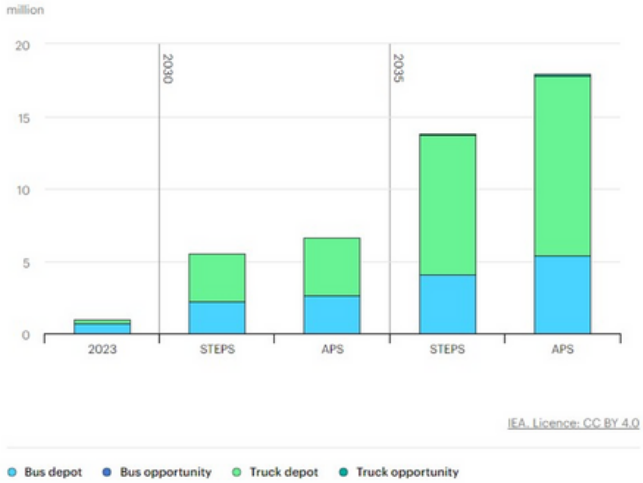


Figure 19. Heavy-duty charger stock in the Stated Policies and Announces Pledges Scenarios, 20232025 [140]

11.1.1 Battery electric vehicles (BEV)

Battery Electric Vehicles, also called BEVs or frequently simply as EVs, are fully electric vehicles with rechargeable batteries without any gasoline engine. All energy to run the vehicle comes from the battery pack which is recharged from the grid. BEVs are zero-emissions vehicles, as they do not generate any harmful tailpipe emissions or air pollution hazards caused by traditional gasoline-powered vehicles.

The demand for the transport of goods within the city is rising which also increases the number of vans and trucks driving around. This has adverse effects on air quality, noise, safety and liveability in the city. LEFVs (Light Electric Freight Vehicles) offer a potential solution for this. Moolenburgh et al. [141] made practical multiple case study in Netherlands, which showed that city logistics with LEFVs require good locations for hubs in the distribution network, robust processes, cooperation between customers, logistics service providers and suppliers, good insight into costs involved, modern Information and communication technologies and good organization.

LEFV is usually a solution alongside other solutions. A mixed fleet guarantees flexibility and offers certainty that customer demand can be met. Not all shipments lend themselves to the profitable use of a LEFV. In addition, planning and control systems must be able to distinguish between the different loading capacities of the available vehicles: which consignments should go in which vehicle? And which routes are ideal for which vehicle? Transshipment points must be located close to or inside the city. The further the distance to transshipment points, the less suitable LEFVs become. For trips with long initial distances (more than 5km to the first stop) and long journeys (more than 30 km), the LEFV is often not an appropriate option.

Heavy-duty vehicles are a major contributor to CO2 emissions in the transportation sector, and it is necessary to develop clean and green technologies to replace diesel trucks. In the EU, heavy-duty vehicles (HDV) including trucks, city buses, and long-distance buses generate over 25% of GHG emissions from road transportation, and they make up more than 6% of the total GHG emissions in the region. These emissions have been steadily rising, particularly in the field of freight transport. Acceptance is a key success factor for new technology and the implementation of policy objectives. Currently, heavy trucks highly depend on diesel fuel. It is an open race as to which alternative power source for HDV will be used in the future. The major truck manufacturers have developed electric versions of even the largest articulated semi-trucks, and new companies, which are specialized in e-trucks, are entering the market [142].

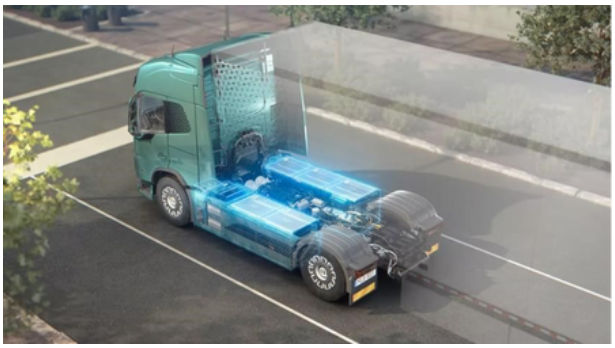


Figure 20. A heavy-duty electric truck with shown batteries by Volvo [143]

Bergqvist et al. [144] conducted research about the accelerating process of EV take-up in the transport and logistic chain. The results show that it would be possible to switch at least 50% of trips to Battery electric heavy duty trucks immediately, saving approximately 13,000 tonnes of CO2 annually at one location, and this figure could rise to 75% in a couple of years as battery capacity increases and more fast chargers are available.

Data were collected from an entire fleet of 21 trucks serving a terminal over a full year. The study concludes that the pre and post haulage intermodal container market is ideal for early adoption of Battery electric heavy duty trucks, due to the short-medium distances per trip, several round trips to and from the terminal where the chargers are located, and sufficient waiting time during loading and unloading to charge the vehicles without impacting vehicle productivity.

Although BEV vehicles are not yet a common occurrence in the agri-food logistic chain, there are numerous solutions that can encourage their introduction. One such solution is battery swapping. Ouyang et al. [145] demonstrated in their research that battery swapping improves transportation efficiency for electric heavy trucks compared to charging. Charging and battery swapping have better economics under different recharge distances. Their study shows that the optimum recharge distance for the battery swapping mode is 156 km. Battery swapping is the most cost-effective energy supply mode for electric heavy trucks when the station utilization rate is higher than 43% and the vehicle operation speed is higher than 32 km/h. This mode is also superior to diesel heavy trucks, and the optimum area for battery swapping will be further expanded with improvements in battery technology and increases in traffic density in the future.

11.1.2 Hybrid electric vehicles (HEV)

Hybrid Electric Vehicles (HEVs) feature both a gasoline engine and an electric motor to power the car. The battery's energy is obtained through regenerative braking, which captures energy typically lost during braking to help the gasoline engine during acceleration. In conventional internal combustion engine vehicles, this braking energy is usually dissipated as heat in the brake pads and rotors. Standard hybrids cannot be recharged by plugging into the grid and are not compatible with EV charging stations.

While electric trucks are not sufficiently developed alternative to diesel trucks, another type of truck could help reduce their fossil fuel consumption. A hybrid engine could significantly reduce diesel consumption, while offering a longer range than an all-electric engine. There are two possible configurations for HEV transport vehicles:

- Parallel Hybrid System: In a parallel hybrid system, the ICE and electric motor can both power the truck independently or work together.

This allows the truck to utilize its electric motor for low-speed driving and regenerative braking, improving fuel efficiency.

- Series Hybrid System: In a series hybrid system, the ICE generates electricity to power the electric motor, which in turn propels the vehicle. This system allows for greater fuel economy, but it may not be as powerful as a parallel hybrid system.

Below are some of the studies comparing HEV trucks with diesel trucks in freight transport.

Diesel-electric hybrid trucks, which played a crucial role in electrifying passenger vehicles, have received limited attention from European truck manufacturers. Fregonese et al. [146] conducted a study that examines the potential and economic viability of hybrid trucks in Europe. Using Amesim® software and its Hybrid Optimization Tool, researchers built and simulated a multi-physical model of a real hybrid electric truck operating in urban delivery with a gross vehicle weight exceeding 16 tons. The results indicate that the simulated diesel-electric hybrid truck achieves a 47% improvement in fuel economy and reduces CO2 emissions by approximately 41% compared to the diesel truck for urban applications. Moreover, the economic analysis reveals that hybrid trucks were already economically viable in 2022, with a total cost of ownership 15% lower than diesel trucks. This cost advantage is expected to increase to 23% by 2030. In conclusion, Diesel-electric hybrid trucks present a feasible and economically viable solution to reduce CO2 emissions in urban delivery applications.

Zacharof et al. [147] investigated the CO2 reduction potential of powertrain hybridisation on heavy-duty trucks and city buses. The results reveal distinct trends for each vehicle type and architecture. In trucks, more significant improvements are observed in urban delivery profiles, reaching up to ~16%, indicating the benefits of hybridisation in transient conditions with energy recuperation opportunities. City buses, particularly those with serial architectures, exhibit significant emission reductions that reach 36%, making them suitable for urban environments. The optimisation of electric motor size and performance plays a crucial role in achieving emission reductions, while battery capacity must be carefully considered to avoid adverse effects.

In terms of market, environmental, and human health impacts, as well as society's travel needs, light-duty vehicles (LDV) are the leading road transport means when compared to other transport means (more than 80% of the total fleet), such as buses (that exceed 3.5 tons) and heavy-duty vehicles (HDV), e.g., trucks.

In this study, Machedon-Pisu et al. [148] have assessed the impact of the most exploited resources available to LDVs in terms of storage and travel demands. The demand forecast was correlated with the GDP, population, and LDV sales and production for the 2020–2050 period. An important aspect that was highlighted in this paper, and that should always work in conjunction with such smart networks based on IoT, is the necessity to charge and store the energy in an effective way. The dependence on energy and raw materials, which was addressed herein, will become more and more demanding in the evolution of LDVs. The energetic challenge also refers to finding new energy management solutions that include the development of communication protocols. The parameters considered are related to the energy and power capabilities of vehicles. Strictly related to the storage of energy, new features such as intelligent power control will facilitate the implementation of heterogeneous solutions such as Hybrid Energy Storage Systems (HESS). Because no single storage device can perfectly fit the applications' requirements, electric hybrid storage solutions were developed. This implies the use of, at minimum, two different storage cells or storage device-like supercapacitors, batteries, and fuel cells. Such solutions will increase the overall lifespan of the vehicles' energetic sources, improving not only the energy efficiency, but also allowing a more efficient usage of raw materials for developing the new transport means.

11.1.3 Plug-in hybrid electric vehicles (PHEV)

Plug-in Hybrid Electric Vehicles (PHEVs) combine an engine and an electric motor to power the vehicle. Similar to regular hybrids, they recharge their battery through regenerative braking. However, PHEVs have a significantly larger battery and can be plugged into the grid for recharging. Once the electric range is exhausted, PHEVs operate like regular hybrids and can cover several hundred miles on a full tank of gasoline. All PHEVs can be charged, but most are not equipped for fast charging.

The main difference between PHEVs and HEVs is that the former has a rechargeable battery. PHEVs can be powered by an engine or electric motor and can drive electrically for moderate distances.

Before delving into scientific research on the performance and advantages of PHEVs compared to other vehicles serving in the same transport chains, it is important to mention Scania. Scania is a European manufacturer of transport vehicles. The company's portfolio includes trucks and buses for heavy transport applications, supported by a comprehensive range of product-related services.

Scania's sustainability efforts are centered around three interconnected priorities: people sustainability, decarbonization, and circular business. Scania produces "domestic trucks from Europe" and offers a range of HEV and PHEV trucks. These Hybrid and Plug-In Hybrid trucks combine the strengths of both electric and traditional combustion engine powertrains, resulting in vehicles capable of running emission-free when needed while maintaining the extended range achievable with biodiesel. This is important to highlight because, in addition to the EU's policies promoting a green transport sector, it provides an excellent example proven on a global scale [149].



SCANIA

Figure 21. Scanias BEV, HEV and PHEV trucks, Scania logo [149]

Xu et al. [150] analyzed the environmental and economic performance of internal combustion engine vehicles, HEVs with different hybridization factors, and PHEV trucks with different battery capacities based on the case of China from 2020 to 2040 by comparing the indicators of wheel-to-wheel CO2 emissions and total cost of ownership. It was found that hybrid electric trucks with high hybridization factors perform best. In the future, plug-in hybrid electric trucks with large batteries will perform best over short distances. Conversely, plug-in hybrid electric trucks with small batteries will be the best for medium and long distances. This is mainly due to the increasing proportion of green electricity and decreasing charging prices.

The research encompassing geographical factors and PHEV vehicles in freight transport was conducted by Limataien et al. [151]. In this study, a geospatial data analysis approach was applied using a battery electric vehicle potential (BEVPO) model with datasets from road freight transport surveys to analyze the potential for large-scale BET adoption in Finland and Switzerland for trucks with a gross vehicle weight (GVW) of over 3.5 tons.

The results show that trucks with payload capacities up to 30 tons have the most potential for electrification by relying on the currently available battery and plug-in charging technology, with 93% (55% tkm) and 89% (84% tkm) trip coverage in Finland and Switzerland, respectively. Electric road systems would be essential for covering 51% of trips (41% tkm) of heavy-duty trucks heavier than 30 tons in Finland. Furthermore, range-extender technology could improve the trip electrification potential by 3–10 percentage points (4–12 percentage points of tkm).

11.1.4 Fuel-cell electric vehicles (FCEV)

Fuel Cell Electric Vehicles (FCEVs) represent the cutting edge of electric vehicle technology. These vehicles use a fuel cell, typically powered by hydrogen, to generate electricity. The only by-product of this process is water vapor. Similar to plug-in hybrids, FCEVs have batteries that store energy produced by the fuel cell. As hydrogen-powered vehicles, FCEVs are entirely emission-free.

Currently, a fully operational transport and logistics chain comprising 100% FCEV (Fuel Cell Electric Vehicle) light and heavy trucks does not yet exist. Nonetheless, numerous pilot projects have been initiated, and extensive research and studies have been conducted. Below, some of these studies will be highlighted. But first, a brief overview will be provided of what constitutes a freight vehicle used in agricultural or other logistics chains.

Every FCEV used in transport and logistics must have components characteristic of FCEV vehicles, which include:

- High power batteries: In a fuel cell electric powertrain, the battery provides power delivery and regenerative braking acceptance, so power density for both charge and discharge is critical. The battery is carefully managed within the system, operating between 40% to 80% State-of-Charge (SoC) in micro-cycling mode so deep discharge cycles are rare.
- Fuel Cell: A key requirement of fuel cells for heavy-duty vehicles is lifetime in operating hours. For example, a bus will do 5,000 hours per year and have a lifetime of 15 years and a refuse collection vehicle will operate for 3,000-4,000 hours a year with a 10-year life span. This can be achieved through a combination of design for long lifetime, operating mode and replacement or refurbishment aiming to minimize total cost of ownership. For road vehicles power requirements are in the range of 50kW-250kW.
- Hydrogen Storage: The requirement is to maximize hydrogen storage while minimizing tank weight, volume and cost. For Arcola Energy's powertrain platform, and for heavy-duty FCEVs in general, the current standard for is 350

- bar tanks, either Type 3 or Type 4. To maximize hydrogen storage these tanks are generally large: 2-3m in length and with an external diameter of at least 400mm. In the longer term, technology improvements may allow the use of 500bar and 700bar tanks for heavy-duty vehicles, and liquid or cryo-compressed hydrogen storage are also future possibilities.
- Power Electronics, Motors and Drives: Fuel cell electric powertrains have some specific requirements and also a number of common elements with other electrified heavy-duty vehicles. There are opportunities in each of these areas and also in the integration of components to reduce part count and improve efficiency. The critical components identified include Fuel Cell DC-DC, Electric drive and Aux power supply high voltage to low voltage [152].

Grahle et al. [153] examined battery electric and fuel cell electric drive technologies with the objective of investigating their decarbonization effects on urban freight transport. Internal combustion engine vehicles (ICEV) operated with diesel provided the base case. Food retailing in Berlin served as a use case. Considering today's technology and fuel prices, a transition from ICEVs to BEVs would increase costs by 23%. A change to FCEV has more than twice the increase with 57%. In the considered future cases with lower fuel and technology prices BEVs are 17% higher compared to the base case. The transition to FCEVs is with 22% higher costs compared to the base case, still more expensive than BEV but the difference is smaller. When the transition to locally emission free trucks is considered today and today's electricity and hydrogen mixes should be used, FCEVs hold the potential to reduce GHG emissions by 33%. This way, they outperform BEV, which would only achieve a reduction of 25% compared to the base case.

Xun et al. [154] performed a study that forecasts regional FCV supply chain development by taking China as the example. The supply and demand trends of commodities in the regional FCV supply chain were modeled. The results show that with peak annual demands for vehicle-use fuel cells of China growing to 350–600 GW in the coming decades, the country will likely face the challenges of high import dependence (>50%) on upstream advanced technology commodities, uncertain degree of FCV market penetration and a huge annual platinum demand up to 86 t. To cope with these challenges and improve the FCV supply chain sustainability, China needs to enhance industrial competitiveness in the upstream supply chain with priority, prepare the whole FCV supply chain in a highly elastic way, and reduce the dependence on imported platinum by improving the end-of-life recycling rates of platinum and increasing imports of platinum-containing scraps.

With proper measures taken, China's FCV supply chain has the potential to evolve in a sustainable way and support the low-carbon transition of the transport sector.

Morrison et al. [155] estimated battery electric (BEV) and hydrogen fuel cell electric vehicle (FCEV) costs from today through 2040 to explore the potential market size of each vehicle type. Two main tasks are performed. First, the total cost of ownership (TCO) – including vehicle purchase, fuel, maintenance, resale, and refueling inconvenience – is estimated for 77 light-duty vehicle (LDV) segments, defined by driving range and size class. Second, data on individual travel behavior is used to estimate the fraction of vehicle owners within each of the 77 segments. The paper finds that BEVs maintain a strong cost advantage over FCEVs today, but the cost advantage quickly diminishes by 2030, driven largely by the sharp cost reductions in FCEVs relative to those of BEVs. This is modeled to occur as greater numbers of FCEVs are deployed and the presumed early-stage technology learning occurs for FCEVs as it has for BEVs. By 2030, the LDV market is split, with roughly one half of segments being competitive for FCEVs and the other half for BEVs. As FCEVs continue to decline in cost, they become the lower cost option in the majority of vehicle segments.

11.2 Good practices in partner countries in agro-food logistics

Table 2. Good practices of Kamenitza AD

Title of best practice	Good practices of Kamenitza AD
Location	Kamenitza operates mainly in Bulgaria with a brewery located in Haskovo, a microbrewery in Plovdiv, and its central office in Sofia. Additionally, the company has 17 commercial offices across the country, ensuring a widespread presence. The transportation network includes a logistics base in Haskovo and a well-established distribution system to efficiently manage the supply chain.
Short description	The company is committed to sustainability and has integrated electromobility into its operations. Kamenitza uses electric vehicles for local deliveries to reduce carbon emissions and enhance environmental sustainability. The company's logistics base in Haskovo and its extensive distribution network across Bulgaria are supported by a fleet that includes electric vehicles, ensuring efficient and eco-friendly transportation of their products. This initiative aligns with Kamenitza's strategy to minimize its environmental footprint and promote green energy solutions within its supply chain.

Long description	Kamenitza's approach to electromobility involves the integration of electric vehicles (EVs) into their distribution network to enhance sustainability and reduce carbon emissions. This initiative includes the procurement of electric delivery trucks, specifically designed for efficient urban logistics. The company has also established charging infrastructure at key logistics centers to support these vehicles, ensuring minimal downtime and operational efficiency.
Relevant images	
Progress status	Completed
Key benefits/outcomes	Kamenitza's implementation of electromobility solutions has yielded significant benefits. The use of electric vehicles (EVs) for local deliveries has markedly reduced the company's carbon emissions, contributing to environmental sustainability. This transition has also optimized delivery routes and lowered fuel costs, enhancing operational efficiency. Additionally, Kamenitza's commitment to sustainable practices has bolstered its brand image, attracting eco-conscious consumers and fostering customer loyalty.
References	Kamenitza AD ESG report [156] Kamenitza AD web page [157]

Table 3. Good practices of Carlsberg Group

Title of best practice	Good practices of Carlsberg Group
Location	The Carlsberg Group implemented several best practices across various territories, with a strong focus on the EU. In Western Europe, the Group sourced 100% renewable electricity for all breweries, contributing significantly to their sustainability goals. They also introduced regenerative farming practices in the UK, working with new partner farmers, and conducted

	grain quality assessments in Denmark to support sustainable agriculture. Additionally, inclusive leadership training and coaching were piloted in the EU, led by external experts to promote diversity and inclusion.
Short description	The Carlsberg Group is advancing its commitment to electromobility as part of its sustainability efforts. In 2022, the Group expanded its fleet of electric vehicles and piloted several initiatives across Europe and Asia. In Switzerland, Carlsberg's fleet of 20 electric delivery trucks completed their first full year of operation, driving approximately 271,349 kilometers and preventing nearly 190 tonnes of CO2 emissions compared to diesel trucks. In the UK, the company began trialling two electric road trucks for secondary distribution on urban routes.
Long description	The Carlsberg Group is significantly advancing its electromobility initiatives as part of its comprehensive sustainability strategy, which aims to achieve a net-zero carbon footprint across its operations. These initiatives span multiple territories, focusing on the deployment of electric vehicles (EVs) and the integration of sustainable transport solutions throughout the value chain. In Bulgaria, Carlsberg has taken concrete steps towards integrating electromobility within its operations. The company's initiatives include the introduction of electric delivery trucks and the installation of necessary charging infrastructure to support the transition. This move aligns with Carlsberg's broader strategy to reduce emissions and promote sustainable practices across all its markets. By focusing on electrification, Carlsberg Bulgaria is not only contributing to the Group's global sustainability goals but also setting an example for other businesses in the region to follow. The shift towards electromobility also extends to warehouse operations. At Carlsberg's Kuala Lumpur site in Malaysia for example, all 18 forklift trucks were converted from LPG to electric, resulting in an annual saving of 194 tonnes of CO2. Additionally, new charging facilities were installed at their largest warehouse in Poland, facilitating the broader adoption of electric forklift trucks. Globally, Carlsberg now operates 2,046 electric forklifts, which constitute 71% of its forklift fleet. A new tendering approach requires forklift suppliers to demonstrate ongoing emissions reductions, further promoting sustainability in warehouse operations.

