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Article

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Abstract: There has been a continuous growth in ecological agriculture (EA) in recent years. It is recognized as a production system with rational energy use and low demand for fossil fuels. There are many studies relating to this subject, in contrast to the few studies regarding the use of energy and its impact on the environment in ecological greenhouses. This article analyzes the strategies adopted by a Transformational Agricultural Society (Sociedad Agraria de Transformación) in order to improve energy efficiency in ecological greenhouses, with regards to the use of fossil fuels. The methodology is based on the Working With People (WWP) Model, which involves social learning processes over 30 years in one of the largest regions of ecological crops in Spain. The results show that the measures taken to manage the greenhouses have achieved a decrease of over 80% in terms of fossil fuel consumption. The experience demonstrates that EA, as opposed to conventional agriculture (CA), is a system with great potential when it comes to reducing energy consumption and environmental improvements through various strategies.

Keywords: Transformational Agricultural Society; ecological agriculture (EA); conventional agriculture (CA); greenhouses; fossil fuels; renewable energy

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1. Introduction

In the overall European context of setting the economy on a sustainable growth path, businesses and rural communities must adapt their systems to find alternatives to our fossil-based economies. This can be achieved by unlocking the potentials of the bio-resources available in the different bio economy and blue-economy sectors, in a sustainable way that is accepted by the citizens. At the same time, Europe must continue to address resource efficiency in light of the increasing pressure on global food systems to meet demand from population and income growth. Society has to turn these challenges into real actions, bringing together the nexus among the primary sector, nutrition and health, and the nexus among food, water and energy [1]. Many of the challenges are of a global nature, requiring global solutions, working with people in cooperation with different partners. Innovative approaches to knowledge exchange such as those foreseen in the European Innovation Partnership "Agricultural Productivity and Sustainability" are of utmost importance to foster the implementation of solutions.

The Political Guidelines for the next European Commission for the 2016–2017 [2] programming period focus on resilient value chains for food and bio-based products, better managing possible future shortages in food and energy, fostering rural innovation with broad societal engagement. In addition, cross-cutting issues such as soil management and energy use efficiency will be taken into account in the EU policies.

Various studies highlight the energy problem within food systems. Firstly, energy is a basic consumable which is used more and more [3] in the production, processing and manufacture of food, with a heavy dependency on fossil fuels [4]. The use of these fuels in modern food production systems continues to increase at an international level [5] leading to a growing number of environmental and social impacts [6]. These production systems rely heavily on fossil fuels, contributing to an annual increase in greenhouse gases (GHG) [7] and the increased use of non-renewable energy [8]. As stated by Fischer et al. [9], energy usage increases with the intensification of agriculture, caused by anthropogenic pressures and the increasing demand for food [10]. Studies carried out by the European Union show that the energy consumed in agricultural production increased between 1989 and 2009, reflecting a lack of efficiency in terms of energy usage [11]. In addition, international policies highlight the use of energy in food systems as a food security problem [12]. Despite this, the efforts of those organizations which are responsible for meeting food demand at a global level [13] have been accompanied by an increase in the production of basic products, primarily in terms of medium scale agricultural exploitation. According to the Food and Agriculture Organization of the United Nations (FAO) [14], it is estimated that 80% of this increase in agricultural production will be as a result of intensified production systems. In addition, new agricultural technologies have emerged which combine increased production with improved environmental protection.

Food production systems and the limitations of energy resources represent a complex dichotomy: ecological agriculture (EA) seems to be an option, with continuous growth at an international level [15] offering different consumables to those used in conventional agriculture (CA). Some studies show an increase in energy efficiency within ecological production [16] as a result of using consumables with low non-renewable energy consumption, in response to the restrictions and increases in prices of basic fuels [17]. On the other hand, other studies show significant differences with regards to the efficient use of energy between ecological production and CA [18]. Sustainable agriculture uses energy from fossil fuels in a more efficient way than agricultural production systems; greater energy efficiency in crop rotation under organic management was attributed to the fact that the forage component was less sensitive to chemical input removal than grain crops [19]. Different studies consider that energy use can be reduced by up to 50% in organic crops compared to traditional ones [20,21]. Greater energy efficiency has been observed with organic crops due to the elimination of chemical inputs and changes to agricultural tasks [6]. However, the growth of the ecological production system is a result of market demand for healthy foods, with consumers and producers being aware of the need for a less contaminated environment, and less use of fossil fuels and more efficient use of energy [22].

