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The re-organization of the supply chain in inner areas to produce biofuel for the transport system. Insights from a Sicilian case study (Italy)

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Abstract

In this article the authors argue that the re-organization of the supply chain could help tackle the crisis of Sicilian inner areas by involving the companies which produce biomethane, and the logistic companies which use vehicles powered by biomethane. In the proposed case study the authors focus their research on the supply chain that involves, with the key role of logistics companies, agri-food companies, biofuel production companies, and large commercial distribution companies, located partly in inner areas and others in urban poles. The research is organised as follows: the first paragraph, specifies the methods of obtaining biogas and biomethane and the international and national conditions that favour this production of energy from renewable sources and the production of biofuels for the transport system. The second paragraph discusses the recent tendency to reorganize production on a regional scale due to the difficulties and increasing costs in the world logistics chain, caused by economic and structural events, such as the Covid-19 pandemic, the war in Ukraine and the increase in freight and container costs. The authors of this article sustain that the regionalization of production favours the role of supply chains located in inland areas, as defined by the National Strategy on Inner Areas, where logistics operators represent a strategic hub for connecting the agri-food operators of the inner areas to the network of commercial distribution operators. Therefore, in the third paragraph, with the support of interviews with selected economic actors and on-desk research, a case study of the supply of biofuels for logistics companies is developed, using the products and/or waste from the processing of agri-food companies located in some inner areas in the ex-province of Enna. The final considerations and possible future research area are given in the last paragraph.

Keywords: Chain, Biomethane, Logistic, Sicily

1. Introduction

The increase in the use of biofuels in the world depends above all on rural development due to the competition between the different use of crops (feed, food, energy), the different prices of products, the preferential taxation for some goods, and finally, but not less important, the

impact of crops on the environment (Amato, 2013; Marsden et al., 1999; van der Ploeg et al., 2000). In addition, "the leading countries in the production and consumption of biofuels lack the land needed to meet the growing demand for bioenergy" (Fatichenti, 2020, p. 16).

In 2015 the UNO Agenda 2030 played mainly a strategic role for the alternative sources of energy and biofuels. UNO setted out 17 Sustainable Development Goals in order to guarantee a future for future generations and, especially with goal n. 12, stressing that it is necessary to reduce: the exploitation of traditional resources to produce energy; food waste and waste as phenomena characterizing urban areas; transport for travel due to the expansion of cities and world trade that mostly satisfies the consumption of the multitude of individuals concentrated there (Alleanza Italiana per lo Sviluppo Sostenibile, 2019). In Italy, the pursuit of goal n.12 "To guarantee sustainable production and consumption models" has involved a series of measures aimed at implementing the circular economy. However, in this context, Sicily was the last region to adopt of interventions relating to the circular economy in 2010 and 2017 (ASviS, 2019, p. 3). In line with the UNO Agenda's principles, attention is growing towards the production and use of biofuels. Biofuels derive from the processing of biological material, such as agricultural raw materials and biomass, unlike fuels derived from fossil minerals. Due to their origin, they are considered a renewable energy source.

First generation biofuels are evaluated as products that interfere with the agri-food market, as they can affect the supply and prices of agri-food resources. Baier et al. (2009) estimate that the increase in worldwide biofuels production pushed up corn, soybean and sugar prices. While new-generation biofuels, so called because they come from organic materials, including non-food ones such as algae, influence the agri-food market much less.

The widespread consumption of biofuels has largely depended on the oil market crisis of the early 1970s and, more recently, on their lower environmental impact which makes them more welcome in urban areas, and on the fueling of goods and transport vehicles of public transport (Capaccioli et al., 2011). In addition the valorization of supply chains producing biofuels may be able to save rural areas from the effects of globalization. This valorization makes the functions and agricultural planning coherent with regional development (Marsden et al., 1999, p. 297). The recent period of uncertainty and concern over the COVID-19 pandemic and the interruption of gas flows to European countries due to the war in Ukraine have caused growing interest in the production of biofuels to maintain low prices as a commodity, with the possibility to begin of a process of rebuilding more regional agro-ecological systems "to integrate space and nature into production processes" (Marsden et al., 1999, p. 299).