Relevant images	
Progress status	In progress
Key benefits/outcomes	The Carlsberg Group's implementation of electromobility has yielded significant benefits and outputs, demonstrating their commitment to sustainability. Key benefits include substantial reductions in carbon emissions, enhanced operational efficiency, and strengthened sustainability credentials. In Switzerland, the fleet of 20 electric delivery trucks prevented nearly 190 tonnes of CO2 emissions in their first year. Similarly, electrifying transport in Sweden cut emissions by 80 tonnes annually, and converting warehouse forklifts to electric in Malaysia saved 194 tonnes of CO2 per year. These initiatives not only lower the company's carbon footprint but also optimize logistics and warehousing processes. Testimonials from partners, such as Einride in Sweden, highlight the collaborative effort to reduce transport emissions by 93% compared to diesel. This best practice demonstrates Carlsberg's proactive approach to sustainability, setting a benchmark in the brewing industry and inspiring broader adoption of green technologies.
References	Carslberg Bulgaria web page [158] Carslberg Bulgaria ESG report 2022 [159]

Table 4. Agios Efstratios - Green Island in Greece

Title of best practice	Agios Efstratios - Green Island in Greece
Location	A small island on the edge of the northeastern Aegean Sea. Agios Efstratios or Ai Stratis is an island with 257 inhabitants according to the 2021 census. Administratively it belongs to the regional unit of Lemnos of the North Aegean region. During the 20th century it was used as a place of exile for leftists.

	The phenomenon peaked during the dictatorship of Ioannis Metaxas (1936-41), when hundreds of opponents of the regime were displaced there.
Short description	With 85% of the energy deriving from wind turbines and photovoltaics, Ai Stratis of about 250 inhabitants will be the first and only energy-autonomous island in Greece so far.As part of the Project, the basic infrastructure for the use of electric vehicles is being created. The use of the vehicles is done by creating the appropriate infrastructure for an integrated vehicle charging station, which can also cover their possible extensive use on the island in the future.
Long description	With combination of various energy needs, very high RES penetration in the electrical systems of autonomous NII islands could be achieved, provided that simplified energy management strategies are adopted. To demonstrate the technical and economic feasibility of this concept, CRES is currently implementing a pilot project in Agios Efstratios. The integrated system consists of: • A RES hybrid power station (wind and solar) 1,0 MW/3,0 GWh annual potential output and 1,0 MW/2,5 MWh Battery Energy Storage (BESS) • A district heating system from the curtailed RES energy, consisting of 800 kWth power-to-heat plant, 500 m3 thermal storage tank (=25 MWhth at ΔT=55o C) and a distribution network for the entire settlement. The new hybrid system should have the capability to feed the island's grid, in both islanded and parallel operation with the PPC power station, which will still remain on standby.
Project full title/ acronym	Program National Strategic Reference Framework 2014-2020 (Beneficiary: Municipality of Agios Efstratios, Implementation: CRES)
Funding programme	European Regional Development Fund (ERDF)
Project target	Main target >85% RES penetration in electricity/heating
Project budget	Total budget 8,5 M€ incl. VAT

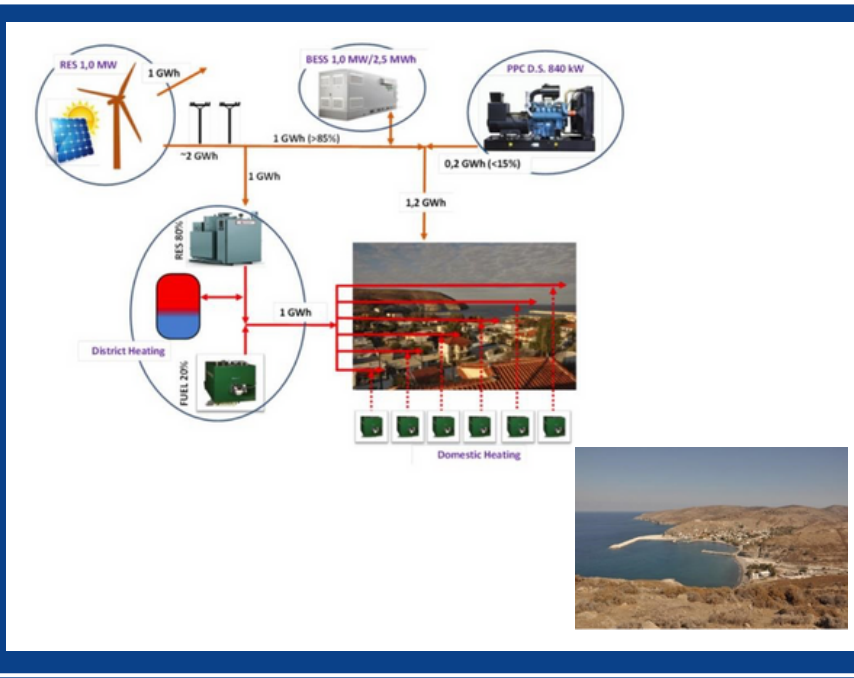
Relevant images	
Progress status	In progress
Key benefits/outcomes	• "One (1) cargo vehicle with box wagon (trolley) - commercial (use by the local authority) • One (1) vehicle, bus type, with a place for disabled persons • Two (2) electric scouters with four (4) safety helmets • Seven (7) electric bicycles with seven (7) safety helmets • A charging station is constructed with the installation of a photovoltaic system in a shelter. "
References	Aistratis as a green island [160]

Table 5. Increase Of Energy Efficiency By Electric MOBIlity In The CITY - EMOBICITY

Title of best practice	Increase Of Energy Efficiency By Electric MOBIlity In The CITY - EMOBICITY
Location	The EMOBICITY project is a European Union project implemented in five member countries: Croatia, Greece, Germany, Romania, and Portugal.
Short description	EMOBICITY aims to strengthen the capacities of all key-stakeholders on e-mobility, especially regarding policy making, through workshops, study visits and peer reviews, as well as to raise public awareness by open campaigns and other communication activities.

	EMOBICITY supports policy learning on e-mobility at a national and regional level, by the exchange of experience, between the project partners, policy and decision makers and other project stakeholders from the EU participating countries.
Long description	EMOBICITY aims to strengthen the capacities of all key-stakeholders on e-mobility, especially regarding policy making, through workshops, study visits and peer reviews. For this reason, the project provides workshops, study visits and other activities, bringing together all key players for discussions and brainstorming, highlighting relative good practices. By this way, EMOBICITY generates high leverage and provide action plans for the improvement of the policy instruments addressed by the partnership, proposing enrichments and amendments, leading to increased e-mobility integration, thus contributing to a low-carbon economy. The following enhancements and innovations are examined during the project, to be included in policy instruments: • Legislative amendments to overcome current obstacles for e-mobility integration • Improvement of Charging/Taxation Models - Energy price for charging • Specialized Regional policies for the development of e-mobility • Promotion of e-mobility in low integration fields • Integration of incentives in policy instruments to stimulate e-mobility by private users • Inner city logistics and autonomous driving • Integration of RES in the energy mix for EV charging
Project full title/ acronym	Increase of energy efficiency by Electric MOBIlity in the CITY - EMOBICITY
Funding programme	Interreg Europe, 08/2019 - 07/2023
Project budget	Total budget 1.071.804€
Releveant images	

Progress status	Completed
Key benefits/outcomes	• Workshops, study visits and other activities, bringing together all key players for discussions and brainstorming • Highlighting relative good practices • Providing action plans for the improvement of the policy instruments addressed by the partnership, proposing enrichments and amendments.
References	EMOBICITY project page [9]

Table 6. The Port Valencia, an example of sustainability

Title of best practice	The Port Valencia, an example of sustainability
Location	Valencia
Short description	The 100% electric truck is already on the move in the Port of Valencia
Long description	A new milestone in the decarbonisation of Valencia port, on this occasion carried out by companies from the port community. The first test in a Spanish port of a 100% electric truck for heavy transport in container loading and unloading operations has been carried out on the quays of the Port of Valencia. Zero emissions, silent and totally electric, it has shown the autonomy and the loading and use capacity of this new milestone in the Port of Valencia. The firm Volvo and the Valencian company Grupo Torres have subjected a 100% electric HGV to port requirements in a Spanish port area to carry out the test with real journeys and goods in the Port of Valencia. With a range of 300 kilometres, this electric vehicle, developed to minimise CO2, noise and air pollution, has been a real success, loading a container at the port terminals and taking it to its destination. A test that shows the commitment of the companies of the port community to decarbonisation and the fight against climate change in all the activities that take place in the port areas. The future is ever closer and the commitment of the sector is clear.
Relevant images	

Progress status	In progress
References	Port of Valencia web page [161]

Table 7. Zero emissions electric bus operate in Valencia

Title of best practice	Zero emissions electric bus operate in Valencia
Location	Valencia
Short description	Valencia's Municipal Transport Company has unveiled the first zero emissions electric bus to join its fleet whitch will operate in the centre of the Valencian capital
Long description	The Irizar ie bus, Irizar's 100% electric zero emissions bus and anotheer 35 hybrid technology units, was unveiled by Major of Valencia. The excellent results of the tests carried out in Valencia led to the purchase of an Irizar ie bus along with a slow in-depot charging system. The Irizar ie bus is a 12-metre long vehicle with three access doors, capacity for 76 passengers and a range of over 200 km. It includes the "Eco Assist" system, whitch assists the driver in real time with a view to optimising driving, reducing energy consumption and increasing the bus's range.
Relevant images	
Progress status	In progress
References	Irizar zero emission bus in Valencia [162]

Table 8. The first fully electric truck in Croatia (Lidl Croatia)

Title of best practice	The first fully electric truck in Croatia (Lidl Croatia)
Location	The first fully electric truck has been implemented in Zagreb County; more precisely, it will transport goods in the logistics chain between the central warehouse in Jastrebarsko and Lidl stores in Zagreb. This is the first fully electric truck in Croatia, but it is not the only one for Lidl. Lidl has also introduced fully electric trucks in other countries where it operates, such as Romania, the Netherlands, Ireland, France, and many others.
Short description	By introducing the first fully electric truck, Lidl Croatia has once again proven its commitment to sustainable business practices. Lidl Croatia implemented this innovation in collaboration with Volvo, specifically Volvo Trucks.
Long description	Other retail chains, both domestic and international, should look to Lidl as a role model. It is important to note that Lidl has introduced a strategy in which it committed to reducing its CO2 emissions by 80% by 2030 compared to 2019. The Volvo FE Electric, with a maximum allowable mass of 28 tons and a payload capacity of over ten tons, can travel up to 250 km on a single charge, depending on the intensity of the operation of the cooling unit, which is also completely emission-free and powered by the vehicle's drive batteries. In one day, the vehicle can supply two stores in Zagreb and return to the central warehouse in Jastrebarsko. Additionally, the electric-powered truck with cooling is very quiet, which is an added benefit for working in the city center, as stores are usually supplied at night or very early in the morning.
Relevant images	 
Progress status	In progress

Key benefits/outcomes	A key benefit, in addition to reducing CO2 emissions, is serving as a role model for other retail chains in Croatia, both domestic and international. For legislators, Lidl serves as an indicator that progress and modernization are possible, setting an example that can be used to demand fleet modernization from others as well. This should start with the transportation chain and extend to other related chains, including the agri-food logistic chain.
References	Lidl press release about Croatia's first fully electric truck [163] Volvo press release about Volvo's first fully electric truck in Croatia [164] Volvo electric trucks fleet [165]

Table 9. ENERMOB

Title of best practice	ENERMOB
Location	The project was implemented in the following territories: Municipality of Ragusa, Italy (lead partner), County of Primorje and Gorski Kotar, Croatia; Tripoli, Greece; Nova Gorica, Slovenia; Kragujevac, Serbia.
Short description	As part of the EnerMOB project, small-scale electromobility network was developed in the form of 3 AC charging stations (2 x 22 kW AC) for electric vehicles in County of Primorje and Gorski Kotar.
Long description	ENERMOB involves mainly regional and local authorities that can plan and implement pilot actions and small-scale investments. Specific object was to enhance capacity for integrated transport and mobility services and multimodality in the Adriatic-Ionian area. Three AC charging stations have been installed and are operating in attractive tourist and traffic locations in Rijeka International Airport, Municipality of Fužine and in the port Melak on Island Rab. All three charging stations can be used 24 hours a day, 7 days a week and are free for all the users. It is only necessary to connect with the appropriate cable. Within the project The County of Primorje and Gorski Kotar also carried out testing of the existing and newly installed infrastructure for electromobility in the County with electric vehicle VolksWagen e-UP.
Project full title/ acronym	Interregional Electromobility Networks for intERurban low carbon MOBility - ENERMOB
Funding programme	Interreg ADRION
Funding programme	https://enermob.adrioninterreg.eu/

Relevant images	 
Progress status	Completed
Key benefits/outcomes	Expanding the infrastructure of electric vehicle chargers paves the way and enables the introduction of electric vehicles into the transportation chain, even in less urban areas.
References	EnerMOB project page [166]

Table 10. Sustainable Port of Bar through EnerNETMob and SuMo projects

Title of best practice	Sustainable Port of Bar through EnerNETMob and SuMo projects
Location	The EnerNETMob project is implemented in Greece, Malta, Italy, Cyprus, Albania, Croatia, Slovenia, Portugal, Montenegro, Spain, France, and Austria. The SuMO project involed activities in Italy, Albania and Montenegro (Bar).
Short description	Through the implementation of EnerNETMob project Port of Bar procured BEV and installed a fast charging station and through SuMo project hybrid bus for users in free zone of the port is to be procured. With help of these projects Port of Bar intends to promote EU values in terms of sustainable transport solutions, less air pollution, environmental protection, etc. "EnerNETMob" project is funded by the Interreg Mediterranean Transnational Cooperation Program (MED 2014-2020). SuMo project is funded by the Instrument for Pre-Accession Assistance (IPA II) and the countries of the Programme (IPA CBC Italy-Albania-Montenegro Programme).
Long description	A notable best practice in electromobility from Luka Bar, Montenegro, involves the acquisition and integration of electric vehicles to promote sustainable transport and reduce CO2 emissions. Through the "EnerNETMob" project, funded by the

	Interreg Mediterranean Transnational Cooperation Program (MED 2014-2020), Luka Bar has introduced a Nissan Leaf electric vehicle for port operations. This initiative not only demonstrates a commitment to reducing the environmental footprint of port activities but also sets a precedent for other local authorities and organizations. The project included training for staff on the use and maintenance of electric vehicles and explored innovative financing mechanisms to sustain and expand the use of electromobility solutions. Luka Bar, as part of the SuMO project, has integrated a hybrid bus (SOLARIS Urbino 12 mild) into its operations. The hybrid bus is used for transporting workers and visitors within the port, replacing the need for hundreds of private cars, thus significantly lowering the port's carbon footprint. The project also includes capacity-building activities and explores innovative financing mechanisms to ensure sustainable development and environmental protection in port operations. In 2023, 444 electric vehicles were registered in Montenegro, according to the Ministry of Internal Affairs of Montenegro. The barriers to further expansion of e-mobility in Montenegro lie in the insufficiently developed network of chargers and the limited availability of electric vehicles on the market.
Project full title/ acronym	1. EnerNETMob - Mediterranean Interregional Electromobility Networks for Intermodal and Interurban Low Carbon Transport Systems 2. SuMO - Sustainable Mobility in the Port Cities of the Southern Adriatic Area
Funding programme	1. Interreg Mediterranean Transnational Cooperation Programme (MED 2014-2020) 2. Instrument for Pre-Accession Assistance (IPA II) and the countries of the Programme (IPA CBC Italy-Albania-Montenegro Programme).
Project website	1. https://www.enernetmob.eu/ 2. https://sumo.italy-albania-montenegro.eu/home
Relevant images	

Progress status	Completed
Key benefits/outcomes	Luka Bar in Montenegro has pioneered sustainable transport through the SuMo and EnerNETMob projects, benefiting from significant CO2 emissions reductions, cost savings, enhanced public image, increased operational efficiency, and improved staff training and capacity building.
References	SuMo project web page [167] EnerNETMob web page [168]

Table 11. Public Utility Company Zelenilo

Title of best practice	Public Utility Company Zelenilo
Location	Podgorica, Montenegro
Short description	Public Utility Company Zelenilo in Podgorica upgraded its fleet with three MG MG4 STANDARD electric vehicles and a Renault Traffic Furgon, enhancing sustainable mobility.
Long description	Public Utility Company Zelenilo has prioritized eco-friendly electric vehicles in its fleet renewal, adding three MG MG4 STANDARD electric cars and a Renault Traffic Furgon. These vehicles will streamline operations, improve efficiency, and save costs in the long term while protecting the environment. This initiative aligns with the company's commitment to sustainable energy sources and environmentally friendly practices, reflecting a significant move towards enhancing electromobility and sustainability in its operations. Zelenilo Podgorica focuses on maintaining public green spaces, designing, constructing, and arranging green areas, nursery production, and providing services to third parties.
Funding programme	Supported by Eco Fund of Montenegro
Relevant images	

Progress status	Completed
Key benefits/outcomes	Improved operational efficiency, cost savings, reduced environmental impact.
References	Public Utility Company Zelenilo web page [169]

Table 12. Synchronicity creates cooperative logistic flows serving sustainable cities

Title of best practice	Synchronicity creates cooperative logistic flows serving sustainable cities
Location	Marseille (France)
Short description	Synchronicity aims to create shared collection systems for waste from artisans and merchants using cargo bikes with or without electrical assistance to ensure decarbonized logistics flows inside the city.
Long description	The project operated by Synchronicity has been funded in France, by both the Region Sud (Provence Alpes Côte d'Azur) and the French national Agency for the Environment and Energy Management (ADEME), through the 2023 regional programme dedicated to low carbon logistic. The regional public authorities support the emergence and testing of sustainable and responsible transport solutions for goods. The project will allow the evolution of logistics chains towards more collaborative models, through the logic of pooling, short circuits or even the circular economy. In doing so, this project includes a component dedicated to raising awareness, training professionals and support social jobs.
Relevant images	
Progress status	In progress

Key benefits/outcomes	Synchronicity will develop and test an app called "COLICOURT" to allow local business stakeholders to organize short circuits for their collections and deliveries inside the city. One person's waste can become another's resource. The creation of a digital platform will respond to the need to provide tools for data collection and flow analysis aimed at optimizing reverse logistics circuits, measuring air quality, and generating interactions between the different stakeholders. This platform will also provide a political decision support system on priorities for equipment and development of cycling infrastructure in dense urban areas.
References	Synchronicity company web page [170]

Table 13. Ultra-fast charging station for electricity-powered trucks serving agri-food industry

Title of best practice	Ultra-fast charging station for electricity-powered trucks serving agri-food industry
Location	Nice (France), national and international growth
Short description	Chargepoly is an international technology and engineering company specializing in high-capacity battery charging for medium and heavy-duty vehicles, particularly in logistics warehouses.
Long description	The Chargepoly's solution has been evaluated by the Capenergies' labelling committee in 2019. This independent body made up of experts from the industry, research, education and finance sectors examine and contribute to the consolidation of innovative projects. Chargepoly's development has then led to successful collaborations with some major logistic actors like Barbero Transports which is a specialist in refrigerated transport serving players in mass distribution and the agri-food industry in Saint-Laurent-du-Var (Métropole Nice Côte d'Azur). This committed family business is also part of the Astre network, the leading European group of transport and logistics SMEs. The local 300kW station can now charge 16t and 26t trucks. The scalable station will allow the easy addition of new satellites to support the electrification of the fleet in the coming years.
Relevant images	

Progress status	Completed
Key benefits/outcomes	"From project conception to completion, the Chargepoly teams were involved and present at our side. We have real support and people available to answer our questions. Chargepoly has enabled us to approach this ecological transition with a great deal of flexibility. Our electric truck drivers are delighted with the system. Our station makes us autonomous and enables us to meet our customers' expectations, but also to improve everyone's daily life". Anthony Rocquencourt, Training and safety manager Barbero Transports
References	Chargepoly company page [171]

Table 14. Green school canteens

Title of best practice	Green school canteens
Location	Bari, Italy
Short description	Since 2015, Bari's school canteen service offers entirely organic, zero-kilometer food, emphasizing nutritional quality and sustainability. Using mainly organic products, it operates plastic-free with biodegradable utensils and electric vehicle deliveries, donating leftovers to NGOs and churches. Recognized annually since 2019 as a "Canteen of Excellence," the service uses awards to reduce tariffs for low-income families, offering free meals to those earning below €12,500. Save the Children acknowledges this policy.
Long description	The Municipality of Bari, since 2015, has launched a real revolution in its school canteen service, introducing, among the first cities in Italy, an entirely organic and zero-kilometer food offer, designed based on nutritional quality and variety, respect for cultural and religious diversity, and organized on environmental protection and sustainability criteria. The school canteen service of the Municipality of Bari, designed by in-house nutritionists, health district doctors and parents, is structured on the guidelines for a correct diet and the prevention of childhood obesity and uses 90% organic products for fruit, vegetables, pulses, processed products of vegetable origin, bread and bakery products, pasta, rice, flours, cereals and derivatives, extra virgin olive oil, 100% for eggs, yoghurt and fruit juices, and 50% for dairy products, meat and fish from aquaculture.