Energy efficiency involves a reduction in the quantity of energy required to produce various food products [23]. In 2006, a study coordinated by Cornell University on the "impacts of organic farming on the efficiency of energy use in agriculture" [24], showed that organic farming systems significantly reduce the fossil energy inputs in production and also improve several aspects of agriculture's environmental performance compared with conventional farming systems. The findings of this study were: improved fossil fuel inputs (30% reduction) compared to conventional production, no use of commercial nitrogen or pesticides in organic systems, less soil erosion, improved water resources and increased organic material in the organic system (up to 50%), greater acquisition of solar energy, and less requirement for fossil fuel (up to 50%). Following the review of information from approximately 50 studies, Belloti [25] states that the majority of organic production systems are more energy efficient than their conventional equivalents. An alternative that has been developed is the application of conservation or regeneration agriculture methods [25–27]. Certain studies have shown that using these methods can ensure an efficient use of energy [28], helping to regenerate the soil and increasing organic material, improving its fertility and crop productivity [29].

Food production requires new low-consumption energy technologies [30]. In order to adopt these energy innovations, technological changes are required, along with a change of vision amongst the receivers to facilitate the implementation of new practices that are more energy efficient [31]. The farmers who have adopted these practices in the most energy efficient way (conservation work, and reducing fuel use) have a mentality and experience which allows them to tackle challenges and unforeseen changes in their surroundings [32,33], which contributes to the promotion of innovation and sustainable development [34,35]. These experiences amongst farmers with a vision for sustainability apply innovative agricultural practices in order to preserve natural resources, finding synergies between natural, socioeconomic and energy flow systems [36]. Figure 1 shows the group of farmers' evolution since the 1970s up to the present day. The experience and learning both within and outside of their field of work (such as their IPMA project management certification and forming part of the European "Food for Life" Platform) has enabled them to create strategies to move away from traditional methods towards innovative activity with a sustainable vision. The farmers' industry experience over the last 30 years has led to energy savings and a more efficient use of the natural resources available to them in their production activity [37].

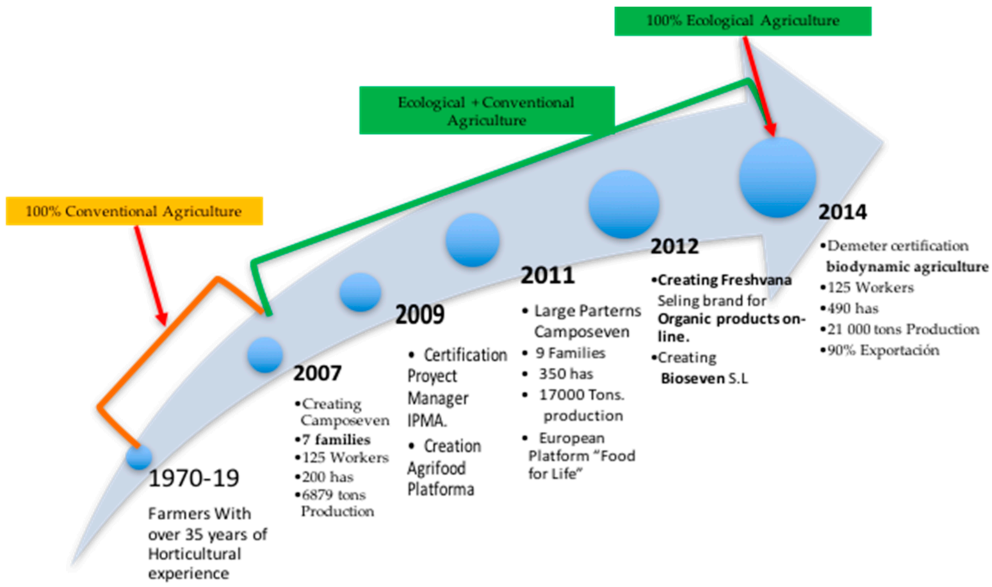

Figure 1. Important milestones in the evolution of the Organic Cooperative. Source: [38].