Naik et al. sustain that the previous generation biofuels appeared unsustainable because of the stress that their production placed on food products (Naik et al., 2009). Some emphasize how the exploitation of the land and the impact on the agri-food chain continue with new generation biofuels (Peskett et al., 2007). On the other hand, Panagos et al. (2015) write that extending cover crops would reduce the risk of soil erosion. Many of these problems disappear when biofuels are obtained from agricultural biomass (Ahman, 2010)[1]. The studies of the World Bank support both the need to avoid a competitive use of land and to improve techniques for obtaining biofuels (Timilsina et al., 2010).

Biogas is produced from the decomposition of organic materials. These residues are placed in a biogas digester in the absence of oxygen. The main raw materials from which obtain biomethane are: agricultural biomass (dedicated agricultural production, by-products, agricultural waste, gardening waste); zootechnical waste (animal waste); agro-industrial waste; organic fraction of municipal solid waste; and sewage (Iddrisu and Zhang, 2012). When biomethane is obtained from agricultural biomass (dedicated crops, agricultural by-products and waste and animal waste) and from agro-industrial biomass

[1] The author argues "that more emphasize should be given to biomethane as a large-scale option given the opportunity to use woody biomass from gasification" (2010, p. 208).

(waste from the food processing chain), the process also leads to obtaining digestate, which is an agricultural soil improver that can also be used in organic farming (Rossi et al., 2018). This process therefore not only does not produce carbon but also helps to reduce it, by removing carbon dioxide from the atmosphere[2]. The production of biomethane can make the application of the principles of the circular economy feasible (Kapoor et al., 2020). Given that it is generated through the products supplied by the agri-food companies, used by the logistics companies for the transport of goods to the points of sale of the commercial distribution, the national energy production increases (Snam, 2019). But, above all, the increasing biomethane production supports the development of the agricultural sector, with the reuse of products and the use of digestate for soil fertility, in addition to the decrease in carbon which characterizes the whole supply chain (Mittal et al., 2019). For this, renewable gases, including biogas and biomethane, will be central to achieving carbon-neutrality and helping the EU become less dependent on external energy supplies[3].

By laws and regulations to ensure the sustainable development of biofuels, many governments all over the world have provided subsidies and cost sharing to sustain the bioenergy industry in order to reduce investment risk. As a result of this aid, biofuels have been marketed in several states (Su et al., 2015).

According to this pattern various measures have been issued both on a national level, such as the Italian inter-ministerial decree of 10 October 2014 and the legislative decree n. 28 of 3 March 2011, and on a European level, such as the European directive 2015/1513/EU and the recent RepowerEU[4], which incentivize the production of energy from alternative sources to limit dependence on non-EU suppliers and, in particular, the production of biofuels for transport. The 2017 National Energy Strategy can be included along the same line, which decisively focuses on increasing the production of biomethane for use in the transport sector, as well as other regulations, such as the inter-ministerial decree of 2 March 2018 which removed the difficulties in the sale of biofuels, allowing the public operator (the Energy Services Manager – GSE) to purchase energy produced by private individuals, borrowing from what had already been done for the production of electricity from renewable sources (Ministero dello Sviluppo Economico, 2018). Increased incentives have also been provided for plants that will be activated by December 2022 using dedicated by-products, wastewater and dedicated crops.

The National Recovery and Resilience Plan (NRRP) also assigns 61 billion euros to the mobility sector, of which 25.40 billion euros for Mission 3 “Infrastructures for sustainable mobility” and 35.60 billion euros distributed across three of the six missions of the plan (Capozzi, 2021). The logic embraced by the NRRP suggests that the interaction between logistics operators, the world of production and that of distribution and commerce is no longer a choice, it is the precondition for recovery, to improve people’s lives and commercial competitiveness. Thanks to these incentives, the production of biomethane has been more developed the recent years, as shown in Table 1. However, France has 337 plants producing biomethane, Germany 198, while Italy has only 27 plants. The plants are especially present in Central-Northern Italy. In the same way, many studies have been carried out on how help companies choose the best location by using GIS methodology (Voivontas et al., 2001). The GIS methodology can provide further applications to develop biomethane production in regions characterized by agricultural activities and especially in less developed countries. GIS can provide useful data about the best soil that provides the raw materials to produce biomethane (Beccali et al., 2009).