	The Municipality of Bari, since 2015, has launched a real revolution in its school canteen service, introducing, among the first cities in Italy, an entirely organic and zero-kilometer food offer, designed based on nutritional quality and variety, respect for cultural and religious diversity, and organized on environmental protection and sustainability criteria.The school canteen service of the Municipality of Bari, designed by in-house nutritionists, health district doctors and parents, is structured on the guidelines for a correct diet and the prevention of childhood obesity and uses 90% organic products for fruit, vegetables, pulses, processed products of vegetable origin, bread and bakery products, pasta, rice, flours, cereals and derivatives, extra virgin olive oil, 100% for eggs, yoghurt and fruit juices, and 50% for dairy products, meat and fish from aquaculture. The service is completely zero impact and plastic free and biodegradable cutlery, plates and glasses have been introduced, meal delivery is made with electric vehicles and the customer satisfaction survey is entirely paperless. Leftover food is distributed to local NGOs and churches. The Ministry of Agriculture, Food and Forestry Policies, starting in March 2019, rewards the service every year as "Canteen of Excellence" for the quality and traceability of the organic products used,assigning Bari an economic award that the municipality allocates to reduce tariffs for the weakest families. The Municipality of Bari, in fact, believes that the school canteen is an opportunity not only for children to access food, but also for learning and socialization. Therefore, since 2014, it has been pursuing a policy of fair pricing that provides for complete gratuity for families with an annual income of less than €6,000, now increased to €12,500 thanks to the bonuses obtained from the Ministry. This policy choice is recognized by Save the Children in its annual report.
Funding programme	10,000,000 for three years from municipal budget
Progress status	In progress
Progress status	The policy impacts on all indicators of the MUFFP monitoring framework in terms of governance (Participatory food governance structures, urban food system policies, knowledge sharing mechanisms), Sustainable diets and nutrition (Urban residents have access to affordable, sufficient, nutritious, safe, adequate, and diverse food, Food, health and education policies), Social and economic equity (Increasing the level of food security for specific vulnerable groups, Fair and decent work and income).

	The policy socially involves 4,500 families, 80% of them with one child, 15% with two children, 5% with more than three children. 55% of users have an annual income of less than €6,000 and do not pay for the canteen. 13% of users fall under the discounted tariff of €1.5 per meal. During the pandemic, it was found that most of the families who could not use the canteen had food poverty problems and the service was temporarily converted to home delivery. From an environmental point of view, the savings in CO2 emissions caused using environmentally friendly vehicles, the promotion of short supply chains and the abolition of plastic have not been calculated, but the policy certainly contributes to the fight against climate change. From an economic point of view, the canteen is supported by the municipal budget and the prize recognized by the Ministry was awarded to a project for the creation of 10 school "educational gardens"; to promote childrens awareness of landscape and food.
References	Milan Urban Food Policy Pact. The practices was provided for the Milan pact award 2022. [172] La gazzetta del mezzogiorno article [173]

Table 15. So. De. Social Delivery

Title of best practice	So. De. Social Delivery
Location	Milan, Italy
Short description	So.De. (Social Delivery) is a sustainable and socially responsible delivery service operating in Milan. It focuses on delivering goods using eco-friendly cargo bikes, ensuring fair contracts and proper training for its riders. So.De. supports local commerce and initiatives against food waste, promoting a low environmental impact while fostering community solidarity. They aim to expand their services to other cities, continuing their commitment to social and environmental causes.
Long description	The success of So.De. in Milan has encouraged plans for expansion to other cities, where they aim to replicate their model of low-impact, community-focused delivery services. Their approach reflects a growing trend towards integrating social responsibility with business operations, particularly in the logistics and delivery sectors. So.De provides a user-friendly and transparent delivery fee system. The company charges a flat fee for deliveries within a specified radius from the restaurant or vendor.

	This approach simplifies the cost structure for both customers and businesses, making it easier to anticipate and manage expenses. For deliveries beyond this radius, So.De implements additional charges based on distance, ensuring that fees are fair and reflective of the service provided. Customers can see the delivery fee during the order placement process, which promotes transparency and helps avoid unexpected costs. Payments can be made conveniently through the app or website, streamlining the transaction process for both users and delivery personnel. So.De's system is designed to be efficient and straightforward, aligning with their mission to enhance urban mobility and reduce environmental impact through sustainable delivery practices.
Funding programme	Launched in 2021 thanks to the Municipality of Milan's Civic Crowdfunding Call
Progress status	In progress
Key benefits/outcomes	So.De. Delivery offers numerous benefits, particularly in terms of environmental sustainability, social responsibility, economic advantages, and user experience. By utilizing cargo bikes instead of traditional motor vehicles, So.De. significantly reduces greenhouse gas emissions, promoting a greener, more sustainable urban environment. This not only lowers the overall carbon footprint but also helps reduce traffic congestion and pollution in cities. The company is committed to social responsibility, ensuring that its riders are provided with fair contracts and proper training, which promotes a supportive and equitable work environment. This approach improves job satisfaction and retention among employees. So.De. also supports local commerce by partnering with small businesses and initiatives against food waste, strengthening community ties and contributing to the local economy. Economically, So.De. offers a cost-effective solution for both consumers and businesses through its transparent and straightforward delivery fee structure. This helps in managing and predicting delivery costs more efficiently. By providing reliable and affordable delivery services, So.De. helps local businesses expand their customer base and improve sales without the burden of high delivery costs. The user experience is enhanced through a user-friendly platform that allows customers to easily place orders and track deliveries. Clear and upfront delivery fees enhance transparency, building trust with customers and reducing the likelihood of disputes or dissatisfaction over hidden charges.

	Collectively, these benefits contribute to positive outcomes for the environment, the community, and the economy, positioning So.De. as a pioneering model in the delivery service industry.
References	So.De web page [174]

Table 16. CAAB - UrbanHubSostenibile

Title of best practice	CAAB - UrbanHubSostenibile
Location	Bologna, Italy
Short description	The Bologna WholeSale Market (CAAB) started a project to become environmentally sustainable by implementing electric mobility.
Long description	The project aims to initiate an environmentally sustainable transport system for goods and power electric mobility within the CAAB (Bologna WholeSale Market) itself and from the CAAB to the city of Bologna, using the surplus energy produced by the photovoltaic plant. In addition, established companies will be able to purchase electricity at significantly lower costs than the market. The objectives will be achieved through multiple collaborations, in order to increase know-how in the respective areas of specialisation to provide the territory with increasingly sustainable and innovative services. The goal is total self-sufficiency of the CAAB with the utilisation of the surplus within one or more CERs at a commercial logistics site by 2024.
Progress status	In progress
Key benefits/outcome	On the energy side, work began in 2012 on Europe's largest roof-mounted photovoltaic plant (CAAB 1 and CAAB 2), with 100,000 square metres of surface area and a production of 11 million KWh. In 2019 the CAAB's photovoltaic system was supplemented with an additional 15,000 panels over an area of 30,000 sqm and an increase in energy production equivalent to 3 million KWh. (CAAB 3). As of 2019, the photovoltaic installations, consisting of 43,750 panels as part of the CAAB 1 and CAAB 2 step, have produced approximately 10,500,000 KWh. These installations have resulted in carbon dioxide savings of approx. 5,000 tonnes and about 1.5 tonnes of PM10 per year. CAAB 3 produces 520,000 kWh of electricity per year and is able to meet the consumption of 200 households. Thanks to this project, CAAB is able to avoid emitting 180 tonnes of CO2 per year and a total amount of more than 5,000 tonnes of CO2 during the lifetime of the project.

References	CAAB web page [175] p. 265 of Report Asvis Territori 2023 [176]

Table 17. ENERNETMOB: A PROMISING EXPERIMENT IN ELECTROMOBILITY FOR URBAN LOGISTICS LED BY CAPENERGIES IN MARSEILLE

Title of best practice	ENERNETMOB: A PROMISING EXPERIMENT IN ELECTROMOBILITY FOR URBAN LOGISTICS LED BY CAPENERGIES IN MARSEILLE
Location	Marseille, France
Short description	In 2022, Capenergies run the local pilot in the Market of national importance (MIN) of Marseille where the demonstration consisted of a recharging station powered by photovoltaic panels dedicated to power electric refrigerated van.
Long description	Funded by the European Commission's Interreg MED programme, the EnerNetMob project aims to create a Europe-wide network of recharging infrastructures to promote electromobility and transnational cooperation. Among the 13 experiments carried out in 12 countries, the pilot in Marseille prevented the emission of 1.6 tonnes of C02 in only 4 months.
Project full title/ acronym	EnerNETMob - Mediterranean Interregional Electromobility Networks for Intermodal and Interurban Low Carbon Transport Systems
Funding programme	Interreg Mediterranean Transnational Cooperation Programme (MED 2014-2020)
Project website	https://www.enernetmob.eu/
Relevant images	  

Progress status	Completed
Key benefits/outcomes	151 rounds of 56km on average (up to 105km) to deliver up to 60 tonnes of fresh produce between April and September 2021 99 charging sessions on the terminal 2,2 MWh of energy supplied Full truck refuelling in less than 3h30 in average 2.9 MWh of self-consumed solar energy 49% PV-powered truck recharging (80% over a full year) The EnerNetMob demonstrator conducted by Capenergies in Marseilles is proof of the effectiveness of electric mobility for urban logistics: the truck's battery autonomy is more than sufficient to cover the needs of the round, recharging time is optimised and the driver experience is improved. It is also a collective learning experience for all the partners in the deployment and use of such an infrastructure. The project will have a number of spin-offs at different levels: • MIN des Arnavaux plans to install 10 additional kiosks and draw up a best practice guide for the deployment of electric mobility for the delivery of fresh produce; • Delivery company Urby wants to expand its range of electric vehicles with larger trucks; • A handbook of best practice for European local authorities will soon be available online on a digital platform.
References	EnerNETMOB project web page [168]

In the above tables number of good practices in the agri – food logistics are listed. Based on this, a simple conclusion can be drawn and it's that green logistics options are already in use, they work well and have numerous benefits over conventional delivery practices.

First example of such practice is brewery Kamenitza AD which operates in Bulgaria. The company has number of offices spread across the country and their well – established distribution system features electric vehicles used for local deliveries. EVs they use specifically designed to be efficient in urban are areas, and their distribution centres are equipped with charging infrastructure enabling minimal downtime and operational efficiency. Another good example is The Carlsberg Group who is advancing their commitment to electromobility by piloting several initiatives across Europe and Asia. Their ever-growing electric delivery truck fleet is accompanied with forklift trucks converted from LPG to electric. This way, warehouse decarbonisation is also utilized.

Their efforts are very important as they are setting example for other businesses in the region. Agios Efstratios – Green Island located in Greece is putting their efforts towards complete energy – autonomous operation and as a part of the project basic infrastructure for the use of EV will be created. This will enable future development and utilisation of green logistics on the island. In the Valencian Port of Valencia 100% electric truck is used for heavy transport in container loading and unloading operations. This example showcases the usage of EVs in heavy local transport is not only possible but yields numerous benefits such as minimisation of CO2 emissions, noise and air pollution. Similarly, Sustainable port of Bar procured BEV and installed a fast-charging station together with hybrid bus used for on – site transportation in Montenegro. Both of these show significant progress in lowering port's carbon footprint as hybrid bus replaced hundreds of private cars otherwise used for transporting workers and visitors. In addition to this, Public Utility Company Zelenilo from Podgorica, Montenegro advanced their fleet with three electric cars which will streamline operations, improve efficiency and save costs during their usual tasks. Company specialises in maintaining green spaces, designing, constructing and arranging green areas, and other. Another way to excel decarbonisation logistics in the urban areas in showcased by Synchronicity in Marseille, France. Their aim is to create shared collection systems for waste from artisans and merchants using cargo bikes. The project also includes a component dedicated to raising awareness, training professionals and support social jobs paving the way for development of effective equipment procurement and development of cycling infrastructure in dense urban areas. Another example is Lidl Croatia's collaboration with Volvo Trucks that resulted in integration of 100% electric truck into the logistics chain Their efforts are very important as they are setting example for other businesses in the region. Agios Efstratios – Green Island located in Greece is putting their efforts towards complete energy – autonomous operation and as a part of the project basic infrastructure for the use of EV will be created. This will enable future development and utilisation of green logistics on the island. In the Valencian Port of Valencia 100% electric truck is used for heavy transport in container loading and unloading operations. This example showcases the usage of EVs in heavy local transport is not only possible but yields numerous benefits such as minimisation of CO2 emissions, noise and air pollution. Similarly, Sustainable port of Bar procured BEV and installed a fast-charging station together with hybrid bus used for on – site transportation in Montenegro. Both of these show significant progress in lowering port's carbon footprint as hybrid bus replaced hundreds of private cars otherwise used for transporting workers and visitors. In addition to this, Public Utility Company Zelenilo from Podgorica, Montenegro advanced their fleet with three electric cars which will streamline operations, improve efficiency and save costs during their usual tasks.

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12. BIOFUEL MOBILITY

Greenhouse gas emissions in the transportation sector have significantly increased over the past decades. The use of biofuels as an alternative to fossil fuels in transportation could help reduce these emissions and enhance energy security, which is why biofuels have become part of the EU's climate and energy policy. Nearly 93% of the energy used in road and rail transport in the EU during 2021 came from fossil fuels. In 2021, the share of biofuels in fuels in the global road transport sector was 4.3% [177]. Today's biofuels need to be blended with fossil fuels. For example, bioethanol can be blended with gasoline, and biodiesel with fossil diesel. Biofuels can be produced from various types of biomass. In the revision of the Renewable Energy Directive presented in 2018 (RED II directive) [178], three main categories of biofuels are distinguished depending on the raw material or technology used for their production. The first category includes biofuels derived from food and feed crops, such as biodiesel produced from rapeseed, sunflower, palm, or soybean oil, or bioethanol produced from corn, wheat, sugar beet, barley, and rye. The second category consists of "advanced biofuels," mainly produced from waste, residues, and by-products that can be processed into biofuels, mostly using advanced technologies. Examples include algae, parts of biomass from mixed municipal waste, straw, liquid waste from palm oil production, and non-food cellulosic or lignocellulosic material. Biofuels mainly produced from waste, residues, and by-products that can be processed into biofuels using developed technologies include biofuels derived from used cooking oil and animal fats that are not suitable for human or animal consumption. For the latter two categories, the RED II directive contains a list of specific raw materials and groups of raw materials.

Biofuels not produced from any raw material covered by these three categories are categorized as "other biofuels." These can include biofuels produced from agricultural crops that are not used for human or animal food production, such as jatropha or fiber crops like flax or hemp. Most of the biofuels consumed in the EU in 2021 were produced from agricultural crops. In addition to biofuels, renewable energy carriers in transportation include renewable electricity and renewable liquid or gaseous fuels of non-biological origin [177].

12.1 Technologies

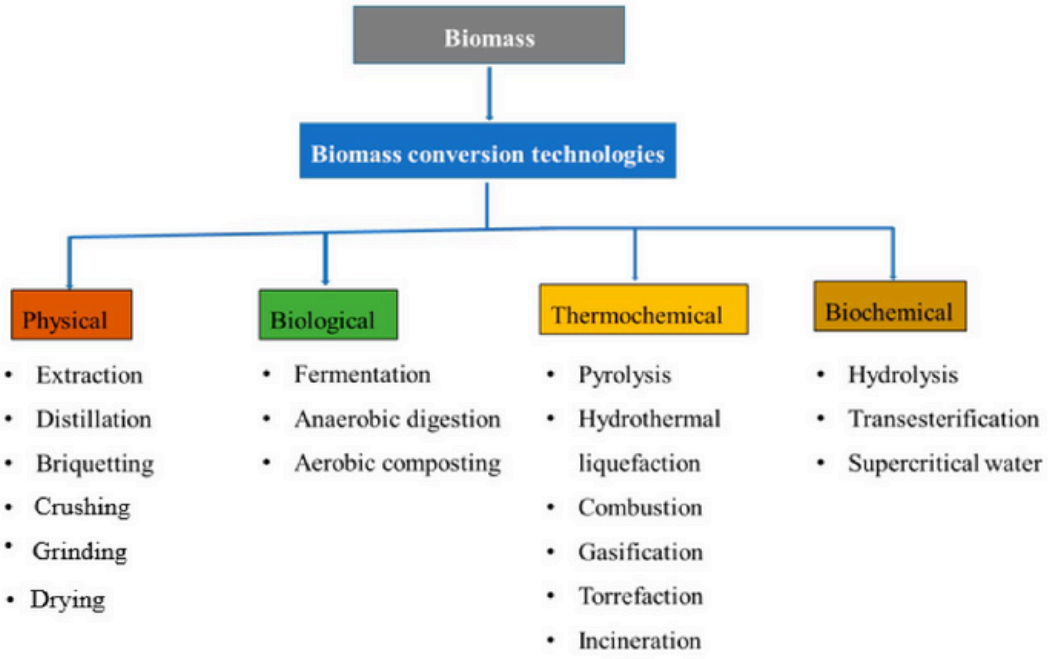


Figure 22. Biomass conversion technologies [179]

The diagram above [179] shows the procedures by which biomass is converted into biofuels. The diagram encompasses all production technologies, from the processes used to produce the first biofuels to the advanced processes representing the latest technological achievements.

12.1.1.1 Thermochemical Conversion

The biomass thermochemical process converts biomass into a higher-quality fuel or H2-rich syngas to chemicals via Fischer-Tropsch production. Drying, pyrolysis, heterogeneous char, and homogeneous reforming reactions of pyrolysis materials are the major phases involved in the thermochemical process. This process is commercially more attractive due to its flexibility, selectivity, higher process effectiveness, and different markets for byproducts. Thermochemical technology mostly uses process settings that entail costly resources in the process equipment and conditions that use high temperatures and pressure. The challenge with thermochemical is that it is expensive to obtain and install the infrastructure as compared to the feedstock's low cost. Most current biomass thermochemical conversion processes use comprise pyrolysis, hydrothermal liquefaction, gasification, combustion, torrefaction, and incineration [180].

12.1.1.2 Biological

Microbial systems such as *Escherichia coli* and *Saccharomyces cerevisiae* are generally used in biological methods. These are enhanced for a specific chemical product by constructing a set of reactions in a metabolic pathway. Biological conversion processes are considered environmentally friendly. But their fermentation period, use of costly hydrolytic enzymes, and the sensitivity of microorganisms to various aspects like growth settings, impurities, sugar substrates, nutrients, and inhibitors render them time-consuming. Some of the biological methods include fermentation, anaerobic digestion, and aerobic composting [179].

12.1.1.3 Hybrid (new) technologies

Hybrid or combined systems are also under research using blends of different technologies, like thermochemical and biochemical technologies. Genetic engineering is also promising area in biofuel technology. By modifying the genetic makeup of organisms used in biofuel production, it is possible to increase the efficiency and yield of biofuel production processes. For example, researchers are using genetic engineering to develop strains of yeast that can ferment both the simple sugars and the more complex sugars in plant biomass, increasing ethanol yield. Similarly, scientists are working on genetically modifying algae to increase their oil content and growth rate, potentially improving the viability of algae-based biofuels [181].

Nanotechnology method involves using nanoparticles to catalyze biofuel production processes, significantly increasing their efficiency and reducing costs [182].

12.1.2 Biodiesel

Biodiesel and bioethanol are the most common biofuels used in transport, with other biofuels also in use but with more limited market penetration. First-generation biodiesel technologies are well-established, producing biodiesel from oil crops and animal fats. Second-generation biodiesel includes a broad range of products generated by conventional technologies but based on novel starch or energy crops [183]. Out of the four generations of biodiesel, only the first two have attained commercial status. To ensure the sustainability of biodiesel, it must be derived from sources that do not interfere with the agri-food system.

Common biodiesels are produced through the trans-esterification of oils or fats, usually with methanol. This reaction produces fatty acid methyl ester (FAME) and releases glycerine as a by-product. FAME biodiesels have properties similar to conventional diesel fuel, making them suitable for blending. Biodiesel fuel blends are designated with 'B' numbers, indicating the maximum percentage of biodiesel in the mixture by volume. For example, B7 contains up to 7% FAME and at least 93% fossil diesel fuel [184].

The European Biodiesel Board (EBB) serves as the association for companies producing biodiesel within the EU, representing biodiesel producers. Biodiesel is primarily used as a substitute for fossil fuels in transport, but its production also contributes to a value chain that generates co-products such as food, feed, biochemicals, and biopolymers. Since its establishment in 1997, the EBB has been the authoritative voice of the biodiesel industry. For decades, it has collaborated with policymakers to ensure that European regulations are appropriate and effective, developing an unparalleled understanding of the regulatory process and its impact on the industry [185].

EBB EUROPEAN BIODIESEL BOARD

Figure 23. EBB logo [185]

12.1.2.1 Transport use and emissions

All biofuels are used as blends with conventional fuels in existing engines. Blending limits in the EU are set according to fuel specification standards designed to ensure compatibility with conventional power trains and refuelling infrastructure. Current fuel standards allow up to 7 volume% FAME (the most common type of biodiesel, B7) in diesel fuel of fossil origin. At low percentage blends (e.g. B7) biodiesel can work with current engine and powertrain technologies and can be pumped directly into the tank of any vehicle. Car engines and powertrains need to be modified to run smoothly with higher blends [186]. Although in general terms biofuels have slightly lower energy content than fossil fuels, tailpipe emissions give mixed results. The impact of biodiesel on regulated pollutant (nitrogen oxides (NOx), particulate matter (PM), carbon monoxide (CO), hydrocarbons (HC), etc.) is not straightforward, since it depends on the blending ratio, the physical properties of the biodiesel, the vehicle/engine technology and the driving conditions. Up until now, the main focus has been on the impact of biodiesel on heavy-duty engines.The general trend in heavy-duty diesel engines is that CO, HC and PM emissions reduce as the blending ratio increases, while NOx emissions increase, reaching a maximum with neat biodiesel [184].