The reason behind farmers' tendency towards more sustainable production models, with regards to energy consumption, is the impact it has on the profitability of farming activity [39]. Innovation in conservation agriculture practices facilitates an efficient use of fuels, in the face of reduced availability of "cheap" fossil fuels [40] (increase in the price of fuels). Some studies show the importance of farmers understanding the comprehensive use of fossil fuels [41] in production systems, due to the fact that each type of crop creates different energy needs [42]. This local, proven experience [43] amongst farmers with regards to the use of fossil fuels makes innovations and strategies for reducing energy resources in different agricultural scenarios more feasible [20]. The use of farming machinery is indispensable in agricultural work. However, it is possible to reduce its use and reduce the cost of fossil fuels [20,40]. In certain studies, it is evident that organic producers are shown to make more efficient use of energy by applying sustainable production methods [44], with production relying on finite energy consumables. In these ecological systems, the use of fossil fuels is substituted by a greater use of human energy, resulting in a greater diversity of tasks [23]. Conversion to organic farming systems will reduce farmers' dependence on energy; and Organic farming can increase the efficiency of energy use per unit of production [24]. This change is accepted by many farmers requiring greater specialization (Figure 2).As stated by Wood et al. [26], the practice of EA reduces the use of energy involved in the production of food, stimulating the metabolism of the soil, water and wind system (the elimination of chemical products, incorporation of crop remains and livestock activity within the soil, increases organic matter, reduces soil, water contamination and reduces greenhouse gas emissions). As well as reducing energy usage, EA also improves the soil's fertility, which contributes to an improvement in the surrounding environment [45]. The integration of organized groups facilitates social learning for innovation based on various strategies for the sustainability and implementation of conservation tasks in EA [43,46–50]. These social learning processes have led to a change in mentality amongst farmers with a sustainability vision [46,51,52], favoring feedback and creating knowledge amongst the organized groups' participants.

Figure 2. Complementary use of heating system and specialization of farmers.

In Spain, in the Murcia region, social learning processes amongst ecological farmers with greenhouses are of particular note [46,48,53]. This ecological production in greenhouses is also regulated by various rules at an international level [54–56], although there is not enough information regarding the environmental impacts and the efficient use of energy [57,58].

It is well known that fruit and vegetable production in greenhouses is one of the systems that consumes the most energy in the agricultural sector, with production increasing based on energy inputs [58]. The basic point of the greenhouse is to understand the quantity of energy that is required in order to meet the caloric needs of each of the crops. The high costs and availability of energy [59], restrict the use of heating [60], making it more important for farmers to make efficient use of energy in the greenhouses. It is because of this that the comprehensive operation of this production system requires skilled personnel [61] in order to make efficient use of the consumables used. The training of greenhouse operatives is fundamental, especially with regards to their knowledge on crops' energy requirements and managing ecological greenhouses. In addition, Sun [62] mentions that the adequate design of the greenhouse (the material used, type of netting, color and thickness), the lighting, water circulation systems, solar energy storage and use as geothermal energy all influence energy efficiency and can make the system more profitable. The management of lighting is another key factor for making efficient use of energy in greenhouses, with light emitting diode (LED) technology enabling a significant reduction in energy [63].

Some greenhouse farmers have been able to increase the profitability of the system as a result of more efficient energy usage [64]. This increased profitability from greenhouses has not only been achieved through the use of fossil fuels, but also through other renewable energies, such as solar energy from mobile panels (Figure 3) [65].