[2] See EBA’s opinion in https://www.europeanbiogas.eu/about-biogas-and-biomethane/.

[3] See the production cycle on European Biogas Association site: www.europeanbiogas.eu/about-biogas-and-biomethane/.

[4] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/repowereu-affordable-secure-and-sustainable-energy-europe_en, we can read “REpowerEU is the European Commission’s plan to make Europe independent from Russian fossil fuels well before 2030, in light of Russia’s invasion of Ukraine”.

2. The role of the supply chain in territorial development in inner areas (the regionalization of production)

In the last few decades of economic globalization, we have seen the spread of urban areas. In Sicily this phenomenon has been aggravated by the contrast between the coastal metropolitan cities (Palermo, Catania and Messina) that offer public and private services as well as by the depopulation of inner areas historically characterized by the presence of agricultural activities (Scrofani and Novembre, 2015). In 2014, and later in 2020, the National Strategy on Inner Areas (SNAI) identified a large portion of the national territory which is characterized by phenomena of depopulation, delayed development and poor social cohesion. These areas, which in the past represented a point of reference for large sections of the population, today represent critical issues which require intervention with appropriate strategies in order to redress the network of relations between the economic-social and territorial structures. Agriculture is still a key sector in the development of inland centres. Even if farmers implement ideas and practices of multifunctional farming ideas and practices, agricultural changes have not been enough to stop the phenomena of depopulation (Petino and Scrofani, 2020).

In the context of sustainable development models for disadvantaged territories, the agri-energy chains play a strategic role because they draw on primary resources, but the chains that involve companies in different sectors, such as commercial distribution, industry, and logistics are equally important (see Palma-Mendoza et al., 2014, on the necessity to manage the supply chain integration). In other words, we can talk about a single supply chain that integrates the activities of companies in different sectors, inspired by common objectives of sustainability and economic development.

This network of production of goods and services strengthens companies in the markets thanks to the greater visibility obtained with the traceability of products, by referring to the principles of environmental and social sustainability. This network/chain requires a new model of rural development which produces beautiful landscapes and natural values and, on the other side, is also capable of making an important contribution to regional employment, without the specialization in agricultural production inspired by the modernization paradigm (van der Ploeg et al., 2000, pp. 392-393).

Plant Code	Plant injecting into / connected to the grid *Plant not injecting into / connected to the grid	Biomethane Production Capacity [m^3/h]	Start of operation
IT-1	Montello (Lombardia)	8000	2017
IT-2	Sarmato (Emilia Romagna)	500	2019
IT-3	Este (Veneto)	2000	2019
IT-4	Maniago (Friuli Venezia Giulia)	3000	2019
IT-5	Foligno (Umbria)	500	2019
IT-6	Bresso (Lombardia)	120	2019
IT-7	Rende (Calabria)	600	2019
IT-8	Faenza (Emilia Romagna)	2000	2019
IT-9	Guglionesi (Molise)	500	2019
IT-10	Trento (Trentino Alto Adige)	500	2019
IT-11	Codigoro (Emilia Romagna)	600	2020
IT-12	Anzio (Lazio)	450	2020
IT-13	Bottrighe (Veneto)	450	2020
IT-14	Finale Emilia (Emilia Romagna)	350	2019
IT-15	Sant'Agata Bolognese (Emilia Romagna)	1000	2019
IT-16	Corbetta (Lombardia)	635	2020
IT-17	Pinerolo (Piemonte)	800	2020
IT-18	Candiolo* (Piemonte)	300	2020
IT-19	Anzio (Lazio)	450	2020
IT-20	Genova (Liguria)	650	2020
IT-21	Verolanuova (Lombardia)	300	2020
IT-22	Verolanuova* (Lombardia)	300	2021
IT-23	Villanova del Sillaro* (Lombardia)	200	2020
IT-25	Carbonara al Ticino (Lombardia)	500	2021
IT-26	Assoro* (Sicilia)	500	2021
IT-27	Albairate (Lombardia)	1000	2020

Table 1. Infrastructure for biomethane production in Italy 2021. Source: own processing on data of European Biogas Association, 2021.