At the level of day-to-day usage, shortened oil change intervals have been reported as one of the consequences of using biodiesels. Lubricating oil dilution due to fuel ingress is common in diesel engines and is known to occur with both conventional diesel and biodiesel. However, the higher boiling point distributions of biodiesels compared to conventional diesels have been observed to lead to greater proportions of permanent dilution of the lubricating oil pool. This results in decreased oil viscosity and thus in accelerated component wear [187]

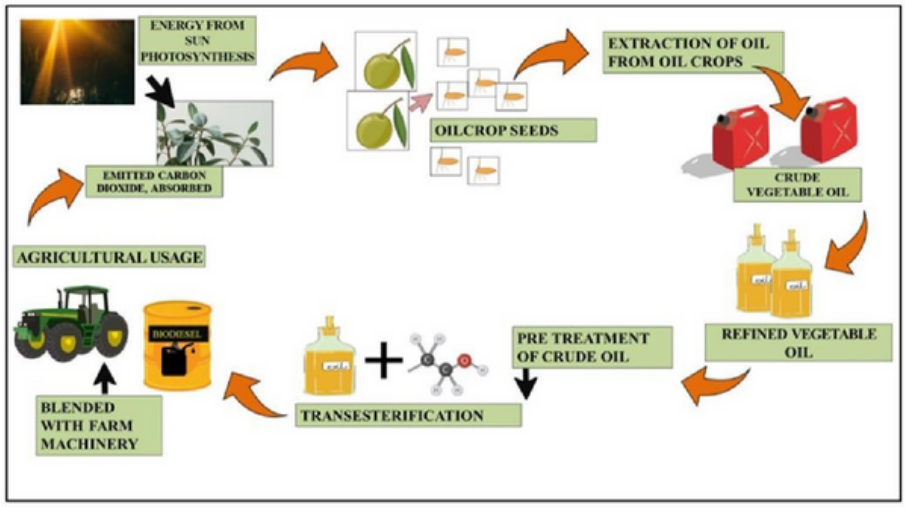


Figure 24. Production of biodiesel and its usage for agriculture purposes [186]

12.1.3 Biogas

Biogas is a renewable biofuel. Various varieties of basic materials can be used to produce biogas. Biogas is primarily produced by microorganisms that graze on organic matter. These bacteria decompose food to produce methane, which can be used locally as-is or converted into biogas with properties similar to those of natural gas to allow the biogas to be transported over greater distances. In addition, during the process, material containing organic nutrients is produced; this material can be utilised in numerous sectors, including agriculture. To facilitate processing, biowaste is slurred by saturating it with liquid. Due to the use of microorganisms in humid environments, biowaste is incinerated at approximately 37 °C. Large containers must undergo approximately three weeks of anaerobic digestion to produce biogas. Carbon dioxide and other impurities are removed during the final phase of gas purification [188]. Compressed biogas (CBG) has existed on the market for some time, while liquid biogas (LBG) has only recently been introduced for heavy vehicles. Currently, biogas in transport is mainly used in buses and to some extent in private cars. However, thus far, in freight transport, there has been a slow diffusion although there are technologies on the market today [189].

Europe is the largest producer of biogas today. Germany is by far the largest market, and home to two-thirds of Europe's biogas plant capacity. Energy crops were the primary choice of feedstock that underpinned the growth of Germany's biogas industry, but policy has recently shifted more towards the use of crop residues, sequential crops, livestock waste and the capture of methane from landfill sites. Other countries such as Denmark, France, Italy and the Netherlands have actively promoted biogas production [190].

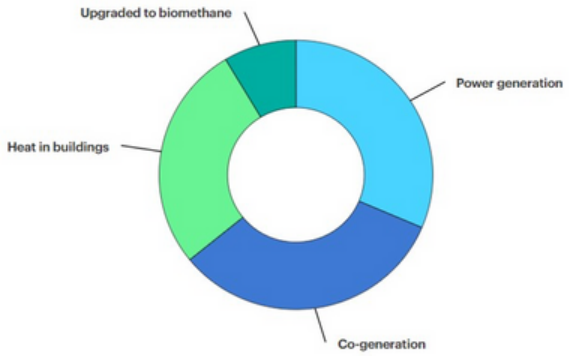


Figure 25. Biogas consumption by end use in 2018 [190]

Biogas has properties similar to those of fossil-based methane (natural gas) and can be distributed to fuelling stations either by pipeline (the gas network) or truck, in the latter case, in either compressed (CBG/CNG) or liquefied (LBG/LNG) form. Biogas for transport purposes can ultimately be used in both heavy- and light-duty vehicles and can be used interchangeably with natural gas in these vehicles. The main benefits of using LBG-trucks instead of CBG-trucks is that the range obtainable with LBG is significantly greater than that of CBG, making LBG particularly suitable for long-distance and heavy transport.

Figure 10 shows a wide variety of feedstocks that can be used to produce biogas – crop residues; animal manure; the organic fraction of municipal solid waste, including industrial waste; and wastewater sludge. Figure 10 also shows that biomethane is produced by upgrading biogas.

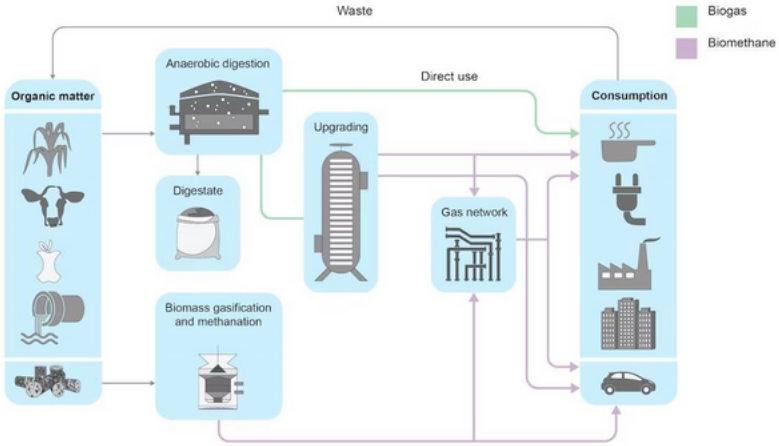


Figure 26. Production pathways for biogas and biomethane [190]

12.1.4 Biomethane

Biomethane is a renewable fuel produced by upgrading biogas and syngas to natural gas quality. It meets all technical requirements set by vehicle manufacturers and natural gas transportation system operators. Biomethane can be used interchangeably with natural gas in all applications [191]. Biogas production is an element in the environmental management of such wastes; biogas plants can also deliver digestate, which contains most of the nutrients in the feedstock and can be an excellent biofertilizer. In addition, it is possible to utilize the carbon dioxide removed in upgrading biogas to biomethane as a product with added value. Biomethane production is part of a larger circular economy, energy, and environmental system. It is very difficult to divorce the energy vector, biomethane, from the system through which it is produced. Also, liquefied biomethane is more energy dense and therefore is optimal to power large engines (both on the road and at sea) for long distances with minimal storage space and weight.

There are two principal ways of supplying vehicles with biomethane:

- Dedicated retail filling stations supplying only biomethane (compressed or liquefied), which often comes from a plant nearby or is shipped in liquefied form (similar to LNG);
- Fuelling stations that are connected to the gas grid and offer natural gas blended with biomethane [192]

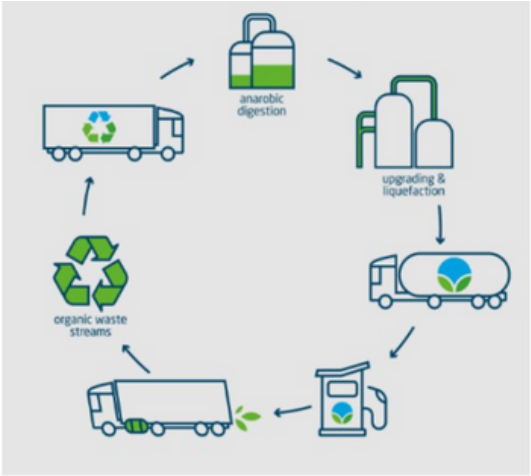


Figure 27. Schematic of biomethane deployment in the transport sector [193]

Methane is also an option in the freight sector both for light and heavy-duty transport. Several different types of methane powered trucks are available on the market. Lighter trucks used for refuse collection and delivery services commonly use compressed gas.

Models designed for regional and long-distance haulage may use either compressed or liquified methane, with a range of approximately 1,000 km, with compressed gas fuelled trucks having a slightly shorter range. As heavy goods vehicles would be considered a hard to abate sector and present difficulties in phase-out of fossil fuels, trucks fuelled by liquid biomethane may be of particular importance as they provide a competitive alternative to liquid fossil fuels in a sector where there are few other decarbonization solutions. Most manufacturers provide dedicated methane fuelled trucks only using the spark-ignited engine. However, some truck manufacturers also provide dual-fuel diesel engines. Sustainable biomethane is a local, renewable and cost-competitive alternative to fossil fuels that can achieve negative emissions1 necessary to achieve the EU climate neutrality targets. Biomethane is proven to be an effective way to abate GHG emissions from transport, especially in hard-to-abate modes such as the heavy-duty segment.

Despite the emergence of climate mitigation policies in the EU, GHG emissions in the EU road transport sector have increased by 33%3 over the last three decades. In the EU, road transport is responsible for about 21% of total GHG emissions, of which 27% is generated by heavy-duty vehicles [194].

Biomethane could substantially contribute to the decarbonised transport sector of tomorrow. The technology is advancing year upon year, making the growing number of upgrading units more cost-efficient. Unlike the electric transport, the mature technology of gaseous transport does not require further big investments and innovation in order to be deployed. Biomethane can provide a bridge technology for passenger cars and an ultimate solution for heavy duty vehicles.

12.1.5 Bioethanol

Together with biodiesel, bioethanol is the most common biofuels used in transport. At the international level, a variety of vehicles are currently using bioethanol. In terms of production cost, the primary barrier to bioethanol production is the cost of producing it. The process of production could surpass the cost of fossil fuels. Using agricultural waste as a bioethanol source can significantly reduce this cost. Bioethanol can be used in blended form, with gasoline or alone. First-generation fuel, bioethanol, can be used in the blended form (gasoline) or alone. In cold weather, bioethanol must be blended with small amounts of petrol, because pure ethanol has difficulty vaporizing, resulting in vehicles stalling. A variety of waste can produce bioethanol, including algae waste, wheat straw, sugarcane bagasse, agricultural waste, rice straw, and vegetable waste.

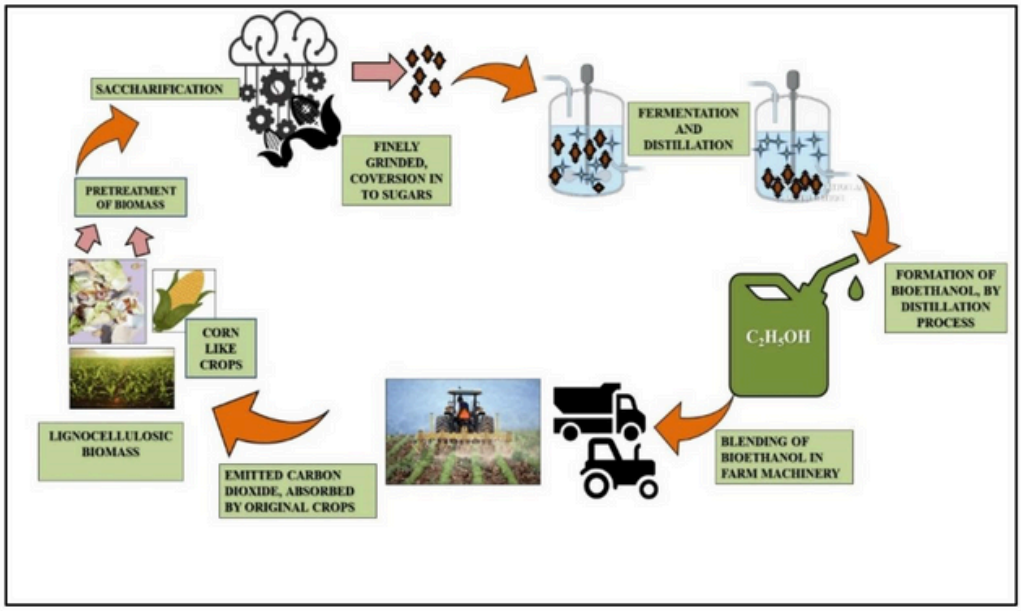


Figure 28. Production process of bioethanol and its blending with with conventional fuels [186]

Bioethanol, or ethyl alcohol, is a clear, colourless liquid that is biodegradable, low in toxicity, and causes little environmental pollution if spilled. When burned, ethanol produces carbon dioxide and water. As a high-octane fuel, ethanol has replaced lead as an octane enhancer in gasoline. Blending ethanol with gasoline oxygenates the fuel mixture, allowing it to burn more completely and reduce polluting emissions. Bioethanol fuel blends are widely commercial sold in the United States, with the most common blend being 10% ethanol and 90% gasoline (E10). Vehicle engines require no modifications to run on E10, and vehicle warranties remain unaffected. However, only flexible fuel vehicles can run on blends containing up to 85% ethanol and 15% gasoline (E85). Bioethanol fuel is primarily produced through the sugar fermentation process, though it can also be manufactured by reacting ethylene with steam. The main sources of sugar required to produce ethanol come from fuel or energy crops, which are grown specifically for energy use [195].

Table 18. Bioethanol properties [195]

Bioethanol properties	
Density [kg/l] at 15°C	0.8 – 0.82
Oxygen content [wt-%]	34.8
Octane number	109
Cetan number	11
Stoichiometric air/fuel ratio [kg air/kg fuel]	9.0
Boiling temperature [°C]	78

Bioethanol is best utilized in spark-ignition engines due to its high octane rating. However, its poor ignition quality (low cetane number) makes it less suitable for diesel engines. Using neat ethanol in spark-ignition engines is generally impractical because of its low vapor pressure and high latent heat of vaporization, which complicate cold starts. The most cost-effective solution is blending ethanol with a small proportion of a volatile fuel such as gasoline. Various mixtures of bioethanol with gasoline or diesel fuels have been employed. Bioethanol has been extensively tested in light-duty flexible fuel vehicles as E85G (85% ethanol, 15% gasoline). Blends of gasoline with up to 22% ethanol (E22G) can be used in spark-ignition engines without any material or operational problems. Similarly, blends of diesel with up to 15% ethanol (E15D - 15% ethanol, 85% diesel) do not introduce any technical engine issues and require no ignition improver.

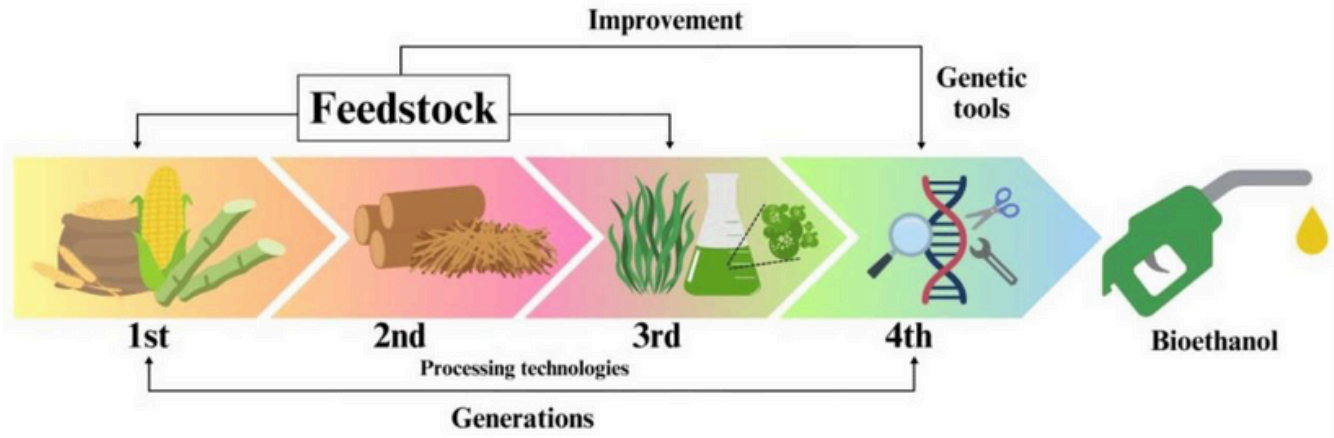


Figure 29. Graphical representation of the different generations in bioethanol production [196]

In the context of the food logistics chain, the use of biofuels such as bioethanol can significantly reduce greenhouse gas emissions associated with the transportation of food products. By integrating bioethanol into fuel supplies for vehicles involved in the food logistics chain, companies can achieve greater sustainability and reduce their carbon footprint. This is particularly relevant for the transportation sector, which is a significant contributor to overall emissions.

The adoption of bioethanol and its blends in food transport vehicles not only supports environmental goals but also aligns with regulatory requirements and market demands for greener logistics solutions.

12.2 Good practices in partner countries in agro-food logistics

Table 19. Good practices of biofuels usage in Kamenitza AD

Title of best practice	Good practices of biofuels usage in Kamenitza AD
Location	Bulgaria
Short description	LPG Logistic and optimization of transportation routes
Long description	Kamenitza AD, a prominent brewery in Bulgaria with a rich history dating back to 1881, has embraced sustainable development strategies to mitigate its environmental impact. The company operates a brewery in Haskovo, a microbrewery in Plovdiv, a central office in Sofia, and 17 commercial offices across the country. It has optimized its transportation routes and increased shipment weights, reducing transport courses by 120 annually, thereby minimizing fuel consumption and emissions. One of the key initiatives is optimizing transportation routes and increasing shipment weights, reducing the number of transport courses by 120 per year. This approach minimizes fuel consumption and emissions. Additionally, Kamenitza AD's warehouse machinery operates entirely on LPG (liquefied petroleum gas), and its mechanized auxiliary equipment uses batteries and LPG vehicles, significantly reducing reliance on traditional fuels. This practice not only enhances energy efficiency but also aligns with their broader sustainability goals, emphasizing the use of renewable energy sources and reducing carbon emissions. Kamenitza AD has also integrated biofuel usage into its energy management systems. The FEWER team, focusing on Fuel, Electricity, Water, Emission Reduction, manages and analyzes energy consumption to identify improvements and implement energy-efficient processes. This strategy aligns with their broader sustainability goals, including reducing carbon emissions and using renewable energy sources.
Relevant images	

Progress status	Completed
Key benefits/outcomes	In 2022, Kamenitza AD managed to replace 1/3 of the company's vehicle fleet, reducing the harmful emissions of 2/3 of the cars to 117 CO2 WLTP (g/km). For GGS level 14 and above, the vehicles were replaced with a hybrid model. In 2023 and early 2024, we will replace the remaining fleet, ensuring all cars have an emission level of up to 117 CO2 ZWLTP (g/km).
References	Kamenitza company ESG report 2022 [156]

Table 20. Good practices of biofuels usage in Kaufland Bulgaria

Title of best practice	Good practices of biofuels usage in Kaufland Bulgaria
Location	Bulgaria
Short description	Food Logistics with CNG trucks
Long description	Kaufland is the first retailer to use natural gas trucks for deliveries to its stores. In 2021, 85% of our hypermarket deliveries were made with CNG trucks. Our logistics partners have the security to invest in environmentally friendly technologies due to the long-term cooperation perspective we offer them.
Relevant images	Kaufland 
Progress status	Completed
Key benefits/outcomes	CNG trucks produce less carbon dioxide (CO2) emissions, which contribute to a lower carbon footprint and help in combating climate change
References	Kaufland sustainability report 2021 [197]

Table 21. Biodiesel in La Ribera (la Ribera en Biodièsel)

Title of best practice	Biodiesel in La Ribera (la Ribera en Biodièsel)
Location	La Ribera county. Valencia region
Short description	Consorci de la Ribera set up in 2003 a public service entitled "Biodiesel in la Ribera" that consist on recycling domestic used vegetal oil (UCO) into biodiesel with the aim of either educing the dependency of external energy sources and reducing CO2 emission from fossil fuels. This service is based, principally, on two typology of activities: i. creation of a container network located along the streets and in public buildings.; ii. conduction of campaigns to raise awareness about the importance of UCO collection. At present, 44 out of 48 are participating in the Biodiesel in la Ribera service. Amost 100 bins are distributed along la Ribera region that in 2023 collected 23,824 kg of UCO that were converted into biodiesel.
Long description	Biodiesel in la Ribera' is a joint service launched by Consorci de la Ribera in July 2003 in order to reduce the impact of used vegetal oils dumped in sewage systems and, at the same time, to favour the production of renewable fuel. Consorci de la Ribera (CRIB) signed an agreement with thirty councils by which CRIB was appointed as a local authorities' representative. In 2004, a biofuel dispenser was installed in petrol station of "El Serrallo" in l´Alcúdia in la Ribera region. This biodiesel dispenser (B10) was available for all the town councils and general population. In 2005, the collection service was widen to domestic oil by installing UCO container on the streets. Besides, biofuel dispensers were installed in some of la Ribera public facilities. Before 2005, CRIB only collected UCO produced by industry and tertiary sector (e.g. restaurants) and the results were 418 SME collaborated and 260,698 L of UCO. Since 2006, CRIB put its efforts in improving the service for domestic sector. In 2023, the UCO network was formed by 91 metal bins and 23,824 kg of UCO.
Progress status	In progress
Key benefits/outcomes	- Reduction of sewage water pollution; - Producton of renewable fuel; - Reduction of fossil fuel emissions; - Promotion of local economy
References	Biodiesel in La Ribera on Consortci de la Ribera web page [198]

Table 22. Agrowaste supply chains for sustainable growth AGROWCHAIN

Title of best practice	Agrowaste supply chains for sustainable growth AGROWCHAIN
Location	Greece, North Macedonia
Short description	Project objective is the promotion of the sustainable management of solid agricultural residues to cover thermal needs in public buildings. In the project the partners worked on the development of supply chains and business models with the Municipal Authorities. Also, the project included the implementation and demonstrative operation of 1 supply chain per country participating in the project, which allowed the control and optimization of the proposed models in real conditions.
Long description	Agricultural residues are an important source of biomass in rural areas, but their management remains largely problematic. The current practice is to either landfill them or burn them in open spaces, leaving them unused and their management is detrimental to the environment. The aim of the project is to promote the sustainable management of agricultural residues in rural areas to meet thermal needs. The branch cuttings can be used for the production of wood chips or pellets and can be used in biomass boilers in municipal buildings. The project partners worked on the development of supply chains and business models with municipalities as the central development focus. The schemes were developed by the project partners during phase 1 of the project in cooperation with local stakeholders. The 2nd phase of the project was dedicated to the implementation and demonstration operation of 2 supply chains in the Municipalities of Amyndeon and Novaci, which will allow the testing and optimisation of the proposed models in real conditions.
Project full title/ acronym	Agrowaste supply chains for sustainable growth - AGROWCHAIN
Funding programme	INTERREG-IPA CBC 2018 - 2021

Relevant images	
Progress status	Completed
Key benefits/outcomes	• 1 supply chain for each municipality demonstrated through a pilot action of 18 months • 1 GIS mapping and logistics tool for agrowastes valorization • Identification of alternative supply chains in Amyntaio and Novaci that can support future biomass installations (at least 2 per Municipality) • 4 case studies for the exploitation of local agrowastes in 4 Municipalities in the Programme area, apart from Amyntaio and Novaci. • 2 training seminars targeting local authorities (25 trainees and 2 days each) • 1 operational interactive platform for biomass suppliers in the cross border area • Development of 1 bioenergy cluster in the former Yugoslav Republic of Macedonia and 1 virtual mega-cluster across the borders
References	aGROWchain project web page [8]

Table 23. CLIMATE - Production of food, biocomposites and biofuels from cereals in the circular bioeconomy

Title of best practice	CLIMATE - Production of food, biocomposites and biofuels from cereals in the circular bioeconomy
Location	On the territory of the Republic of Croatia, in Zadar, Zagreb and in areas where wheat and barley are grown (Osječko-baranjska county, Virovitičko-podravska county, Vukovarsko-srijemska county, Požeško-slavonska county and Brodsko-posavska county).
Short description	The project included research on appropriate agrotechnical measures for old and new varieties of wheat and barley.