This type of system, the option of using renewable energy enables a reduction in the use of fossil fuels and improves farmers' incomes [65]. Other strategic decisions for transitioning from conventional systems [66] to innovative systems have focused on the use of farming and forestry waste as sources of bioenergy [67,68].

Based on a vision of modernizing agriculture for sustainability, this article analyzes the dynamics of an Agricultural Society through a social learning process of 25 years of experience with EA and the efficient use of energy and finite resources [1]. The importance of the study is to show how organic farming can reduce and rationalize the use of fossil fuels in the ecological system. The article focuses on the use of fossil fuels in the operation of ecological greenhouses in the Region of Murcia, Spain. The analysis is carried out through several dimensions, political-contextual, technical-entrepreneurial and ethical-social, which impact the sustainable management of these non-renewable resources [47,49].

Figure 3. Greenhouse with mobile panels [65].

The article is structured as follows: Section 2 describes the methodology used for carrying out the work as part of the European Rethink Project. Section 3 presents the results and a discussion of these, demonstrating the strategies implemented by an organic cooperative with more than 30 years of experience in Spain. The results are divided into three subsections based on the WWP methodology used. Finally, Section 4 presents a conclusion, limitations and some recommendations.

2. Methodological and Conceptual Framework for the Analysis

2.1. RETHINK Organic Production in Spain: Cooperate to Innovate

One Organic Cooperative in Spain was selected as a success story highlighted by the FP7 research (RETHINK project) in the European Commission's 7th Framework Programme [69]. In this research project, alternative trajectories of agricultural modernization and rural resilience are explored based on case studies in 14 countries [70]. The key research question asked is how actors are connecting economic, social and environmental systems in different strategies for modernizing and improving prosperity and energy efficiency. RETHINK is a transdisciplinary research, under the "multi-actor approach" concept, which is necessary to engage farmers in highlighting innovative and successful connections between farms and other stakeholders.

The conceptual and analytical frameworks applied in the case studies and analysis build on the results obtained in a large number of EU-funded research projects which emphasized the multifunctionality of rural areas [71,72], biological diversity [73], rural economy [72,74], social capital and innovation processes in rural development [49,75].

The Organic Cooperative in Spain, RETHINK case study, focuses on analyzing the evolution of a social learning process amongst farmers with over 40 years' experience in the agricultural sector (production, transformation and commercialization of fruit and vegetable organic and biodynamic crops, both open-air and in greenhouses) and taking advantage of the region's ideal climatic conditions. The current mission of this Organic Cooperative (Camposeven) is "promoting the health of people developing organic product lines through the use of sustainable techniques" [38].

This Organic Cooperative has the following characteristics. (1) It has vast experience accumulated over many years. (2) It promotes social learning processes amongst organic producers, companies, research bodies and local and regional governments; it also encourages a favorable environment where farming partners make decisions together and benefit from different ways of learning (training, informal meetings, experiments on their own farms). (3) It is considered as a successful case study for the transformation of ecological products with an associative nature and socioeconomic purpose. (4) It has an innovative energy efficiency strategy which has won several prizes (including the 2007 Thanit Prize for Development and Technological Innovation). (5) By stimulating the farmers involved to exchange knowledge, and by upholding strong partnerships with universities and research groups, knowledge can be created, shared, and used efficiently. The idea behind this approach is that it strengthens the ability of small farmers to adapt to challenges and opportunities through networking and joint learning [69]. (6) It has a highly energy efficient greenhouse production system, which has enabled a reduction in the use of fossil fuels (over 80% in the last 10 years).