These new trends are finding greater support in the business world also due to the Covid-19 pandemic, which has imposed a review of the organization of agro-energy-industrial production which makes use of various operators at different geographical scale[5].

In particular, the aspect of logistics relating to the internationalization and globalization of markets has encountered various criticalities over the last 2 years, such as the blocking of distribution chains and the slowdown in deliveries (Okitasari et al., 2021 and its references). In addition, we have the more well-known structural criticalities, such as the fragmentation of deliveries and the increase in distances between customers and suppliers, the risks of obsolescence, customer needs, the maintenance of volumes that are too high or too low in the distribution channels (Palmentieri, 2021).

Economic operators are therefore moving towards regionalizing production to cope with economic crises, such as those linked to the pandemic that interrupted logistic chains several times, and caused the increase of freight and container prices. This should cover the increase in the cost of fuels and the widespread risks involved in insurance. It has become rather inconvenient to travel around the world, due to multi-localized processing phases, products with low added value, such as many of the agri-food products (Paciarotti and Torregiani, 2021). The company, on the other hand, combines competitiveness with sustainability by participating in the supply chains rooted in the territory, because they pollute less or not at all, create jobs and strengthen territorial identity (Vescovi and Gazzola, 2007). These supply chains make the economic system better at recovering quickly and with less difficulty precisely because they are made up of companies with a greater degree of self-sufficiency, including energy, being spatially close and less linked to long and complex supply chains that necessarily involve a large number of actors located even in remote geographical areas (Valenti et al., 2018a). A strategic role is attributed to the consumer in this production system (Klein, 2000), who acquires greater awareness not only about the choice of a single product purchased but above all by choosing the entire production chain (Tecco and Peano, 2015).

Biogas obtained from the anaerobic digestion of biomasses has been considered a feasible alternative to energy production from fossil fuel, and the biogas sector in Sicily could have a large scale implementation (Valenti et al., 2018a). Last but not least, the production of biofuels in inland agricultural areas – biofuels currently exploited by logistics operators – allows for a new relationship between peripheral and central areas, making the former participants in the commercial distribution networks that mainly affect the markets which exist in the latter (Rizzo, 2016; Selvaggi et al., 2017). In other words, the production of biofuels from biomass and its use in logistics makes it possible to strengthen the relationships between inner areas and urban poles.

This paper tries to answer to the main research question: are these above mentioned factors sufficient to start biomethane production or are there other local factors which stimulates the production? The case study provide us some clear answers. In the following paragraph, it can be seen how industrial plants present in Dittaino (Enna) and in Modica (Ragusa) produce biofuels used by logistic companies serving the largest regional commercial groups, such as Arena-Decò, and national ones, such as Lidl, present in the major urban areas of the island.

3. The case study of the supply chain where companies produce and use biomethane in Sicily

As well as Marsden et al. (1999, p. 300) sustain that "need for a more spatialized approach" to regional development, so the

[5] See the interview to Luca Vignaga, CEO of Marzotto Lab (Dario Di Vico, Il tessile torna a casa. Lino e cotone li produciamo in Europa, Sette supplemento al Corriere della Sera, 20/05/2022), and the interview to Christine Lagarde, the president of European Central Bank, on the strategies facing post-globalization (askanews, 22/04/2022, available in https://www.askanews.it/economia/2022/04/22/regionalizzazione-lagarde-indica-la-strada-post-globalizzazione-pn_20220422_00185/).

authors propose the case study[6], based on a chain of companies belonging to production of biomethane, logistic services and trade[7]. One of the most important characteristic of this chain is the proximity of firms to minimize the geographical distance among the actors[8]. Therefore, the chain is developed from Enna ex-province to near Catania Metropolitan Area, well linked with highway and a connected road system. Due to the poor use of the railway, the roads are much more widely used (Grasso, 2008). Another characteristic is the location of many agricultural firms in Sicilian inner areas and the spread cultivation of wheat and, to a lesser extent, of olives. According to the SNAI classification, the municipalities included in the ex-province of Enna are ordered from the "intermediate" to the "ultra-peripheral" level, without any pole or belt area. Thus presenting a particular state of underdevelopment with a constant loss of people[9] (Dipartimento per le Politiche di Coesione, 2022). In these areas, the main source of income comes from the agricultural sector, besides the public service sector. Sicily is one of the four principal regions that provide wheat to Italy's production (the other regions are Apulia, Tuscany and Emilia Romagna). It produces about 7.298.250 quintals of wheat, cultivated in 264.525 hectares, sited especially in inner areas of Enna, Caltanissetta and Palermo ex-provinces (Istat, 2022).