	The project demonstrated how utilizing residues can turn potential waste into raw material (circular bioeconomy).
Long description	The best practice of this project lies in the number of workshops, conferences, and training sessions held across the entire territory of Croatia, covering a wide range of age groups. For example, as part of the project activities, a workshop for preschool children titled "The Story of the Life of a Corn" was held in September 2023. The workshop was conducted by professors from the Department of Pedagogy at the University of Zadar. For primary school students, a workshop called "Fascination of Plants Day" was held at the Faculty of Agriculture in Zagreb. A series of workshops were also held for students and young workers, such as the "Grubišno Polje Workshop," which included visits to the family farm Cenger Dario and the company Bioel Ltd. Numerous papers and training sessions were published as part of the project, and the most significant research results were presented at the ASC Fall 2023 conference in San Francisco.
Relevant images	   
Progress status	Completed
Key benefits/outcomes	Numerous scientific studies, published scientific articles, raising awareness about biofuels, climate change, risk management, numerous educational sessions, establishing collaborations with small businesses, and participation of the project team in international conferences.
References	Project website [199] Papers as a product of project [200], [201]

Table 24. BIODIESEL VUKOVAR

Title of best practice	BIODIESEL VUKOVAR
Location	Vukovar, Vukovar-Srijem County, Eastern Slavonia, Republic of Croatia
Short description	The company Biodiesel Vukovar Ltd. is a member of the Envien group. Biodiesel Vukovar Ltd. is currently the largest biodiesel plant in the Republic of Croatia, capable of producing 35,000 tons of biodiesel annually.
Long description	Biodiesel Vukovar is the largest biodiesel producer in Croatia, primarily using rapeseed as a raw material in its production process. The biodiesel complies with the European standard EN 14214 and meets the requirements of the ISCC EU and REACH regulations. The company's production facilities are located in the city of Vukovar and currently employ 26 workers. The production and wholesale of biodiesel are the main business activities of the company, which has successfully implemented a quality management system compliant with the requirements of the international standard ISO 9001:2015. In addition to biodiesel production, the company also produces crude glycerin with an annual production capacity of approximately 6,500 tons.
Relevant images	 BIODIZEL VUKOVAR Member of Envien Group
Progress status	In progress
Key benefits/outcomes	The largest national biofuel producer.
References	Biodiesel Vukovar company page [202]

Table 25. OSATINA GROUP, VIŠKOVCI

Title of best practice	OSATINA GROUP, VIŠKOVCI
Location	Osatina Group, Viškovci, Đakovština, Republic of Croatia
Short description	Osatina Group Ltd. is a company engaged in crop production, fruit and vegetable production, milk and meat production, and animal feed production, retail seed products and many others. Osatina Group also produces electricity from biogas.
Long description	Osatina Group, in addition to its wide range of business activities (crop production, fruit and vegetable production, milk and meat production, animal feed production, wholesale and retail of seed products, fertilizers, and plant protection products, etc.), produces electricity from biogas. This company was the first in Croatia to build a biogas plant on its farm in Ivankovo. The construction of the biogas plant marked the beginning of sustainable waste management and the circular economy. Today, Osatina Group has three biogas plants: Ivankovo, Tomašanci, and Slašćak. The total capacity of the plants is 6 MWe / 6 MWt. All produced electricity is distributed into the HEP grid.
Relevant images	
Progress status	In progress
Key benefits/outcomes	Osatina Group is an excellent example of how large companies from the rest of the country can also start sustainable waste management and biofuel production, specifically biogas in this case. The plant does not necessarily have to be large; it is possible to build multiple small plants, as demonstrated in this example. After biogas production, the biogas does not have to be used for electricity production but can be redirected to other parts of the agri-food logistic chain.
References	Osatina group web page [203]

Table 26. BIOGAS PLANT, PISAROVINA

Title of best practice	BIOGAS PLANT, PISAROVINA
Location	Biogas plant, Pisarovina, Republic of Croatia
Short description	In 2020, a biogas plant was opened in Pisarovina. Pisarovina is an agricultural region, so the plant uses manure, slaughterhouse waste, and other forms of biomass waste from nearby farms and agricultural estates as feedstock.
Long description	The reasons for opening this plant are: simultaneous production of electrical and thermal energy from renewable sources; management of manure, slaughterhouse waste, and other forms of biomass; enrichment and improvement of soil quality through digestate application, etc. The produced thermal energy is partly used in the biogas production process and represents a significant potential for use in district heating systems, greenhouses, pasteurization, biomass drying, and preparation, among others. Besides biogas, the product of anaerobic fermentation is digestate, which enhances soil quality when applied to arable land. This biogas plant represents an excellent example of utilizing available resources from its surroundings.
Relevant images	  
Progress status	In progress
Key benefits/outcomes	This plant serves as an excellent example of how to utilize biomass from nearby agricultural and livestock farms in a region or specific area in the rest of Croatia for biogas production. It is up to the Croatian government and the relevant ministry to redirect the current use of biogas from electricity/heat production towards transportation. Biogas is a type of biofuel and, as such, can be used to fuel vehicles. This would also allow biofuels to find application within the agri-food chain.
References	Biogas plant in Pisarovina fact sheet [204]

Table 27. Food hub of Toulouse using biofuel vehicules for the last mile delivery (Bio GNV)

Title of best practice	Food hub of Toulouse using biofuel vehicules for the last mile delivery (Bio GNV)
Location	Toulouse France
Short description	Food last mile logistics from the food hub to urban center with vehicles using biofuel (Bio GNC)
Long description	TenLOG initiated the construction of a CNG station in Toulouse on the site granted by the city of Toulouse opposite the Marché d'intérêt national. Little by little, wholesalers and distributors at the MIN became interested in the opportunity to replace their light commercial vehicles (mainly 20 m3) with vehicles running on gas and then biogas. Some trucks of 12 to 18 tonne (Heavy Good Vehicles) have also been brought into service. This example shows the importance of energy infrastructures as a leverage for local authorities to developp low carbon mobility.

Table 28. Start up retrofiting vehicules to biofuel (GNV - Bio GNV)

Title of best practice	Start up retrofiting vehicules to biofuel (GNV - Bio GNV)
Location	Toulouse - Occitanie, France
Short description	Retrofit of vehicle diessel engine to biofuel (GNV)
Long description	The start up Lypech was created in 2015 with the goal of decarbonizing the professionnal transport (small trucks, ambulance...). In 2018, the company started the experimentation in retrofiting diessel engine to GNV / Bio GNV. In 2022, the solution is approved : the retrofit cost is between 10 000 and 15 000 euros and take one week. Compared with the diesel engine in its initial configuration, this new engine mean a 90% reduction in fine particles, a 60% reduction in nitrogen oxides, and a 30% reduction in CO2.
Relevant images	

Progress status	In progress
References	Lyptech company page [205]

Biofuels are yet another possible solution to decarbonize the logistics sector. Although their current usage is mostly as a blend with fossil fuels, their potential is significant, so any effort to promote their adoption is valuable. The showcase of best practices of biofuel usage is listed in the tables above. Biofuels are great way to practice circular economy as they can be produced from various food industry, agriculture and domestic sector waste. Despite that, there are still some obstacles to overcome in the terms of their usage in the agri – food logistics as can be seen in the best practices examples.

In Bulgarian brewery Kamenitza AD a lot of effort is put into the optimization of its transportation routes and increased shipment weights to minimize emissions. To fulfil their sustainability goals, they emphasise the use of renewable energy sources as well as biofuels in their energy management systems. Also, as a part of their sustainability strategy they replaced most of their vehicles with hybrid models. Additionally, remaining fleet will also be replaced by the end of 2024. Another example of biofuel usage in Bulgaria is Kaufland Bulgaria which utilises CNG trucks for their hypermarket deliveries. Both examples are showing how can biofuels be integrated into otherwise fossil fuel dominated sector and yield good results whilst being beneficial towards the environment. Very good example of circular economy and biofuel usage is La Ribera's public service "Biodisel in la Ribera". The main idea of the service is to collect and recycle used vegetable oils from restaurants, industry and domestic sector. Collected oil is used for the production of the renewable fuel, biodiesel, which is then distributed to local petrol stations.

The service offers a wide range of benefits, from reduction of the impact of the used vegetable oils on sewage systems to reduction of emissions and implementation of circular economy. Similarly, in Greece and Republic of North Macedonia, as a part of the AGROWCHAIN project, sustainable management of solid agricultural residues is promoted. The aim of the project is to utilise these agricultural residues into production of thermal energy via wood chips and pellets or in biomass boilers. As biomass is already collected there is window of opportunity to integrate production of biofuel that could be further used, for example in said biomass transportation or in other sectors. In Croatia, there are few biofuel usage examples.

Firstly, project CLIMATE demonstrated how utilising residues can turn potential waste into raw material. Project also procured number of scientific studies and articles raising awareness about biofuels and their importance. On the other hand, there is company BIODISEL VUKOVAR, that is the largest biodiesel plant in Republic of Croatia with production of 35,000 t/a. They mainly use rapeseed as a raw material in the production process. Produced biodiesel is sold on the market. Osatina Group Ltd. which mainly deals in food production, has integrated biogas plant into their portfolio thus utilising circular economy. They use waste from food production as well as livestock manure to produce biogas that is later used in three biogas plants that produce electricity. This is an excellent example of sustainable waste management and circular economy, although lacking in usage of produced biofuel for transportation needs. This is mainly due to government regulations and lack of support towards more biofuels in the fuel portfolio. Moreover, in Toulouse (France), effort towards biofuels broader usage is showcased by construction of CNG station that creates opportunities for local wholesales and distributors to swich their vehicles running on gas to biogas. This example outlines the importance of energy infrastructure in transition towards low carbon mobility. Another way to assist transition towards broader biofuel usage is showcased by French startup Lypech which is specialised in retrofitting diesel engine to GNV / Bio GNV. Retrofitted engines offer 90% reduction in fine particles emissions, 60% reduction in NOx, and 30% in CO2 emissions. The whole retrofitting process takes about a week thus offering their customers quick solution to decarbonise their existing vehicles.

As can be seen, there are numerous examples of good practices on the biofuel usage but there is still a lot of space for improvement and integration of biofuels into agri – food logistics.

13. MAIN LEARNINGS FROM ANALYSIS OF SUSTAINABLE SOLUTIONS TO REPLACE FOSSIL FUELS IN LOGISTICS

- **Importance of understanding the role of light electric freight vehicles (LEFV) in city logistics:** LEFVs are usually applied as a solution among other solutions in city logistics. According to Moolenburgh et al. (2020) [141], a mixed fleet of different vehicle types is necessary to guarantee flexbility needed to provide certainty that customer demands can be met. Not all shipments and deliveries will result in profitable use of LEFVs. Advanced planning and control systems are required to develop optimized routes and loading of each vehicle in the fleet. Transshipment points must be located close to or inside the city. The further the distance to transshipment points, the less suitable LEFVs become. For trips with long initial distances (more than 5km to the first stop) and long journeys (more than 30 km), the LEFV is often not an appropriate option.

- **Full potential of LEFVs can only be exploited with proper infrastructure and management:** LEFVs require adequate infrastructure to be properly utilized in urban supply chains. Aside from charging stations, this also implies new concepts such as smart newtorks based on IoT, smart charging, V2G etc. city logistics with LEFVs require good locations for hubs in the distribution network, robust processes, cooperation between customers, logistics service providers and suppliers, good insight into costs involved, modern Information and communication technologies and good organization.

- **Retrofitting as a solution in accelerating uptake of electricity in light and heavy-duty vehicles:** Retrofitting transforms an I.C.E. vehicle into an electric one by replacing the petrol/diesel engine and fuel tank with an electric motor and battery. The cost saving of converting existing vehicles into electric vehicles is estimated to be about 50% the cost of buying a new eLCV. In recognition of how retrofitting can be important in transitioning to cleaner transportation, governments are increasingly offering incentives and support programs to facilitate retrofitting.

- **Biomethane as a viable biofuel option for light duty vehicles in supply chain logistics:** Biomethane can be supplied to light duty vehicles (LDV) (also heavy duty) in two ways:

Dedicated retail filling stations supplying only biomethane (compressed or liquefied), which often comes from a plant nearby or is shipped in liquefied form (similar to LNG), or 2) Fuelling stations that are connected to the gas grid and offer natural gas blended with biomethane. Bin2Grid project [1] assessed technical requirements for usage of biomethane in local filling stations was assessed, with particular focus to transportation sector (e.g. waste management trucks).

14. PUBLIC POLICIES AND MECHANISMS

14.1 Current European Legal and Policy Framework

This section presents the outcomes of the review that was undertaken of the existing legal and policy framework for energy transition, focus on the current regulatory measures, requirements and financial initiatives that could support the transformation of the food distribution logistics chain in order to embed green, more sustainable solutions to optimize their operations. One of the most important element for this transformation is the sustainable mobility.

The EU policy framework for sustainable mobility aims to promote the use of clean, safe, and efficient transport systems. It includes measures to reduce greenhouse gas emissions from the transport sector, encourage the adoption of electric vehicles, and improve public transportation networks. The framework supports the development of integrated mobility systems that combine different modes of transport.

14.1.1 European Green Deal

The European Green Deal is a comprehensive plan aiming to make Europe the first climate-neutral continent by 2050. It includes a set of policy initiatives designed to reduce greenhouse gas emissions, promote sustainable industry, and protect the natural environment. Key related aspects include:

- New Circular Economy Action Plan
- EU Biodiversity Strategy for 2030
- The Farm to Fork Strategy
- Measures to decarbonize the energy sector

It also encompasses financial mechanisms such as the **Just Transition Mechanism** to support regions most affected by the green transition. However, challenges such as securing sufficient funding and ensuring member states' cooperation remain and continuous monitoring and adjustments are necessary to address these issues.

14.1.2 Legislative Package Fit for 55

The Fit for 55 package is a comprehensive set of proposals aimed at aligning EU

policies with the goal of reducing net greenhouse gas emissions by at least 55% by 2030. It includes revisions to existing legislation and new initiatives covering areas such as renewable energy, energy efficiency, emissions trading, and land use.
In the transport sector, the package proposes:

- Stricter CO2 emission standards for cars and vans
- Promotion of sustainable aviation fuels
- Introduction of a carbon border adjustment mechanism

These measures are designed to ensure that the EU meets its climate targets while supporting economic growth and technological innovation.

The Fit for 55 package is currently under negotiation, with several proposals already adopted by the European Parliament and Council. The implementation process involves transposing the new regulations into national law and ensuring that Member States have the necessary frameworks in place to meet the targets. Challenges include balancing economic growth with environmental sustainability and ensuring fairness and solidarity among Member States.

14.1.3 European Climate Law

The European Climate Law [206] enshrines the EU's commitment to climate neutrality by 2050 into law. It sets a binding target of reducing net greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels. The Law includes:

- Measures for monitoring and reporting progress
- A framework for setting intermediate targets
- Provisions for adapting policies as needed to ensure the targets are met.

The Act also establishes the European Scientific Advisory Board on Climate Change to provide independent scientific advice.
The European Climate Law has been adopted and entered into force in July 2021. Member States are required to submit national long-term strategies and implement policies aligned with the climate targets. The Law's implementation is supported by regular reviews and updates to ensure progress towards the 2050 climate neutrality goal. Challenges include ensuring compliance and achieving the necessary emissions reductions across all sectors.

14.1.4 Sustainable and Smart Mobility Strategy (SSMS)

The Sustainable and Smart Mobility Strategy (SSMS) [207] outlines the EU's vision for the future of transport, focusing on sustainability, digitalization, and resilience. The strategy aims to reduce transport emissions by 90% by 2050, through measures such as boosting rail and inland waterway transport, promoting the use

of sustainable fuels, and enhancing the deployment of digital technologies. It also includes initiatives to improve urban mobility and ensure that transport systems are inclusive and accessible to all. Key aspects include regulatory measures, financial support for infrastructure projects, and incentives for clean technology adoption.

The SSMS is in the early stages of implementation, with several key initiatives already underway, such as the promotion of alternative fuels and the expansion of the Trans-European Transport Network (TEN-T). However, achieving the ambitious targets set by the strategy will require sustained effort and collaboration between Member States, industry, and other stakeholders.

14.1.5 Regulation (EU) 2019/631 — establishing CO2 emissions performance standards for new passenger cars and for new light commercial vehicles

The regulation [208] establishes CO2 emissions performance requirements for new passenger cars and new light commercial vehicles (e.g. vans). It aims to make road transport cleaner, to achieve the European Union's (EU) greenhouse gas emissions reduction targets (see summary) for 2030 and beyond and to contribute to the objectives of the Paris agreement.

Regulation (EU) 2023/851 [209] amends Regulation (EU) 2019/631, aligning EU CO2 emissions reduction targets for new cars and vans with revised EU CO2 targets, set out in the European Climate Law (Regulation (EU) 2021/1119).

These requirements will also contribute to the EU's target of reducing greenhouse gas emissions in sectors not covered by the Emissions Trading System by 40% by 2030, compared to 2005.
The amended Regulation (EU) 2019/631 will:

- contribute to reaching at least 55% net greenhouse gas emission reductions by 2030 compared to 1990 as well as achieving climate neutrality by 2050, in line with the European Climate Law;
- provide benefits to EU citizens and vehicle users as a result of the wider deployment of clean and affordable zero-emission vehicles,
- spur innovation in zero-emission technologies, strengthening the EU’s technological leadership of the automotive value chain and stimulating employment in the EU.

Target levels
Below are the EU fleet-wide CO2 emission targets set in the Regulation:

2020 to 2024

- Cars: 95 g CO2/km
- Vans: 147 g CO2/km

These target levels refer to the **NEDC emission test procedure.**

2025 to 2034

The targets that will apply from 2025 onwards are based on the **WLTP (Worldwide harmonized Light vehicles Test Procedure)** and were set out in Commission Implementing Decision (EU) 2023/1623 [210]:

- Cars: 93,6 g CO2/km (2025-2029) and 49,5 g CO2/km (2030-2034)
- Vans: 153,9 g CO2/km (2025-2029) and 90,6 g CO2/km (2030-2034)

From 2035 onwards, the EU fleet-wide CO2 emission target for both cars and vans is 0 g CO2/km, corresponding to a 100% reduction.

The annual specific emission targets of each manufacturer are based on these EU fleet-wide targets, taking into account the average mass of its registered new vehicles. Since 2021, those specific emission targets are based on the WLTP.

The manufacturer targets for the **years 2021-2024** are calculated in accordance with point 4 of Annex I (parts A and B) to Regulation (EU) 2019/631, using the values set out in Annex II to Commission Implementing Decision (EU) 2022/2087 [211].

The manufacturer targets **from 2025 onwards** are calculated in accordance with point 6 of Annex I (parts A and B) to Regulation (EU) 2019/631, using the values set out in Annex II to Commission Implementing Decision (EU) 2023/1623 [210].