The Camposeven Organic Cooperative is situated in one of the regions of Spain with the largest proportion of EA, in the Community of Campo de Cartagena; it covers 1163 km^2 and has a total population of 358,927 inhabitants. In this area, the food industry has a long agricultural tradition. However, in the Mediterranean region, this sector represents a profound environmental, social and economic problem due to the existing conditions, which are restrictive for agriculture, such as a dry climate with a serious lack of water. Using just 3% of Spain's water resources and channeling investment towards an improved water supply system and treatment has enabled the region to evolve and exceed the Spanish average. However, the strong presence of tourism in the area puts significant pressure on natural resources and land prices, affecting farming's ability to survive. Murcia's economic dynamics are largely driven by the farming sector, the food industry is one of the key development forces and one of the main pillars which contributes the most to GDP and regional equilibrium. Murcia is the Autonomous Community with the largest area dedicated to EA in Spain [45] with an area of 58,820 hectares (10% of the regional agricultural area and 3.7% of the national agricultural area). According to the latest official figures from 2015, the area being studied covers 95% (205.68 has) of the 216 hectares of ecologically certified greenhouses in Spain. The study has obtained direct information from over 30% (65.00 hectares) of ecologically certified greenhouses in Spain [76]. This information, which has been obtained from 30% of existing greenhouses, can be considered statistically [77] representative of the entire Murcia Region due to the similar environmental conditions and systems used in ecological greenhouses [38,53].

Due to its physiographic characteristics (Figure 4), the region of Murcia faces a critical dilemma with regards to creating agricultural food products, with its problems with the lack of water to maintain productivity and energy use prompting it to make efficient use of the natural resources it has available. The objective of the region's producers is both to make the most of the limited water as well as fuels in order to generate enough energy to distribute sufficient water resources. As a result, they have opted to modernize the irrigation lands by moving towards automated irrigation systems in improved production structures with land consolidation processes.

The direct consequences for the farmer are improvements in working conditions, more time available, and improved financial results. The correct design and subsequent use of the installations provides a water release with environmental aims, and in particular contributes to a reduction in the over-exploitation of aquifers due to water savings and energy savings as a result of not requiring as much pumps.

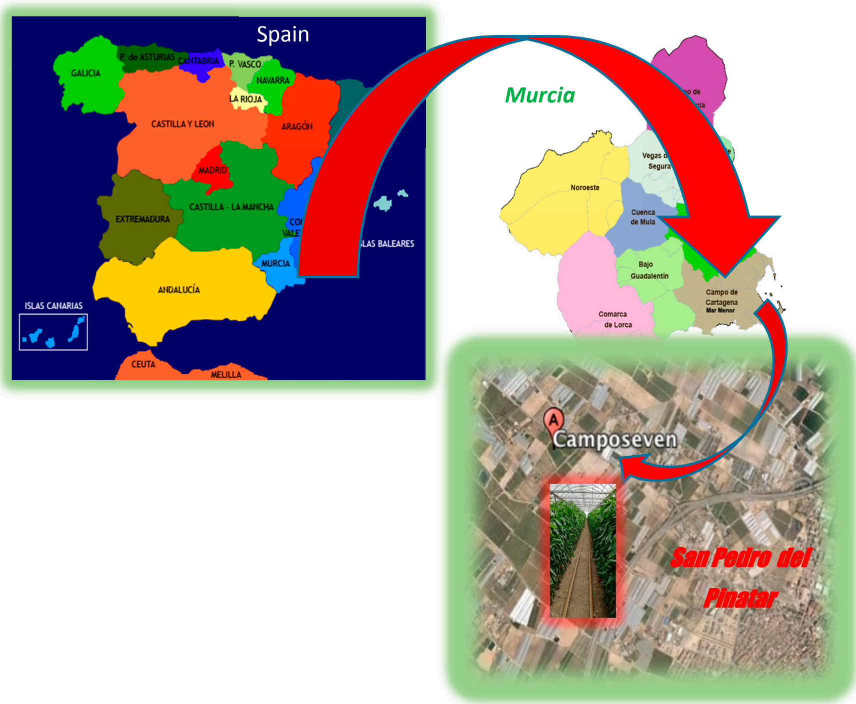

Figure 4. Location of the case study.

2.2. Materials and Methods

In order to collect information and systemize the analysis, a common methodological framework was designed by a panel of experts made up of 38 researchers from 14 countries in the EU, within the European Rethink project [1]. This common methodological framework was based on an analysis of the strategies for managing finite resources through the WWP model [49]. This proposal goes beyond the traditional technical-economic vision and aims to analyze the behaviors of the parties involved and the contexts in which they operate. The WWP methodological framework incorporates social learning processes for analyzing and building strategies for rural prosperity and sustainable management based on three dimensions, as shown in Figure 5 [46].