In contrast, the industrial area of Dittaino, belonging to the municipalities of Enna and of Assoro, plays the strategic role in the industrial development of the production and consumption of biogas. In the past scholars have asserted that the most important criticality of these areas depends on the heterogeneity of the plants located there, which makes cooperation in production processes difficult (Li Donni, 1980; Ruggiero, 1982; Viganoni, 1999). Now, the use of new low cost technologies to produce biomethane by biomass has favoured the integration of activities located in the same area. The industrial area of Dittaino, well linked to the principal Sicilian towns, Palermo and Catania, by the highway A19, has been chosen by many agro-food companies thanks to its location in the heart of the region's cropland of wheat and olives. For instance, the Cooperativa Valle del Dittaino collects the wheat produced by many local farmers to turn it into baked goods, and the Arena-Decò company has a logistics hub for the sorting of goods to its points of sale. Among these companies, Assoro Biometano group began its business in the same industrial area in 2019. In that year, the Assoro Biometano factory began the first production process of biogas from biomass, thanks to the participation to farming chain contract (contratto di filiera) called "Filiere Mediterranee Sostenibili". This farming chain contract, stipulated on December 2019 between eight farmers and the Minister of agricultural, food and forestry policies, provided an economic support to cultivation and production activities, recognizing the integration of the different segments of the agro-energy supply chain from raw materials to gas production[10]. At the same time, the Assoro Biometano linked another commercial

[6] The case has been developed by interview to a CEO (Mr Edoardo Bonaccorsi of Assoro Biometano) and other employees belonging to the companies of the chain.

[7] The results obtained in the production of biogas and described here are also the result of the assistance and consultancy activities carried out by the company IES Agri & Farm for the construction, management and assistance phases of biogas and biomethane plants, directing companies in the agricultural and livestock sector to the energy production. IES Biogas, founded in 2008, has already built over 220 biogas and biomethane plants, through the dedicated division of IES Agri & Farm. Since 2018 IES Biogas has become part of the Snam public group, leader in Europe in the energy transition and in the management of natural gas infrastructures.

[8] "Co-location of production at existing industrial sites may decrease production cost when integration benefits can be leveraged" (de Jong et al., 2017, p. 1056).

[9] SNAI divides all the municipalities in 6 classes: poles ant inter-municipal poles (with some important public services), belt areas (very close to the poles), intermediate areas (far away from the poles between 20 and 40 minutes), peripheral areas (from poles between 40 and 75 minutes) and ultra-peripheral areas (from poles over 75 minutes). The last three classes identify the inner areas.

[10] Awi et al. (2019, p. 361) argued that "contract farming protects the farmer against the many risks he is facing, in particular the risk of volatile crop prices on the commodity spot markets, yield risks, and the difficulties off inding buyers for their crops".

distribution company (Arena-Decò) and a logistics one (Nicolosi) to the activities of the companies in the farming supply chain.

On following, we clear better the characteristics of the companies involved in biomethane production and consumption. Assoro Biometano group planned the building of three plants that use agricultural waste, by-products, minor productions and manure from animals subjected to anaerobic treatment[11]. Biogas is produced from the decomposition of organic materials, products of agro-industry and industry food. These residues are placed in a biogas digester in the absence of oxygen. With the help of a range of bacteria, organic matter is broken down, releasing a blend of gases, including methane and carbon dioxide. The first plant was started by the Assoro Biometano in the industrial area of Dittaino, which produces 4.4 million Sm3/year of biomethane obtained from 74,500 tons per year of livestock effluents, agri-food by-products, including waste from the processing of wheat, olive pomace and silage from second-harvest crops. The biogas produced is sent to the upgrading plant for the production of biomethane, compressed at 220 bar in road tankers for transport. Subsequently, some will be used in the Snam network and a liquefied part will be destined for consumption as LNG (Liquefied natural gas) to power the green fleets vehicles for the distribution of goods[12]. The other two plants of the Assoro Biometano group are the Agricola Cugno Biometano S.r.l. in Catania, and the Biomethane Ibleo Società Agricola in Modica (Ragusa). The latter is near the Avimec chicken farm from which it receives most of the material to be processed to obtain biomethane[13].