14.1.6 Existing EU initiatives for the acceleration of the energy transition

The following tables present a review of the EU-wide initiatives related to the project objectives, including structures introduced by these networks, for coordinating and monitoring energy transition plans and actions. The main objectives of the provided elements are described as well as the implementation status e.g. progress, expected or achieved impacts and possible barriers.

Table 29. Covenant of Mayors for Climate & Energy - Europe

Region/Country	Europe
Element of the legal or policy framework	Covenant of Mayors for Climate & Energy - Europe
Description/Key aspects	Launched in 2008, the CoM has grown to be the largest movement for local climate and energy actions, bringing together thousands of local governments voluntarily committed to implementing EU climate and energy objectives. Commitment of signatories to achieve 40% CO2 reduction in their territories by 2030 and common approach for the mitigation and adaptation to climate change. Shared vision for decarbonization by 2050. CoM signatories (municipalities from all over the EU and beyond) commit to submitting, within two years following the date of their adhesion to the CoM, a Sustainable Energy and Climate Action Plan (SECAP) outlining the key actions they plan to undertake.
Implementation status	Since its initial launch in 2008, CoM - Europe has grown to be the largest movement for local climate and energy actions, bringing together thousands of local governments voluntarily committed to implementing EU climate and energy objectives. The initiative key success factors are considered to be the introduced bottom-up approach to energy and climate actions, the multi-level cooperation model and its context-driven framework for action. The initiative now gathers 10,000+ local and regional authorities across 54 countries. (54 countries, 10,948 Signatories, 233 Coordinators, 241 Supporters)
References	EC CoM web page [212]

Table 30. Global Covenant of Mayors for Climate & Energy

Region/Country	Europe - World
Element of the legal or policy framework	Global Covenant of Mayors for Climate & Energy

Description/Key aspects	The Global CoM for Climate & Energy (GCoM) is the largest global alliance for city climate leadership, build upon the commitment of over 11,500 cities and local governments sharing a long-term vision for combatting climate change. GCoM was created in 2017, formally bringing together the EU Covenant of Mayors (launched in 2008) and the Compact of Mayors (launched in 2014) – the world's two primary initiatives of cities and local governments – to advance city-level climate action and demonstrate global impact. GCoM serves cities and local governments by mobilizing and supporting ambitious, measurable and planned climate and energy action in their communities. Committed cities work towards compliance with the GCoM framework and as part of their commitments, signatories: (1) develop a greenhouse gas emissions inventory and report their results; (2) assess climate risks and vulnerabilities; (3) define climate change mitigation targets; (4) develop integrated climate action plans to meet their stated targets and goals; (5) implement planned measures to reach targets and goals; (6) monitor, measure and report progress on a regular basis, to share their results and improve their ambition implementation over time.
Implementation status	The GCoM has grown to be the largest global alliance for city climate leadership, built upon the commitment of 11,500+ cities and local governments, from 6 continents and 142 countries, sharing a long-term vision for combatting climate change.
References	Global Covenant of Mayors web page [213]

Table 31. ManagEnergy – Energy Agencies leading the energy transition

Region/Country	Europe
Element of the legal or policy framework	ManagEnergy – Energy Agencies leading the energy transition
Description/Key aspects	ManagEnergy is a European Commission initiative (first launched in 2002) with the objectives of supporting regional and local energy agencies in becoming leaders in the energy transition and of increasing sustainable energy investments in regions and cities. It provides information, know-how and networking opportunities. ManagEnergy offers support to Energy Agencies through the following services:

	• Master Classes: A tailor-made 3-day programme in Brussels, delivered by leading energy experts and targeting senior and management level energy agency staff. • Expert Missions: Providing know-how to energy agencies in the field of energy efficiency financing in their own region/city. • Networking Events: Annual networking events organized to increase cooperation, knowledge and peer exchange between energy agencies across Europe. ManagEnergy Talks: A range of Public Talks held in the evenings to inform interested stakeholders about the latest developments in energy efficiency financing and project development
Implementation status	In the period 2017-2020 many of the above events were organized and information is available on ManagEnergy website. Between 2001 and 2015 ManagEnergy organized 45 capacity building workshops in EU Member States and 33 networking events.
References	ManagEnergy web page [214]

14.2 REGIONAL/NATIONAL REGULATIONS AND MECHANISMS

All the European Directives mentioned in the previous section, applicable to mobility and challenges of the food distribution logistics chain, have been or will be transposed into the legal system of each of the member countries of the European Union.

Although most of these directive transpositions focus on the objectives of reducing CO_2 emissions, the use of renewable energy and the drive towards the transformation of current mobility into a more sustainable one, there are also some regulations (national/ regional) and/or lines of support that directly aim at transport, mobility and the challenges of the food distribution logistics chain. Below a summary of Regional/National policies in the area of mobility and challenges of the food distribution logistics chain is presented.

Table 32. The Sustainable Energy and Climate Action Plans (SECAP) and the National Renewable Energy Action Plans (NREAP) in Montenegro

Region/Country	Montenegro
Element of the legal or policy framework	The Sustainable Energy and Climate Action Plans (SECAP) and the National Renewable Energy Action Plans (NREAP) in Montenegro
Description/Key aspects	Montenegrin national government has implemented policies to improve sustainable mobility, focusing on reducing greenhouse gas emissions and promoting public transportation. This includes subsidies for electric and hybrid vehicles, incentives for using public transportation, and developing infrastructure for non-motorized transport like cycling and walking paths. The Sustainable Energy and Climate Action Plan (SECAP) and the National Renewable Energy Action Plan (NREAP) outline Montenegrin commitments to increase energy efficiency, reduce carbon emissions, and expand the use of renewable energy sources. These plans set specific targets for renewable energy adoption and outline measures to achieve these goals, including investments in infrastructure and technology. Regional policies support the national strategy by promoting renewable energy projects and sustainable mobility at the local level. Regions within Montenegro are encouraged to develop their own Sustainable Urban Mobility Plans (SUMP) and to participate in national programs that provide financial support for local renewable energy projects. Montenegro offers various subsidies and grants to support renewable energy and sustainable mobility projects. These include financial incentives for installing solar panels, wind turbines, and other renewable energy systems, as well as grants for research and development in energy efficiency technologies. Additionally, there are tax reductions for businesses and households that invest in green technologies. The government has initiated several training and education programs aimed at building capacity in the renewable energy and sustainable mobility sectors. These programs target engineers, technicians, policymakers, and the general public, providing them with the knowledge and skills needed to implement and maintain sustainable energy systems. Public awareness campaigns are also conducted to educate citizens on the benefits of renewable energy and energy efficiency measures. *Regional: Serbian National Renewable Energy Action Plan targets a 27% share of renewable energy in gross final energy consumption by 2025, focusing on hydropower, biomass, and wind energy projects.*

	Bosnia and Herzegovina is implementing the Framework Energy Strategy until 2035, promoting hydropower and wind energy to enhance energy security and reduce greenhouse gas emissions. *North Macedonia aims to achieve a 23% renewable energy share in its final energy consumption by 2025, with significant investments in solar and wind energy as part of its Energy Development Strategy.*
Implementation status	Montenegro is making significant strides in implementing its Sustainable Energy and Climate Action Plan (SECAP) and the National Renewable Energy Action Plan (NREAP). Key initiatives, such as the development of the Bijela wind farm and various solar projects, are progressing well. Public transportation improvements, including the installation of electric vehicle charging stations and the introduction of electrified buses, are underway. Challenges include securing adequate funding for large-scale renewable energy projects, overcoming bureaucratic hurdles, and ensuring technical readiness. The integration of new technologies into existing infrastructure also presents technical challenges. While some projects are on track, others have experienced delays due to regulatory approvals and logistical issues related to project financing and implementation.
References	NATIONAL STRATEGY FOR SUSTAINABLE DEVELOPMENT OF MONTENEGRO [215]

Table 33. Low emissions zone in urban center of the main metropoles in France

Region/Country	France
Element of the legal or policy framework	Low emissions zone in urban center of the main metropoles in France
Description/Key aspects	"Low emission zones are a tool to improve air quality. Their implementation responds to the need to protect public health. Indeed, air quality is improving in France, but remains a major public health issue, particularly in large cities, which requires continued action. Two main laws govern the establishment of Low Emission Zones (ZFE) in France: • Mobility orientation law of December 24, 2019: This law encourages the development of alternative mobility solutions to the individual car, including retrofit. • Climate and Resilience Law of August 22, 2021: This law sets ambitious objectives for reducing greenhouse gas emissions,

	• which can encourage the retrofit of polluting vehicles. • Order of March 13, 2020 relating to the conditions for transforming vehicles with thermal engines into battery or fuel cell electric engines: This order defines the technical conditions that a retrofit kit must comply with to be approved in France. • Low Emission Zones (ZFE): ZFEs, which prohibit or restrict the circulation of the most polluting vehicles, can encourage owners of these vehicles to retrofit them in order to continue using them. In April 2023, the government adopted a national action plan dedicated to retrofitting to support the development of the sector, including administrative simplification and national financial aid or bonuses. Finally, the Government supports the definition of a European framework for retrofit, making it possible to harmonize the different national frameworks and create a true European market. Low Emission Zones in Marseille Following Paris, Nice or Toulouse, Marseille has installed a ZFE. This is an area where the circulation of certain categories of vehicles is prohibited or limited. The different categories of vehicles are identified using the Crit'Air sticker system, which classifies vehicles according to their level of pollution (year and type of fuel). Since September 2022, within a perimeter of 19.5 km² in the city center of Marseille involving 314,000 inhabitants, access is prohibited 7 days a week and 24 hours a day to Crit'Air 5 and non-classified vehicles. Across Bouches-du-Rhône, this concerns 2% of personal vehicles, 4.4% of heavy goods vehicles and 1% of utility vehicles. Since September 2023, Crit'Air 4 vehicles are no longer authorized to drive or park within the perimeter of the ZFE. From September 2025, only vehicles equipped with a Crit'Air 2, Crit'Air 1 or Crit'Air 0 sticker will be authorized to drive or park within the perimeter of the ZFE."
Implementation status	In progress
References	The Regional Directorate for the Environment, Planning, and Housing of Provence-Alpes Côte d'Azur communication on Marseille LEZ [216]

Table 34. Loi d'orientation agricole / law on the future of agriculture (2014) in France

Region/Country	France
Element of the legal or policy framework	Loi d'orientation agricole / law on the future of agriculture (2014) in France
Description/Key aspects	Creation of the territorial food projects (Plan alimentaire territoriaux) and the national food program, which offers financial instruments for this purpose. The Territorial food projects (PAT) aim to relocalize agriculture and food in local areas by supporting the installation of farmers, short supply chains and local products in canteens (mass catering). They are drawn up collectively on the initiative of local players (local authorities, agricultural and agri-food businesses, craftsmen, citizens, etc.).
Implementation status	In progress (from 2014). Today, 11 territorial food projects have been recognized by the French Ministry of Agriculture as successful initiatives, and a further 10 applications are due to be submitted in the near future.
References	Ministry of Agriculture, Food Sovereignty and Forestry of France – information on territorial food projects [217]

Table 35. Derogations in the French rural code authorizing farmers to carpool their produce as part of a mutual aid scheme

Region/Country	France
Element of the legal or policy framework	Derogations in the French rural code authorizing farmers to carpool their produce as part of a mutual aid scheme
Description/Key aspects	Farmers are eligible for exemptions from the general road haulage regime. 3 main exemptions for farmers : - Article R 3211-3 of the French Transport Code: exemption for individual farmers carrying out transport activities within a 100 km radius; - Article R 3211-4 of the Transport Code: exemption for groups of agricultural of agricultural enterprises; - A derogation included in the Rural Code: mutual agricultural assistance.

	The Law on mobility (Loi d'orientation sur les mobilités - LOM) n°2019-1428 of December 24, 2019 art. 40 and the Décret n° 2020-1088 of August 24, 2020 relax some rules allowing farmers to co-transport products with the aim of delivering their customers: • the application procedure for authorization to operate as a road haulier has been simplified for all, including farmers. • the definition of mutual agricultural aid has been clarified. The specificity of agricultural mutual aid is that it's a free contract and that the sharing of expenses is authorized, which is not the case in the Transport Code. • Definition of shared parcel transport
Implementation status	Running (from 2020). Expert consider there is still some improvement to do on the legislation to allow the mutualisation of transport by farmers in good conditions.
References	Sharing of transport among actors in short supply chains report [218]

Table 36. Egalim Laws in France

Region/Country	France
Element of the legal or policy framework	Law Egalim I (2018) for balanced trade relations in the agricultural and food sector and healthy, sustainable food accessible to all. Law Eglim II (2021) to protect farmers' income Law Egalim III (2023) to strengthen the balance in commercial relations between suppliers and distributors -France
Description/Key aspects	Encourages the introduction of local and environmentally-friendly products in collective catering: Article L. 230-5-1 of the CRPM stipulates that by January 1, 2022 at the latest, meals served in the collective restaurants mentioned in article L. 230-5 of the CRPM for which public corporations are responsible must include 50% sustainable and quality products, 20% of which must be organic (labelized). Sustainable and quality products include, in particular, eco-labeled products, products bearing the ""EU outermost regions"" graphic symbol, products from farms with High Environmental Value (HVE) certification, fair-trade products, and products purchased on the basis of ""environmental performance"" and ""short circuit"" criteria. In the case of ""organic farming products"", only products bearing the (national or EU) organic farming label and in-conversion products of plant origin labelled ""in conversion to organic farming"" can be counted under this heading.

	In addition to these two obligations, from January 1, 2024, public purchasers will also have to acquire 60% of beef, pork, sheep, poultry and fish products qualifying as sustainable, high-quality meat and fish as defined in the aforementioned article. For collective restaurants run by the State, its public establishments and national public enterprises, the rate is set at 100%."
Implementation status	Running (From 2022 and 2024)
References	French law on n the balance of trade relations in the agricultural and food sector and healthy, sustainable and accessible food for all [219]

Table 37. Law 2016-138 of February 11, 2016 on the fight against food waste, known as the Garot Law - France

Region/Country	France
Element of the legal or policy framework	Law 2016-138 of February 11, 2016 on the fight against food waste, known as the Garot Law - France
Description/Key aspects	Garot law authorizes the tax exemption of food donations • Food stores over 400 m2 must sign a donation agreement with associations to take back unsold food that can still be consumed. • A ban on food distributors making unsold food unfit for consumption.
Implementation status	Running (From 2016)
References	French law on the fight against food waste [220]

Table 38. The National Development Strategy of the Republic of Croatia until 2030

Region/Country	Croatia
Element of the legal or policy framework	The National Development Strategy of the Republic of Croatia until 2030

Description/Key aspects	The aim of the Development Strategy is to provide a clear vision and goals for the development of Croatia, in line with the goals set out in the European Green Deal and the European Territorial Programme 2030. Regarding mobility, the Strategy does include sustainable mobility as one of its strategic goals; however, only general implementation measures are given. The promotion of zero-emission transport and investments aimed at reducing GHG emissions are listed as one of the priorities.
Implementation status	In progress
References	Croatian Development Strategy [221]

Table 39. The Low-Carbon Development Strategy of the Republic of Croatia until 2030 with an outlook to 2050

Region/Country	Croatia
Element of the legal or policy framework	The Low-Carbon Development Strategy of the Republic of Croatia until 2030 with an outlook to 2050
Description/Key aspects	Indicated as one of the basic traffic measures for achieving low-carbon transport, the Strategy includes the use of low-CO_2 and alternative fuels. Sustainable freight transport is also included as a basic measure. There is an increase in the use of natural gas, synthetic gas, and biogas in buses, and vehicles transporting both light and heavy goods. The Strategy signifies that the usage of biofuels should be limited to advanced biofuels, whose production does not negatively affect agricultural production. It emphasizes the importance of incentives and innovations in developing advanced biofuels to make it a sustainable fuel of the future. Low-carbon urban transport is emphasized as a priority in achieving sustainable transport systems in city centres. Optimization of urban freight transport logistics systems and the use of low-emission fuels are key measures to be taken by 2030. By 2050, it is expected that alternative fuels will be in widespread use, and intelligent logistics systems will be developed in cities, thus almost completely eliminating GHG emissions from urban areas.
Implementation status	In progress
References	The Low-Carbon Development Strategy of the Republic of Croatia until 2030 with an outlook to 2050 [222]

Table 40. Updated integrated national energy and climate plan for the republic of Croatia for the period 2021 - 2030

Region/Country	Croatia
Element of the legal or policy framework	Updated integrated national energy and climate plan for the republic of Croatia for the period 2021 - 2030
Description/Key aspects	The NECP projects the share of renewable energy (RE) in the transport sector to reach 21.6% by 2030, however, the plan has not specified an equivalent target for GHG reduction. Main measures indicated include the promotion of EVs and charging infrastructure, as well as the introduction of mandatory quotas for the consumption of conventional and advanced biofuels by 2030. Furthermore, the plan envisions that the share of advanced biofuels will significantly contribute to the RE targets set for 2030. Transport decarbonization includes measures such as regulatory instruments, standards, and taxes, promoting the utilization of low-emission vehicles, which will also contribute to the uptake of public transport and active mobility (e.g., cycling). However, the plan is not clear on the expected uptake of zero-emission vehicles and how the provisions of the Alternative Fuels Infrastructure Regulation will be fulfilled. Even though the plan envisions a broad set of financial measures and incentives matching the general objective, and scenarios with a steep increase of RES in transport, the projected share of EV and plug-in hybrid vehicles is only expected to be 10% by 2030.
Implementation status	In progress
References	Croatian updated NECP draft [223] EC recommendation on the updated NECP draft [224]

Table 41. Law 4710/2020 on the Promotion of e-mobility - Transposition of directive 2019/1161/EU into the Greek legislation

Region/Country	Greece
Element of the legal or policy framework	Law 4710/2020 on the Promotion of e-mobility - Transposition of directive 2019/1161/EU into the Greek legislation
Description/Key aspects	The purpose of this Law is the promotion of the use of electric vehicles, the development of publicly accessible recharging infrastructure and the formation of a full-fledged regulatory framework for the e-mobility market. The Law includes:

	• General rules and incentives for the promotion of e-mobility • Tax incentives related to the purchase, leasing and use of electric vehicles • Regulations for the organization and operation of the e-mobility market Urban planning regulations apply for the installation of charging stations and spatial planning regulations for the development of publicly accessible charging stations
Implementation status	Progress: • Subsidies for the purchase of electric vehicles • Subsidies and tax exemptions for companies • Replacement of the vehicle fleet in Municipalities (25% of new vehicles are expected to be electric, form 08/2021) Barriers: • Lack of infrastructure – few chargers in the road network • Distrust of this new technology
References	Greek law on the promotion of e-mobility [225]

Table 42. Greek National Energy and Climate Plan (2019)

Region/Country	Greece
Element of the legal or policy framework	National Energy and Climate Plan (2019) The Greek government's strategic plan for climate and energy issues, setting out a detailed roadmap regarding the attainment of specific energy and climate objectives by 2030
Description/Key aspects	The NECP stresses Greece's priorities and development potential in terms of energy and addressing climate change and aims to serve as the key tool for drawing up the national energy and climate policy in the next decade, taking into account the Commission's recommendations and the UN sustainable development goals. The NECP sets out and details the individual policy priorities for the forthcoming period and the corresponding policy measures that are being planned for implementing the priorities and attaining the objectives of the NECP, under seven different themes: 1. Climate change, emissions and removals of greenhouse gases 2. Renewable energy sources 3. Improvement in energy efficiency 4. Security of energy supply 5. Energy market 6. Agriculture, shipping, tourism (new theme) 7. Research, innovation and competitiveness

	The NECP addresses: • An integrated model for sustainable and viable growth in all economic sectors • Combined energy sector development and environmental protection through bold measures for addressing climate change • Choosing energy policies with the most cost-benefit ratio for energy transition • Waste management and utilisation by the use of state-of-the-art circular economy technologies • Transforming Greece into an energy hub with a strong contribution to the EU's energy security and security of supply • Ensuring the strategic diversification of energy imports, while at the same time modernising and developing energy infrastructures and putting an end to the energy isolation of the islands • Setting up attractive investment environment to support energy transition, focusing on innovation and new technologies • Ensuring the maximum possible use of community resources and mechanisms • Ensuring openness and innovation in order to achieve growth that will create new jobs
Implementation status	Barriers-delays: • The technical measures described in the NECP are not accompanied by a mobilization of investment costs. • Limited mobilization of private funds
References	Greek NECP (2019) [226]

Table 43. Energy Efficiency Action Plan of Split-Dalmatia County for the period 2022. – 2024.