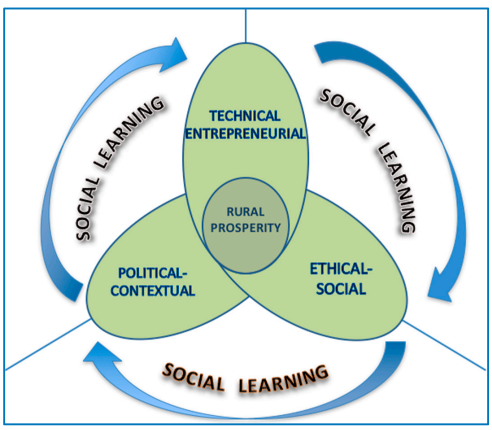

Figure 5. Dimensions of the Working With People (WWP) Model [49].

The ethical-social dimension considers the strategies adopted with regards to improving knowledge, behavior, attitudes and values amongst the people involved throughout the production, transformation and commercialization processes. The technical-entrepreneurial dimension includes the strategies that have been adopted to create ecological products, based on quality standards, with energy and resource efficient technology and processes. The political-contextual dimension enables organizations to adapt their strategies and projects to the contexts in which they operate, in order to achieve success from sustainable and efficient management. Lastly, social learning is the unifying dimension [78] linking the discoveries from the three dimensions that influence the Organic Cooperative's management.

Based on this common methodological framework, the results of the study incorporate various tools and sources of information. On the one hand, a summary and review of various secondary sources (scientific literature and historic information from the Organic Cooperative) regarding the previous concepts and projects carried out by the cooperative.

On the other hand, as the main source of information, the research incorporates empirical information obtained through a social learning process with key stakeholders: the timescale covers a learning process of 30 years of experience and knowledge in the ecological greenhouses sector in the region with the most acreage dedicated to organic farming in Spain.

The Figure 1 shows the major milestones that have influenced changes and adaptations of the Camposeven Organic Cooperative. This temporary bonding process between farmers and the interplay between external producers and agents, has involved a social learning process for joint planning and development of common strategies among the private sector, civil society institutions and R + D + i [49].

In order to collect and systemize the proven expert knowledge, two complementary participative processes were used: (1) direct interviews with parties involved in the Organic Cooperative's activity; and (2) Workshop-Focus Group (Agri-Food Platform). The scope of these participatory processes, over the years, is summarized in the following sections: (a) for the in-depth direct interviews, a questionnaire was designed based on the European Rethink project's methodological framework. The questionnaires included four sections with questions linked to the different dimensions of sustainable management and rural prosperity: the first section was aimed at understanding the vision of those interviewed with regards to sustainable management and rural prosperity; a second block with questions about the strategies adopted in relation to the ethical-social dimension; a third block regarding the strategies linked to the technical-entrepreneurial dimension, with questions about production, transformation and use of resources, as well as energy management; and, a final section, regarding the strategies linked to the political-contextual dimension, with questions aimed at analyzing the relationship between the agricultural organization and its environmental, socioeconomic and political context. The fieldwork was carried out between March and December 2015 by the project's research team. A total of 42 in-depth interviews took place, representing 100% of the key actors involved in the organic cooperative's activity: farmers, suppliers and collaborating companies, public-administrative sector of governments and business associations. The people selected for this process cover a learning process of over 30 years of knowledge demonstrated in the EA sector. (b) Workshop Focus Group: Another tool used to obtain empirical information and integrate knowledge and learning was the "Agri-Food Platform"; it is a tool for social learning and innovation network for developing innovative patterns of production by generating new knowledge. Since it was established in 2009, the "Agri-Food Platform", which was co-founded by the Camposeven Organic Cooperative along with the FGUPM and the Technical University of Madrid, a meeting point is formed for the "WWP" model bases. During this time, numerous workshops and Focus Groups between companies, universities and technology centers related to the food industry have been carried out. In May 2011, the Agri-Food Platform was integrated into the European Food for Life Platform, within which a new working group was created, the director of the Organic Cooperative is the president of this new working group. Each group explores innovative solutions to problems and opportunities, based on the experience gained in projects linked to the different dimensions of sustainable management and rural prosperity. Each Focus Group meets different key stakeholders (15–20 experts), including farmers, advisers, researchers and agri-business representatives, to collect and summarize knowledge on best practices and strategies to improve energy efficiency in ecological greenhouses.