The agro-energy supply chain described above is well implement by the Nicolosi Trasporti company, that is very important to connect all the other members of the chain[14]. The company, founded in 1962 thanks to the work of Sebastiano Nicolosi, today has a headquarters of 100,000 square meters with covered warehouses for 25,000 square meters and temperature-controlled refrigeration warehouses with an area of 3,600 square meters. The greatest advantage of the plant located in the industrial area of Pantano d'Arci in Catania is the presence of the biomethane distributor, produced by Assoro Biometano, which facilitates the refueling of vehicles with LNG. Using modern vehicles, the company has ascertained the reduction of carbon dioxide by over 25,700 tons per year and for this environmentally friendly management, the company ranks among the leading companies in Europe. The fleet, made up of numerous methane-powered vehicles, thanks also to the recent purchase of 77 LNG-powered Scania tracks that produce zero emissions, carries out deliveries throughout Italy and abroad, relying on the branches in Naples, Anagni, Parma, Genoa and Malta. The vehicles powered by biomethane are used to transport goods to the Sicilian stores of the Arena-Decò and Lidl commercial groups. The collaboration between the companies Assoro Biometano, Nicolosi and Scania Italia is giving an important boost to sustainable mobility in Sicily. The Sicilian Region has introduced total exemption from the payment of road tolls for biofuel-powered vehicles in the approximately 300 kilometers of motorway network managed by the Sicilian Highway Consortium (called CAS).

It is important to underline that other transport carriers in the Etna area, such as Fratelli Di Martino, Luigi Cozza Trasporti, now also have dozens of vehicles powered by liquid methane. Running on methane was not a discretionary choice for them but, on the contrary, a necessary condition for obtaining important orders from large Italian distribution.

[11] See de Notaristefani et al. (2018), for present economic convenience of producing biomethane in Italy.

[12] In 2021, the Assoro Biometano company won the "Viller Boicelli" award assigned by the Italian Biogas Consortium, one of the most important awards dedicated to innovation and environmental sustainability.

[13] In this case, raw materials are transferred from neighboring farms directly to the biofuel plant to avoid the cost of intermediaries. But, in other cases, as written by Iddrisu and Zhang (2012), some agricultural cooperatives supply biomass raw materials, harvesting them from farms and transporting them to the biofuel refinery plant.

[14] On the scientific literature concerning the role of supply chain and logistics in the food and grocery retail sector, as described in our case study, see Lagorio and Pinto, 2021.

Examples of the creation of a sustainable food supply chain, integrating production and marketing aspects, are the cases of Lidl, engaged in 2020 in the promotion of logistics using biomethane, and of Barilla, which has invested in the purchase of large vehicles powered by liquid methane already in 2017 (ANSA, 2020).

Some data on the Arena-Decò group can help to understand its significant contribution to the supply chain of biomethane consumption in Sicily. The Arena Group is leader in Sicily and in the ex-province of Reggio Calabria in organized distribution with a network of over 180 stores with the "Decò" sign, over 2,500 employees, a turnover of 2.5 billion euros in 2021 and the acquisition of a share of the national market equal to 2.5% and 25% of large-scale distribution in Sicily. In 1922, the family business was set up in Valguarnera Caropepe, in the ex-province of Enna, but it was in the mid-1970s that the Arena family founded the company Fratelli Arena with two outlets. The awareness of the Arena group towards sustainable mobility is seen not only by the request for logistical services from the Nicolosi group, which uses biomethane-powered vehicles, but also by the use of electric vehicles for its own home deliveries service.

The supply chain (shown in Figure 1) is therefore formed by the agri-food companies that supply products, by-products and waste from agricultural processing (a), by Assoro Biometano and by the other companies of the group that use the aforementioned materials to produce biomethane (b), by the Nicolosi Group which provides logistics services using biomethane-fueled vehicles (c), by the Arena-Decò Group which uses eco-sustainable logistics services for procurement and sale (d). Finally, the final consumers weren't considered as being strictly part of the supply chain because by using the products sold by the Arena-Decò group they contribute significantly to the new demand for goods from agri-food companies.