Region/Country	Split-Dalmatia county as an example, Croatia
Element of the legal or policy framework	Action plan for energy efficiency of Split-Dalmatia county 2022-2024 as a good practice, based on National Energy Efficiency Action Plan, Energy efficiency action plans in Croatia are developed on regional level (and large cities) on three year basis with the current ones covering the scope of 2022-2024"
Description/Key aspects	Transport is identified as one of the three main technical measures for energy efficiency, along with buildings and public lighting. Transport measures aim to promote electromobility in three main areas: public vehicles, taxi vehicles, and light delivery vehicles (N1 category). Through financial incentives and subsidies, the county aims to cofinance up to 20% of new

	delivery EVs. These measures will result in approximately 100 new delivery EVs. Other regional action plans have similar transport measures, as transport is identified as a priority in the national master plan.
Implementation status	In progress
References	Energy Efficiency Action Plan of Split-Dalmatia County for the period 2022. – 2024. [227]

Table 44. Regional Plan for the Adaptation to Climate Change of the Region of Crete

Region/Country	Greece
Element of the legal or policy framework	Regional Plan for the Adaptation to Climate Change of the Region of Crete
Description/Key aspects	The Region of Crete has recently completed the Study of the ""Regional Plan for Climate Change Adaptation of the Region of Crete"" which is the strategy to address the threat of climate change, with the main goal of reducing the vulnerability of the Region resulting from climate change and its shielding against it. The elaboration, as well as the specifications and the specific content of the Regional Plan for the Adaptation to Climate Change (RPACC) are specified by the Ministerial Decision no. 11258/2017 (Government Gazette 873 /B/ 16-03-2017). The project has been financed by the Operational Program of Crete, priority axis 2 "Sustainable Development by upgrading the environment and addressing the effects of climate change in Crete". The "Regional Plan for Climate Change Adaptation" elaborates the changes that will occur in the coming decades in the Region by assessing 14 key areas affected by the effects of climate change and the geographical areas that should be given priority were identified. The study also identifies and prioritizes the necessary measures and actions for adaptation to climate change for the next 5 to 15 years, their timeline and costs. The "Regional Plan for Climate Change Adaptation" is expected to be a guide for the Region and will allow municipalities and other competent bodies to prepare and mature all projects related to adaptation to climate change, for their successful integration in the new programming period for the NSRF (2021 - 2027).
Implementation status	In progress
References	Regional Plan for Climate Change Adaptation [228] SafeCrete webpage [229]

Table 45. Regional plan: REPOS - Positive energy region (Act II - 2022): Plan for the power to live and energy sovereignty in France

Region/Country	Région Occitanie (France)
Element of the legal or policy framework	Regional plan : REPOS - Positive energy region (Act II - 2022) : Plan for the power to live and energy sovereignty in France
Description/Key aspects	Objective: To achieve the objective set by the Region of covering almost half of its energy needs through the production of local renewable energies by 2030, and 100% by 2050. How ? (measures linked with GARDEN) : • To double the number of electric charging points (5,000 more) by the end of the mandate, including high-power, fast-charging stations offering a high-quality service. • A new eco-mobility voucher dedicated to craft businesses for new light commercial vehicles. The scheme will be available to all craft businesses in the Occitanie region. The scheme, which is currently being finalised, will be put to the vote of the Standing Committee in December. • Eligible vehicles will be those ordered after October 1 and delivered after January 1, 2023, subject to the scrapping of an old vehicle and with the advantage of recovering VAT. The amount can be up to €3,000. The Region will also be offering assistance of up to €1,000 for the purchase of a cargo bike.
Implementation status	In progress (from 2022)
References	Plan for the power to live and energy sovereignty in Région Occitanie [230]

Table 46. Clean energy for all Europeans' package, the Clean energy for EU islands initiative

Region/Country	EU islands
Element of the legal or policy framework	Clean energy for EU islands
Description/Key aspects	As part of the 'Clean energy for all Europeans' package, the Clean energy for EU islands initiative, launched in 2017, provides a long-term framework to help islands generate their own sustainable, low-cost energy.

	The initiative builds on a political declaration, signed by the European Commission and 14 EU countries with large island populations (Croatia, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Malta, Portugal, Spain, and Sweden). As a follow-up, the parties also signed a Memorandum of Understanding (MoU) in June 2020, to establish a long-term framework for cooperation to advance the energy transition and identify best practices on challenges that cannot be addressed at island-level. In 2018, the European Commission, in cooperation with the European Parliament, set up the **Clean energy for EU islands secretariat** to deliver the objectives of the Clean energy for EU islands initiative
Implementation status	Since the launch of the initiative, the Community now includes 76 islands, 29 of which have published Clean Energy Transition Agendas / Plans. 14 EU countries with large island populations (Croatia, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Malta, Portugal, Spain, and Sweden)
References	Vision for clean energy islands [231]

Table 47. Energee-Watch: The European Network of Regional GhG Emissions and Energy Watch

Region/Country	EU
Element of the legal or policy framework	Energee-Watch: The European Network of Regional GhG Emissions and Energy Watch
Description/Key aspects	ENERGee WATCH is a European network of GhG Emissions observation and gives its name to a European project of peer-to-peer learning program enabling regional and local authorities to properly define, monitor and verify their sustainable actions. Members of the Energee Watch network and mentors of the project all have tools to inform energy transition policies and monitor their implementation on their territories.
Implementation status	20 members - 11 countries
References	ENERGee Watch – overview of regional observatories [232]

Table 47. DAFNI – Network of Sustainable Greek Islands

Region/Country	Greece
Element of the legal or policy framework	DAFNI – Network of Sustainable Greek Islands
Description/Key aspects	DAFNI – Network of Sustainable Greek Islands is a non-profit organization of island local and regional authorities. Founded in 2006. DAFNI aims to strengthen island local governance and help islands embark on a sustainable development paradigm, through the integrated management of natural resources and infrastructures, the uptake of sustainable tourism and the enhanced interdependence of the primary, secondary and tertiary sectors.
Implementation status	Several projects have been initiated by DAFNI. Among them are initiatives such as the "Pact of Islands" and the "Smart Islands Initiative", as well as the Smart Islands Education. The aim of the Smart Islands Education initiative is to create a network of teachers with strong action both in the school and in the local community of the island, willing to get in touch with innovative technologies and practices for the sustainable management of the infrastructure of the islands through their participation in Of Greece. The program was attended by 10 secondary school teachers from a number of Greek islands (Rhodes, Tinos, Cephalonia, Crete etc.) DAFNI also provided technical support to the Municipal Service for water supply and sewage in order to promote all the necessary studies for the construction of a wind farm with a capacity of 1.8 MW at Agia Marina in the Municipality of Kos. DAFNI Network counts 56 members of which 52 island Municipalities, the Regions of North Aegean, South Aegean, Ionian Islands and the Regional Union of Municipalities of the Ionian Islands.
References	DAFNI Network of Sustainable Greek Islands web page [233]

Table 48. Greening the Islands Foundation

Region/Country	Tanzania, Greece, Maldives, Italy, Malta, Germany, Tunisia, Spain, Estonia, Croatia, United Kingdom, Cape Vert
Element of the legal or policy framework	Greening the islands

Description/Key aspects	Greening The Islands matches islands needs with innovative solutions and facilitates the origination of projects for the sustainable transition of islands and their replicability on the mainland by acting as a catalyst in relationships between governments, business, academia and citizens, disseminating knowledge and best practices. The Greening the Islands Observatory aggregates key stakeholders to: • Match island needs and innovative sustainable solutions • Produce reports & studies to address strategies and policies • Originate projects, business models and financing opportunities • Promote the cooperation between governments and corporates
Implementation status	The Greening the Islands Observatory was launched at the 2018 Greening the Islands international conference of Minorca. There are 20 members.
References	Greening the Islands Foundation [234]

Table 49. Cretan Energy cluster

Region/Country	Greece
Element of the legal or policy framework	Cretan Energy cluster
Description/Key aspects	The CRETAN ENERGY CLUSTER is a small cluster for renewable energies and environmental technologies. It provides services for green-tech companies in the field of renewable energy and energy efficiency technologies, and it is located in Crete, Greece. In order to strengthen and extend his position, the CRETAN ENERGY CLUSTER is supporting member companies as a personal business partner through innovation and R&D support, international marketing and access to new markets. CRETAN ENERGY CLUSTER aims to: • The organized promotion of RES systems; • The emergence of our natural energy resources; • Informing and educating our members about new markets; • The communication with local educational institutions and public bodies; • Organized contact with suppliers.
Implementation status	Slow pace of expanding the network with new project initiatives and new members. The Cluster includes 10 companies which employ more than 140 people.
References	Cretan Energy cluster web page [235]

14.3 Local Authorities Regulations and Mechanisms

The GARDEN project partners have conducted an extensive search for policies and regulations that local authorities in the Mediterranean area can and/or do apply in the area of mobility and the challenges of the food distribution logistics chain.
The information gathered concludes that at a local level, sustainable mobility has become a shared concern for most cities, which are committed to the quality of public transport, the promotion of non-motorised modes (walking and cycling), sensitivity towards the environment, a more rational use of public space and, ultimately, policies that directly impact the quality of life of their citizens and improve the image of the city.

In this sense, local authorities implement policies and/or regulations that contribute to this objective. These policies and regulations, beyond the adoption of specific measures, seek above all to consolidate certain patterns and sensitivities in the local management of mobility, seeking consensus and participation, maintaining long-term guidelines and improving information and decision-making systems.
Few of these policies and/or regulations refer specifically to the de carbonisation of food transport logistics. However, although these are not specific regulations for food logistics, most of the initiatives adopted by local authorities in the field of sustainable mobility and reduction of greenhouse gas emissions directly affect food logistics and transport.

Mainly local authorities in the Mediterranean area make use of 3 types of regulations in the field of sustainable mobility. These regulations and mechanisms are the following:

- **Develop and implementation of Sustainable Mobility plan (SUMP)**
- **Develop and implementation of Sustainable Energy Action Plan (SECAP)**
- **Creation of Low Emission Zones in urban areas (LEZ)**

Below are some summary tables with the different regulations and mechanisms applied by local authorities.

Table 50. Low Emission Zones (LEZ) in Sofia, Bulgaria

Region/Country	Bulgaria
Element of the legal or policy framework	Low Emission Zones (LEZ)
Description/Key aspects	Low Emission Zones (LEZ) restrict access to certain areas for vehicles that do not meet specific emissions standards. The goal is to reduce air pollution, particularly in urban centers. In Sofia, for instance, the LEZ is implemented to decrease the concentration of NOx and particulate matter (PM2.5 and PM10). Vehicles must comply with Euro 4 standards for petrol and Euro 6 for diesel to enter the zone without incurring fines. This initiative is supported by public awareness campaigns and subsidies for vehicle upgrades.
Implementation status	The LEZ in Sofia is currently in operation with ongoing expansions planned. Initial results show a reduction in air pollutants, but challenges remain in terms of public acceptance and enforcement. Continuous monitoring and adaptation of the regulation are necessary to address these issues.
References	Sofia municipality web page [236]

Table 51. Montenegro: SUMP, SECAP, LEZ

Region/Country	Montenegro
Element of the legal or policy framework	Sustainable Urban mobility Plan (SUMP) Sustainable Energy and Climate Action Plan (SECAP) Low Emission Zones (LEZ)
Description/Key aspects	The Energy Development Strategy of Montenegro aims to reduce greenhouse gas emissions by integrating more renewable energy sources into the national energy mix. This includes leveraging hydropower, wind energy, and solar power to reduce reliance on fossil fuels. The strategy mandates the use of best available technologies to minimize emissions and sets stringent standards for energy production facilities to comply with environmental regulations. Montenegrin strategy includes implementing Sustainable Urban Mobility Plans (SUMP) that promote public transportation, cycling, and walking to reduce vehicular emissions. The Sustainable Energy and Climate Action Plan (SECAP) outlines measures to increase energy efficiency and promote renewable energy across municipalities.

	There are also plans to establish zero-emission zones in urban areas to further reduce pollution levels. The strategy emphasizes the development of a robust public transport network, including electrified buses and trams. Public charging stations for electric vehicles are being installed across major cities, with reduced fees to encourage their use. Additionally, there are incentives for reducing municipal vehicle taxes for electric and hybrid vehicles. Active mobility initiatives include creating pedestrian zones and cycling paths to promote healthier lifestyles and reduce traffic congestion. Financial support programs are available to households and businesses for installing renewable energy systems, such as solar panels and small wind turbines. Tax incentives are provided for investments in energy efficiency improvements and renewable energy projects. The government has also introduced ordinances to reduce property taxes for buildings that meet green building standards.
Implementation status	The strategy is in the implementation phase, with key projects like the Bijela wind farm reaching financial closure and expected to start construction in early 2025. Challenges include securing necessary financing, regulatory approvals, and ensuring the technical readiness of new energy projects. Projects are progressing according to the strategic timeline.
References	• https://wapi.gov.me/download-preview/04984c44-4299-4bf8-8ced-98e984758f94?version=1.0 • https://www.energetskiportal.com/regulations/legislation/strategies/ • http://www.mvteo.gov.ba/Content/Read/energetika-strateski-dokumenti?lang=en • https://economy.gov.mk/Upload/Documents/Adopted%20Energy%20Development%20Strategy_EN.pdf

Table 52. Low-carbon logistics in Provence-Alpes-Côte d'Azur

Region/Country	France
Element of the legal or policy framework	Low-carbon logistics
Description/Key aspects	This French regional call for projects supports the emergence, experimentation and deployment of concrete and practical solutions in favour of efficient and collaborative low-emission logistics. The projects must contribute to the optimization of logistics chains and the reduction of negative externalities of

	deliveries in the Provence-Alps-Côte d'Azur region by relying on collaboration and pooling between shippers, operators and communities. It must participate in the emergence of exemplary and reproducible projects in different areas of the regional territory.
Implementation status	The first edition of the call closed in 2023 with 14 winning local projects. A second edition has opened in Summer 2024.
References	Low-carbon logistics in Provence-Alpes-Côte d'Azur – ADEME and the Region summarise the projects supported in 2023 [237]

Table 53. Low Emission Zones (LEZ), France, Marseille, Montpellier

Region/Country	Marseille, Montpellier. France
Element of the legal or policy framework	Low Emission Zones (LEZ)
Description/Key aspects	A low-emission zone is a perimeter in which the circulation of the most polluting vehicles is limited or prohibited. It is a mandatory national scheme created by the French Mobility Orientation Law (LOM - see the national policies) in 2019. It is based on the evaluation of the vehicle pollution (from 0 to 5 - being 0 the less polluting). In metropolitan France, the Low-emission zone will come into effect on July 1, 2022 and the traffic restrictions will be progressive. In the event of failure to comply with traffic restrictions, the driver of a vehicle risks a fixed fine of 68€. This fine can rise to 135€ for the driver of a heavy vehicle, bus or coach driver. In Montpellier, in 2024 small trucks classified 0, 1 and 2 only can enter the Low-emission zone of the city (0, 1, 2, 3 for cars). From 2025, car 0, 1 and 2 only will be able to enter the city. From 2028, vehicles 0 and 1 only will be able to enter the city.
Implementation status	In the metropolis of Montpellier and Marseille the implementation is following the provisional plan.
References	LEZ communication [238]

Table 54. Sustainable Energy and Climate Action Plan (SECAP), Island of Brač

Region/Country	Island of Brač, Croatia
Element of the legal or policy framework	Sustainable Energy and Climate Action Plan (SECAP)
Description/Key aspects	The SECAP for the Island of Brač was developed within the scope of the Interreg Italy-Croatia project Joint_SECAP. Similarly, under the COMPETE4SECAP Horizon 2020 project, SECAPs were developed for the following cities: Osijek, Rijeka, Velika Gorica, and Zadar. SECAPs and similar action plans, which define commitments to mitigation and adaptation to climate change, and address energy poverty until 2030, have been developed and approved in 29 Croatian cities and municipalities. Mobility is one of the targeted sectors in all developed local action plans. Good practice example: The SECAP for the Island of Brač was developed with the aim to cover the period up to 2030. All proposed measures target the 2021-2030 period. The SECAP defines necessary measures and actions to reduce GHG emissions and has been adopted by local authorities. It serves as a key tool for the timely reaction and resilience of the local community to the risks and dangers associated with climate change. The SECAP includes a reference emission inventory for monitoring climate change mitigation activities, climate change mitigation measures, risk analysis, and vulnerability assessments of individual sectors to the impacts of climate change, along with climate change adaptation measures. One of the key areas for GHG emissions reduction identified in the Island of Brač's SECAP is the transport and mobility sector. Main measures and activities for reducing GHG emissions in the transport sector include using EVs and hybrid vehicles for public purposes. For instance, the municipality of Postira envisioned the procurement of a communal EV, with an investment estimated at around 200,000 EUR. Another measure indicated in the SECAP is the improvement of electromobility-related infrastructure, mainly charging stations for EVs. In the scope of SECAP, 2 municipalities envision the development of charging infrastructure. Another key measure is related to boosting the use of biofuels. Finally, the SECAP envisions the development of a Sustainable Urban Mobility Plan (SUMP) and a Sustainable Electromobility Plan (SEP).
Implementation status	Development still ongoing for most of Croatian local authorities. It is expected that most of 174 signatories (2024 data) of Covenant of Mayors in Croatia, will develop their SECAPs in the next 2 years.

References	Island of Brač SECAP [239]

Table 55. Sustainable Urban mobility Plan (SUMP), Croatia

Region/Country	Croatia
Element of the legal or policy framework	Sustainable Urban mobility Plan (SUMP)
Description/Key aspects	Out of 128 cities and 428 municipalities in Croatia, as of mid 2023, 17 local governance units have developed SUMPs; Nin, Novalja, Novigrad, Zabok, Umag, Križevci, Koprivnica, Šibenik, Bjelovar, Dubrovnik, Varaždin, Sisak, Pula, Slavonski Brod, Zadar, Split, and Brdovec (only municipality to develop SUMP) As an example of a Sustainable Urban Mobility Plan (SUMP) developed at the city level, the SUMP of the city of Sisak is assessed. Regarding the logistics of the city center, the plan clearly defines two phases to provide medium-term sustainable solutions. The first phase includes the modification of the Decision on the Regulation of Road Transport in the City of Sisak (Official Gazette of Sisak-Moslavina County Nos. 14/06, 6/09, 1/13) to clearly define parking spots suitable for delivery vehicles in Sisak's city center. Furthermore, as a subsequent phase, the plan proposes the construction of the logistics distribution center in Sisak, with the beginning of construction aimed at 2025. Only after the construction of the center, the plan envisions a focus on concepts such as eco-friendly delivery vehicles (such as electric, hybrid, or biofuel vehicles). It is proposed that only these delivery vehicles will be allowed entrance into the city center. However, the shift to greener public transport is planned sooner, with the SUMP already planning the procurement of 15 such buses.
Implementation status	Significant barriers to the development of local SUMPs arise due to a lack of national support and funding. Furthermore, it is necessary to define a methodology for development and guidelines for SUMP implementation, taking into account the national context. There are also no clear indicators and evaluation methods provided at the national level. All this makes it extremely difficult to develop SUMPs, especially for municipalities and smaller cities. This is clearly evident, as only 1 out of 428 municipalities in Croatia has developed a SUMP.
References	City of Sisak SUMP [240] National support for SUMP development [241]

Table 56. Sustainable Energy and Climate Action Plan (SECAP), Crete, Greece

Region/Country	Region of Crete, Greece
Element of the legal or policy framework	Sustainable Energy and Climate Action Plan (SECAP)
Description/Key aspects	18 Sustainable Energy (and Climate) Action Plans (SEAPs / SECAPs) of Municipalities in the Region of Crete, in the framework of the Covenant of Mayors initiative. The EU Covenant of Mayors for Climate & Energy is the world's largest movement for local climate and energy actions. It brings together thousands of local governments voluntarily committed to implementing EU climate and energy objectives. In order to translate their political commitment into practical measures and projects, Covenant signatories (Mayors from all over Europe) commit to submitting, within two years following the date of the local council decision, a Sustainable Energy and Climate Action Plan (SECAP) outlining the key actions they plan to undertake. The commitments for Covenant signatories are linked to the EU's climate and energy policy framework: the 2020 climate and energy package for signatories who have joined between 2008 and 2015 and the 2030 climate and energy framework as well as the EU Strategy on Adaptation to Climate Change for signatories joining after 2015. Covenant signatories commit to adopting an integrated approach to climate change mitigation and adaptation. They are required to develop, within the first two years of adhesion, a Sustainable Energy and Climate Action Plan with the aims of cutting CO2 emissions by at least 40% by 2030 and increasing resilience to climate change.
Implementation status	18 Municipalities of the Region of Crete are signatories of the Covenant of Mayors Community while 16 Municipalities have submitted a Sustainable Energy Action Plan. Barriers-delays: • Lack of monitoring reports (only 4 of the 16 Municipalities submitted monitoring/progress reports) • Lack of data regarding the energy consumption and climate and energy indicators • There is not direct involvement of the technical staff of the municipality (external contractor typically prepares SEAP)

References	Covenant of Mayors list of developed plans [242]

Table 57. Sustainable Urban mobility Plan (SUMP), Crete, Greece

Region/Country	Cretan Municipalities, Greece Heraklion, Rethymno, Chania, Agios Nikolaos, Malevizi, Ierapetra
Element of the legal or policy framework	Sustainable Urban mobility Plan (SUMP)
Description/Key aspects	The Law 4784/2021 about Sustainable Mobility Action Plans and the Micro-mobility was one of the key enforcement measures to promote the development of SMAPs in Crete. Among others, this law enforces and includes measures in the national Road Traffic Code for e-scooters, roller skates and skate boards, Self-balancing vehicles (such as Segway) and electric vehicles that do not fall into any of the above categories. So far the 6 largest Cretan municipalities (Heraklion, Rethymno, Chania, Malevizi, Agios Nikolaos, Ierapetra) are developing their Sustainable Mobility Action Plans considering among others the reduction of CO2 emissions from all the means of public transportation, while more than 10 have applied in the recent Open call of the Green Fund for the development of a strategic plan for Micro-mobility. The National observatory of Sustainable Mobility Action Plans is presented in the following link: https://www.svak.gr/
Implementation status	Sustainable Mobility Action Plans and the Micro-mobility.
References	Municipality of Heraklion SUMP [243] Municipality of Rethymo SUMP [244] Municipality of Chania SUMP [245] Municipality of Malevizi SUMP[246]

Table 58. Sustainable Energy and Climate Action Plan (SECAP) , Valencia

Region/Country	Valencia, Spain
Element of the legal or policy framework	Sustainable Energy and Climate Action Plan (SECAP)
Description/Key aspects	City of Valencia municipal public transport company (EMT Valencia) aims to reduce CO2 emissions by replacing fossil fuels busses by electric or hybrid vehicles. By end of 2024, 68% of