A seminar-workshop took place with executives and senior workers from different departments in the Organic Cooperative. The sessions took place over four working days in their own facilities based on the WWP technique, applied to various sustainable development projects in rural organizations [38,49,79]. The workshops reflect on these dimensions of the strategies analyzed in the interviews and provide a deeper understanding of other aspects linked to the organization for efficient management and ecological production.

This participatory process analyzes the producers' experience and represents 415 hectares of EA production, of which 65 hectares are ecological greenhouses. The information obtained from the greenhouses covered the production cycles from 2002 to 2014. The information between 2002 and 2007 is based on CA. EA starts from 2007 with the integration of the ecological cooperative. Information was gathered regarding the greenhouses' type of production system, type of fuels used, the way in which they received the fuel, the use of fuel in tons of oil equivalent (toe) by period, and energy used by period (MWh). In order to study these, international Fuel and Natural Gas energy equivalents were considered.

3. Results and Discussion

In this section, the different strategies adopted by the Organic Cooperative are analyzed. These are aimed at improving energy efficiency in ecological greenhouses and achieving success in terms of sustainable management. The results are presented in a logical way, based on the three dimensions of the WWP model (technical-entrepreneurial, political-contextual and ethical-social) and according to the scores from the parties involved.

3.1. Ethical-Social Strategies

Table 1 shows the scores given to different strategies adopted within the ethical-social dimension, to promote sustainable success and energy efficiency.

Table 1. Ethical-social dimension strategies [38].

Strategy Adopted	Scores from the Parties Involved (1–4)	Current Aplication (%)
Creating a new innovation company based on trust and business ethics	3.6	100
Transforming the work process and changing mentality amongst members	3.5	100
Training personnel in sustainable management and ecological production	3.4	100
Promoting involvement, collaboration and cooperation	3.2	100

3.1.1. Creating a New Innovation Company Based on Trust and Business Ethics

This is the highest scoring strategy in this dimension. It was implemented following the incorporation of the Organic Cooperative in 2007. It is a business set up by seven producers with more than 30 years of agricultural experience, in keeping with common interests. From its beginnings, Camposeven has been established on principles of trust and mutual support. The group's activities are guided by values that are shared by its members. The creation of the society was a result of a separation from another company with a different vision. The Organic Cooperative's vision is to evolve production processes and create trust amongst members. Trust is the indicator that the members consider to be the most important value. A farmer and member states: "*From my experience across all these years, I've learned that it is very important to have trust and specialize in something, it is fundamental to have a good team of people, teamwork and personnel*".

The organic farmers also consider that, in order to improve efficiency, it is necessary to be open-minded towards changes and differentiate themselves [80] from other companies with the same production activity.

3.1.2. Transformation of the Work Process and Change in Mentality amongst Members

Included in the new company's strategy is a change in work processes and a change in mentality, in order to completely transform their fieldwork and that of the farming industry in general. This also refers to the processes of creating awareness amongst farmers as well as other external actors in the "Food and Agriculture Platform", reinforcing the arguments on the need to create healthy products for people in order to achieve differentiation and to be widely accepted by consumers. This transformation develops a sense of identity; it makes them different, enabling a transformation process from CA to EA, with a vision for energy efficiency and profitability. As confirmed by an organic farmer: "*The main differences between Camposeven and other Agricultural Societies is its ways of working: innovation, looking after people, research*" [38].