4. Conclusions

The exploitation of the residual biomass produced by crops management could significantly contribute to achieving the challenging environmental goals set by European policy for the next decades. The whole Sicilian supply chain has to be managed properly to get low costs, even if the combining of different sectors and different actors is not easy. The logistic company is highly strategic inside the supply chain because of its role in connecting agricultural sector and commercial one.

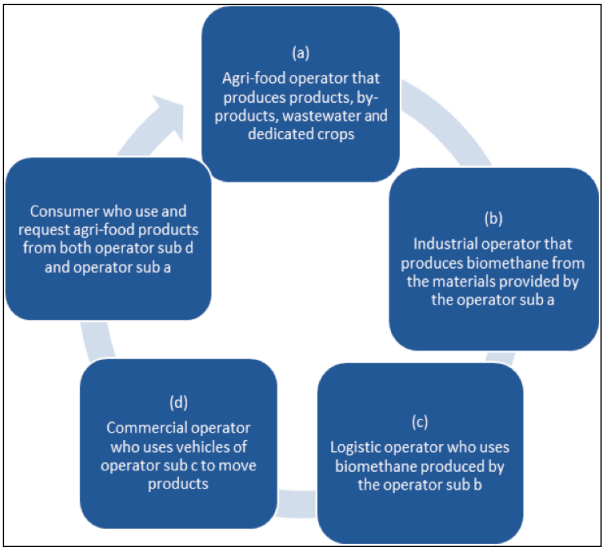

Figure 1. The actors involved in the supply chain of producing and using biomethane in Sicily. Source: own elaboration on case study.

As Sierk de Jong et al. (2017, p. 1068) state "furthermore, the geographical characteristics of the study area and choice of feedstock-technology combination influence the results. Whereas a higher transport cost and lower feedstock density will limit the impact of economies of scale". Our case study demonstrates how the presence of supply chain companies in the same industrial area and the opportunity to stipulate specific supply chain contracts can overcome various obstacles and obtain public funding.

Sicily can therefore propose a development model based on the reorganization of the supply chain. A reorganization that, first of all, makes it possible to produce biofuels by exploiting the waste from agri-food production, agricultural

by-products, animal waste. Raw materials are available in inner areas, which therefore can contribute to the chain with a strategic role in the production of energy in general and biofuels in particular (Selvaggi et al., 2018). These biofuels are becoming widely used in logistic companies which, in collaboration with manufacturing companies, adapt their vehicle fleets to the logic of sustainable mobility, given that most of the freight transport in Italy is still carried out on the road. The logistic companies supply the stores of the large commercial distribution companies, which in turn feed the chain with the demand for agri-food products.

Moreover, the role of the regional institution has also contributed to the development of the model by encouraging sustainable mobility with the reduction of motorway tolls in favor of bio-methane-powered vehicles, a regulatory provision that places Sicily at the forefront of the challenge to environmental sustainability. Political support, linked to technological learning, remains essential in making biofuel production costs competitive with current fossil fuel prices. As Marsden et al. (1999, p. 299) argue "these arguments also imply the need for action at the national and regional level". In this view, Beccali et al., who presented an overview of the energy potential of biomass coming from the agricultural and forestry sectors in Sicily, argue that, despite the feasibility of energy production from biomass, it is necessary to "stress that the use of biomass depends on assistance from public entities such as the Strategic Operative Plan, Rural Development Plan, National and Regional Programs and Regional Energy Master Plan" (2009, p. 87)[15]. Therefore the contribution of the regional authority places further reflection on some choices which, when they involve changes in the economic-productive, regulatory, social and cultural fields, require a systemic[16] approach that involves public and private operators and a harmonization of the decision-making process at different geographical levels (local, regional, national, European).

[15] As regarding more specialist studies about development of biomethane production, see Pappalardo et al., 2022, and Rossi et al., 2018.

[16] See in Kapoor et al. the suggestions for changing cultural, technological and economic approach in the similar Indian case study (2020, p. 2).

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