	Valencia city bus transport system will be electric/hybrid vehicles and only 32% will be fuelled by fossil fuels. In 2024, EMT Valencia is going to substitute 10% of standard fleet units by low-carbon units. Municipal bus network of Valencia city has got 500 buses. Since 2015, EMT Valencia.
Implementation status	The decarbonisation of bus public network is part of the Sustainable Energy Action Plan (SECAP) of Valencia city. 3 out of 4 public buses are using a more enviromental-friendly technologies.
References	Valencia SECAP [247]

Table 59. Low Emission Zones (LEZ), Valencia

Region/Country	Valencia, Spain
Element of the legal or policy framework	Low Emission Zones (LEZ)
Description/Key aspects	City of Valencia will implement a low emission zone the 1st January 2025. To be allowed to enter the city, vehicles have to meet certain standards. A sticker DGT (Distintivo Ambiental) is required. To be allowed to enter a ZBE (low emission zone) they have to be registered. It is not mandatory for vehicles registered in Spain to have an Emissions Sticker in the lower right corner of the front glass, but it is advisable. Stickers can be bought from post offices, workshops, administrative managers, Gavam (for fleets) and online. The Valencia City Council has begun the installation of the 278 cameras that will control the accesses to the Low Emission Zone designed to progressively reduce pollution in the city. The implementation of the EPZ will be carried out in phases, starting in 2025 with an informative stage without sanctions. Effective restrictions will begin in January 2026, limiting access to A-label vehicles from outside the province of Valencia. By January 2027, the limitation will be extended to all unlabelled vehicles from outside the city, and from January 2028, the restrictions will be total.
Implementation status	LEZ will entry into force in 2025.
References	Valencia LEZ [248] Urban access regulations in Valencia [249]

Table 60. Urban strategy 2030 of city of Valencia

Region/Country	Valencia, Spain
Element of the legal or policy framework	Urban strategy 2030 of city of València
Description/Key aspects	The Urban strategy 2030 of city of València is the roadmap that will allow a comprehensive, innovative and transformative development of the city for the next decade. València 2030 Urban Strategy is a strategic project of the city. It is based on reflection, deliberation and citizen participation in order to propose responses to the different future challenges that the city faces. Line of Action 7.5: SUSTAINABLE LOGISTICS: Line of Action that aims to increase the efficiency and sustainability of urban logistics systems, so that the movement of people coexists adequately with the movement of goods, advancing solutions such as: the development of innovative solutions based on urban consolidation centres for goods as logistics micro platforms; the development of new last mile distribution management models based on the promotion of horizontal partnerships between logistics operators; progress in new autonomous and smart logistics solutions; the development of new shared logistics solutions between delivery companies or the introduction of tools and technologies for the improvement of collection systems and services in work centres and communication hubs - pickboxes. Status: Previous studies.
Implementation status	Status: Previous studies.
References	Valencia Urban Strategy 2030 [250]

Table 61. Sustainable Urban mobility Plan (SUMP), Valencia

Region/Country	Valencia, Spain
Element of the legal or policy framework	Sustainable Urban mobility Plan (SUMP)
Description/Key aspects	The Valencia Municipal Bicycle Agency was created on July 30, 2015. The Agency is the public body responsible for coordinating the necessary measures to increase the use of bicycles in a safe and appropriate manner, both in the city of Valencia and within the municipal area. - Address the needs and requirements of bicycle users in Valencia.

	Agency objectives are among other the following ones: - Increase the safety and comfort of bicycle users. - Promote the bicycle as a significant part of everyday mobility, making it a real alternative for urban transport and normalizing its use. - Create the appropriate urban conditions (safety, coherence, connectivity, intermodality...) so that the bicycle becomes a common mode of transport in Valencia. - Strengthen intermodality between bicycles and other means of transportation. - Encourage the inclusion and integration of spaces for bicycles in future urban planning and development programs for the city. -Promote participatory processes with interested groups from all sectors related to bicycles, including, among others, the Valencia Bicycle Forum
Implementation status	In progress since 2015
References	The Valencia Municipal Bicycle Agency website [251]

Table 62. Sustainable Urban mobility Plan (SUMP), La Ribera county, Spain

Region/Country	La Ribera county, Spain
Element of the legal or policy framework	Sustainable Urban mobility Plan (SUMP)
Description/Key aspects	BioDieNet project was a project funded by the Intelligent Energy for Europe Programme to facilitate the uptake of used cooking oil to produce biodiesel. The objective of BioDieNet was the promotion of localised biodiesel production for transportation purposes, by means of the active involvement of key local actors in more than 10 European countries. The project ended 31st December 2009. The action established a working network of Energy Agencies, working closely with their associated local municipalities and regional governments and other market actors across Europe who were engaged in or planning to be engaged in the supply of locally-produced biodiesel from used cooking oils. The network provided specific, practical information, education, dedicated tools and support to help set up and maintain projects which result in greater uptake of locally-produced biodiesel by public and private vehicle fleets as well as individual vehicle owners. Through the involvement of Energy Agencies traditional barriers of centralized biodiesel structures were addressed to enable easier introduction in higher concentrations (20-100%), reduce high risks involved for potential biodiesel producers, and create localized supply chains.

	The project had in addition providde a comprehensive synthesis of existing knowledge and experience in the field including a set of case studies demonstrating how existing local biodiesel projects have been established, the barriers they have faced and how successful they have been in overcoming them.CRIB is nowadays collecting domestic used cooling oil (UCO) in 45 municipalities of la Ribera county.
Implementation status	In progress
References	Consorci de la Ribera home page [252]

Table 63. Low-carbon logistics, EMT and ENCICLE, Spain

Region/Country	Valencia, Spain
Element of the legal or policy framework	Low-carbon logistics
Description/Key aspects	City of València municipal transport company (EMT) and ENCICLE enterprise has launched a project to foster sustainable mobility by means of sustainable last mile delivery service. Through this agreement, EMT allocates 95 square meters space on the first floor of a city centre parking, which is entirely dedicated to logistics vehicles. ENCICLE's electric delivery vans drop off all mail and products in this space from 4 to 9 in the morning. This is the logistics distribution point where electric bikes and scooters come to begin the sustainable collection and delivery across various parts of the city, with zero emissions. This project will eliminate 500 daily trips made by vehicles that use fossil fuels, which is equivalent to preventing 9 tons of CO2 emissions into the atmosphere each year.
Implementation status	In progress since 2024
References	EMT MAS SOSTENIBLE [253]

Table 64. Urban Strategy- Local Action Plan , Valencia

Region/Country	Valencia, Spain
Element of the legal or policy framework	Urban Strategy- Local Action Plan

Description/Key aspects	On 2022, the European Commission announced the 112 cities selected to participate in the EU Mission for 100 climate-neutral and smart cities by 2030, also known as the Cities Mission. The designated cities, 100 coming from all 27 EU countries and 12 coming from Horizon Europe associated countries, are receiving tailor-made advice and support from the Mission Platform, managed by NetZeroCities, to reach climate neutrality by 2030 and inspire other cities to follow suit by 2050. One of this climate-neutral and smart city is València. The Cities Mission will involve local authorities, citizens, businesses, investors as well as regional and national authorities to 1)Deliver 100 climate-neutral and smart cities by 2030 and 2) Ensure that these cities act as experimentation and innovation hubs to enable all European cities to follow suit by 2050. València Mission is based on its Urban strategy Valencia 2030. Programme 10 is focused on sustainable and local food. This action line seeks to strengthen and re-territorialise the municipal agrifood system, focusing on the values and potential of a city-region agrosystem and providing an open-air public space that can be used as a reference or meeting point for local, sustainable, healthy and culturally-rooted products and the city's population. At the same time, this programme aims to transform the city's agri-food culture towards a more sustainable production, with the use of social and environmental models that advance the development of fairer value chains that can improve the profitability of farms. For the implementation of this programme, special attention should be paid to the farms in our city and to the farmers as the key players in this activity. Sustainable action lines such as promoting distribution and logistics projects adapted to short marketing channels or generation and scaling up of a network of direct sales platforms for local agri-food products with environmental and social criteria are foreseen.
Implementation status	In progress since 2024
References	Local Action Plan Valencia [254]

14.3.1 *How can tools such as LEZ meet a number of challenges?*

In 2020, air pollution was responsible for a significant number of premature deaths across the EU. Specifically, exposure to concentrations of fine particulate matter (PM2.5) exceeding the 2021 World Health Organization guideline resulted in around 238,000 premature deaths, while nitrogen dioxide (NO_2) exposure led to approximately 49,000 premature deaths. Acute exposure to ozone contributed to an additional 24,000 premature deaths [255].

The last mile logistics have a high pollution impact: for example, it accounts for around 25% of the environmental footprint of the food supply chain in France [256].

This pollution, and its health consequences have a cost for public authorities as city councils. For example, the Montpellier metropolitan area estimates its pollution-related expenditure at €180 million (source: Health costs of air pollution in European cities and the linkage with transport – European Public Health Alliance). In London, air pollution-related costs are estimated at around €11.38 billion annually, mainly driven by increased healthcare needs and reduced productivity. Bucharest faces similar challenges, with the annual economic burden reaching €6.35 billion. In Berlin, the costs are estimated to be about €5.24 billion per year due to poor air quality [255].

Example (1): the low-emission zones of Montpellier

Two successive laws, introduced in 2019 (Mobility Orientation Law) and 2021 (Climate and Resilience Law), have made it compulsory to set up low emission zones in 12 and then 35 French metropolitan areas. These regulations aim to enable French cities to comply with the emission thresholds for nitrogen dioxide (NO2), particulate matter (PM10), and PM2.5 set by European Directive 2008/50/EC. In France, the low-emission zones take the form of a perimeter within which only the least polluting vehicles can circulate. A scale based on the type (petrol or diesel) and age of the vehicle has been introduced to classify vehicles from 0 to 5 according to their level of emissions, making it easier to check vehicles using a sticker system. In Montpellier, the low-emission zones came into effect on 1 January 2022. From 1 January 2024, category 1, 2, and electric commercial vehicles and HGVs will be authorized in the EPZ. Only category 1 and electric vehicles will be authorized from 2025 for heavy goods vehicles and from 2028 for light commercial vehicles [238]. To support the public, and professionals in particular, in their transition, temporary exemptions and several specific aid schemes exist for professionals.



Figure 30. Map: Date of entry into force of the EPZ in Montpellier. Orange on July 1, 2022, green on July 1, 2026 [238]

Example (2): the low-emission zones in Sofia, Bulgaria

Starting December 1, 2023, Sofia will enforce low emission zones (LEZ) in an effort to reduce air pollution, particularly during the cold, foggy months when emissions are highest. The new regulations, established by the Sofia Municipal Council, will initially ban the most polluting vehicles, those in the lowest environmental category, from entering the central parts of the city. This central zone, also known as the "small ring," includes major streets like Vasil Levski Boulevard and Opalchenska Street. Vehicles classified in higher environmental categories will face restrictions in the coming years.

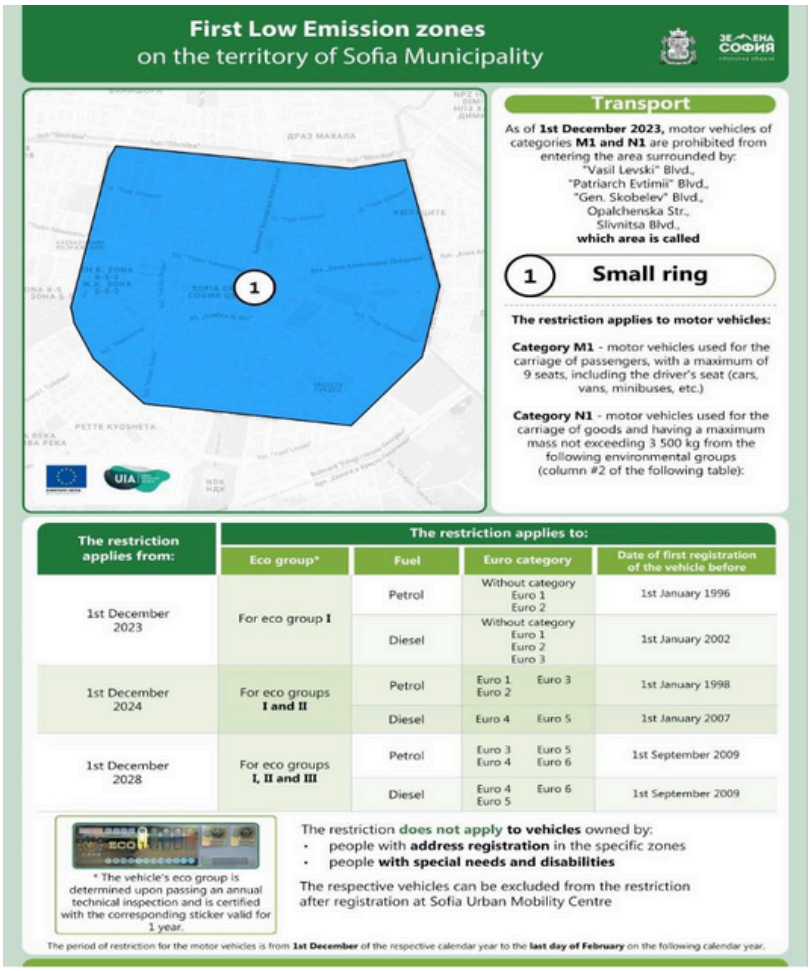


Figure 31. LEZ in Sofia [236]

The idea behind these zones is to reduce harmful emissions by limiting the use of older, more polluting cars while providing alternative routes for traffic. The "large ring," encompassing a broader area, will also begin implementing restrictions in 2025, with further bans planned for the following years. This approach mirrors measures taken in over 300 cities worldwide, where low-emission zones have been introduced to combat urban air pollution.

Exemptions exist for residents of the affected zones, allowing them to register their vehicles for continued access, as well as for people with disabilities, who can register up to two cars. These measures are part of a broader initiative to make Sofia a greener and cleaner city.

Source: Sofia Municipal Council. "Ordinance on the Creation of Low Emission Zones for Harmful Substances in the Ambient Air on the Territory of Sofia Municipality." Decision No. 931 under Protocol No. 67 from December 15, 2022. Effective from December 1, 2023.

Example (3) : the low-emission zones in Senigallia, Italy

The municipality of Senigallia has a Limited Traffic Zone (LTZ), which regulates access to areas in the historic centre to limit traffic and preserve the quality of life and the urban environment.

Methods of application:

- Permits: Access is permitted only to vehicles with specific permits. There are different types of permits for residents, workers, loading and unloading operations, electric vehicles, and other categories with special needs.
- Electronic control: Entry into the LTZ is monitored by electronic control systems based on number plate reading, which automatically detect any violations. This eliminates the need for continuous control by the local police.
- Digital services: Permits can be purchased and managed online through a specific platform or via an app, which facilitates the process for citizens and businesses, reducing management time and simplifying operations.

The introduction of the LTZ in Senigallia has brought several benefits, including:

- Traffic reduction in the most sensitive areas of the historic centre, improving air quality and liveability.
- Support for sustainable mobility: electric vehicles have easier access, encouraging the use of environmentally friendly vehicles.
- Improved urban management: thanks to the digitisation of the access and control system, the process has become more efficient and accessible to citizens.

Furthermore, although Senigallia does not currently have a true Low Emission Zone (LEZ) specifically for polluting vehicles, there are restriction measures to limit access to the most polluting vehicles during certain periods of the year and at certain times of the day. These restrictions were introduced mainly to combat air pollution caused by particulate matter (PM10). These measures, although not officially referred to as the 'Low Emission Zone', work in a similar way and have contributed to reducing the environmental impact of transport in the center of Senigallia.

14.4 Main learnings from analysis of public policies and frameworks

Alternative and sustainable mobility solutions, as well as advanced agro-food logistic systems are key drivers for local legal or policy frameworks such as LEZ in cities, or SUMP and SECAP plans: Mainly local authorities in the Mediterranean area make use of 3 types of regulations in the field of sustainable mobility: 1) development and implementation of Sustainable Urban Mobility Plans (SUMPs), 2) Development and implementation of Sustainable Energy and Climate Action Plans (SECAPs), 3) Creation of Low Emission Zones in urban areas (LEZ). By integrating sustainable logistics and mobility solutions, local authorities can create synergies across SUMPs, SECAPs, and LEZs, accelerating their implementation and fostering a transition toward greener, more livable cities.

15. DISCUSSION

The state of the art on short and local food supply chains highlights that logistics—particularly the last-mile delivery component—remains one of the most challenging and impactful aspects in achieving sustainability goals. In urban contexts, where delivery distances are often short but routes are fragmented and complex, logistical inefficiencies can lead to disproportionately high costs and environmental burdens. This situation places a significant strain on small-scale producers aiming to reach urban consumers, often accounting for up to a quarter of their turnover. Addressing these logistical hurdles is therefore central to reducing the overall environmental footprint of SFSCs and enhancing their economic viability.

A key lesson emphasized in the analyses is that improvements in logistics should follow the consolidation and growth of commercial flows. Without sufficient demand or well-structured market outlets, logistics optimization or the adoption of sophisticated models—such as shared distribution hubs and consolidation platforms—remains economically unfeasible. Accordingly, intermediaries, including traditional wholesalers and emerging logistics facilitators, appear paradoxically necessary in some SFSC models. While their involvement may seem to contradict the directness ideal, it provides a pragmatic means to pool volumes, reduce per-unit transport costs, and render local products more accessible to a larger set of buyers.

Collaboration among stakeholders emerges as a central theme. Producers, logistics operators, wholesalers, buyers (e.g. shops, restaurants, and catering services), local authorities, and even end-consumers must engage in dialogue to coordinate delivery schedules, identify common infrastructures for transshipment, and integrate digital platforms that streamline the entire chain - from order management to billing. Beyond improving cost-effectiveness, these collaborative efforts can be leveraged to incorporate clean vehicle technologies, implement cargo bikes or electromobility solutions, and install charging facilities or micro-hubs.

From a technological perspective, several solutions show promise in reducing the environmental footprint of SFSC logistics. Electromobility approaches, including battery electric vehicles (BEVs), hybrid or plug-in hybrid electric vehicles (HEVs and PHEVs), and fuel-cell electric vehicles (FCEVs), offer the potential to significantly cut greenhouse gas emissions and improve air quality in urban areas. Implementing these solutions effectively, however, demands investment in charging

infrastructure, retrofitting older fleets, and coordinating vehicle types to match delivery volumes and routing patterns. Retrofitting internal combustion engine vehicles into electric or biomethane-powered models can accelerate the transition, providing a cost-effective, short-term pathway to cleaner fleets without necessitating full vehicle replacement.

Biofuels, such as biodiesel, bioethanol, biogas, and biomethane, also offer transitional solutions. They can be integrated into existing logistics systems with fewer infrastructural changes and help create a circular economy by reusing agricultural residues and waste. Nevertheless, issues of supply scalability, cost, and standardization must be addressed before biofuels can be mainstreamed as a preferred solution in SFSCs.

Digital platforms and decision-support tools have a crucial role in facilitating these technological transitions. By providing real-time data on traffic, delivery times, routes, and vehicle charging needs, such tools enable precision planning and load consolidation. Their capacity to integrate sales, billing, and inventory management systems creates a stable framework within which electric or biofuel-powered fleets can operate efficiently. However, interoperability and ease of adoption remain challenges, given the heterogeneous nature of SFSC stakeholders and their varying levels of technological readiness.

At the policy level, public authorities can accelerate the uptake of low-carbon mobility solutions and digital innovations through targeted subsidies, grants, training programs, and the development of supportive infrastructure—charging stations, micro-hubs, and food logistics platforms. Regulatory measures such as Sustainable Urban Mobility Plans (SUMPs), Sustainable Energy and Climate Action Plans (SECAPs), and Low Emission Zones (LEZs) also provide a favorable environment for stakeholders to embrace cleaner technologies. Overall, by integrating technology, policy, organizational innovation, and stakeholder cooperation, SFSCs can move towards more sustainable, resilient, and economically sound logistics models.

16. CONCLUSION

In conclusion, building more sustainable short and local food supply chains hinges on effectively linking organizational strategies, stakeholder collaboration, technological innovation, and supportive policy frameworks. Achieving a critical mass of commercial flows is a necessary first step before deploying sophisticated logistics solutions, such as shared hubs or specialized distribution platforms. Intermediaries can help consolidate volumes and professionalize operations, while including buyers early on ensures that logistical adjustments align with market needs.



Technological transitions—from adopting electromobility and biofuel solutions to retrofitting existing fleets—can substantially reduce the carbon intensity of last-mile deliveries. However, these approaches demand the establishment of suitable infrastructure, robust digital platforms, and stronger interoperability to truly unlock their potential. Public authorities have a pivotal role to play by providing financing, training, and conducive regulatory environments. Policies such as SUMPs, SECAPs, and LEZs can act as enablers, accelerating the implementation of cleaner transport modes and encouraging the integration of digital solutions that optimize delivery routes and vehicle use.

Ultimately, the success of these interventions will depend on each local context's specific conditions and the willingness of stakeholders to engage in dialogue, share data, and adopt best practices. Consumer awareness and education, in turn, can reinforce market demand for locally sourced, sustainably delivered products—thus creating a virtuous cycle that benefits producers, logistics operators, consumers, and the environment. By embracing these interconnected strategies, SFSC stakeholders can collaboratively drive the transition towards greener, more resilient, and economically viable local food systems.

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