3.1.3. Training in Relation to Sustainable Management and Ecological Production

This strategy incorporates proven expert knowledge [48,78] and learning in each of the actions. The focus amongst personnel to homogenize technical knowledge leads to a production process which makes it stand out from other companies within the industry. Training leads to sustainable practices and actions. The effectiveness of the ecological production system requires the timely implementation of agricultural works. This new system's actions are aimed at maximizing the efficiency of energy usage by eliminating fossil fuels and making the process profitable [81]. Establishing and maintaining ongoing processes for training people, as well as improving members' knowledge are key strategies for Camposeven. The Organic Cooperative carries out actions to modernize and update training, enabling the development of specific skills in relation to EA, as a differentiator for sustainable success. One aspect of the organization's success is the support for improving training amongst workers and farmers. The level of training for farmers affects the extent of development of the agricultural system [82]. As stated by a member of the Organic Cooperative: "*From my experience across all these years, I've learned that it is important to specialize in something, it is crucial to have a good team of people, teamwork and personnel are fundamental*".

3.1.4. Promoting Participation, Collaboration and Cooperation

The strategies are the product of a plan implemented by an agricultural leader who is trusted by a group of other farmers. According to Suh [83], leadership aimed at creating relationships based on trust and assurance enables feedback and complementarity across all of the company's activities as well as the existence of collaboration. The Organic Cooperative is an example of teamwork, which values the technical and production values of the goods and services produced, as well as the people involved [48]. The Cooperative's organizational structure facilitates decision making amongst members [38], as a result of their participation. The organization's management has enabled it to go through changes which have resulted in decisions thanks to members' interventions. The strategy for involvement in management processes enables the existence of relationships between people in the organization as well as other parties involved, with one supplier commenting that "*The relationship with Camposeven is collaborative, we have a relationship with the members. We work with them every day*". The Organic Cooperative's decisions are not made by a single person; there is involvement in decision making. The current structure [38] shows the dynamic nature of internal involvement in terms of managing production processes, as well as the appropriate use of natural resources through production systems involving conservation work and rational use of fossil fuels. Various studies state that this rational use of fossil fuels can be linked to people's behavior [30].

3.2. Political-Contextual Dimension Strategies

Table 2 summarizes the strategies adopted within the political-contextual dimension to promote sustainable success and energy efficiency. Based on the political-contextual dimension, the Organic

Cooperative incorporates strategies in order to adapt to and connect with the socioeconomic and environmental dynamics, in particular with the aim of eliminating chemical supplies and fossil fuels.

Table 2. Political-contextual dimension strategies [38].

Strategies	Perception Amongst Members (1–4)	Current Application
Consideration and analysis of the Organic Cooperative and exploitation activity's environmental effects	3.6	High
Creation of commercial alliances in order to access international markets with demand for ecological products	3.2	High
Creation of R + D + i alliances	3.0	Medium
Self-management	2.6	High

3.2.1. Consideration and Analysis of the Environmental Effects of the Organic Cooperative's Activities and Operations

One of the premises that the change in production activity was based on, in parallel to the creation of the Transformational Agricultural Society, was the direct links between all the company's farmers and the new fieldworks. The fieldwork includes conservation work. The ecological certification of the new production systems, which currently applies to all farmers, is 100% focused on protecting the environment and regenerating natural resources. These are activities that involve eliminating chemical supplies and withdrawing (or making more efficient use of) fossil fuels. The result of these actions is a reduction of more than 80% in the use of fossil fuels in the company's greenhouses. One farmer states that: "*I'm very happy with the ecological production system, its objective is to produce food which is healthy for people*".

3.2.2. Creation of Commercial Alliances to Access International Markets with Demand for Ecological Products

The Organic Cooperative's objective is to produce ecological food at an international standard, highly competitive with differentiating factors [80] in the market. Business management led by the Cooperative's commercial team has enabled commercial alliances to be created directly with high profile customers in the EU region. As a result of this strategy, more than 90% of the Cooperative's ecological production is in international markets, this being one of the key pillars of success for the organization and the prosperity of the associated operations. International and national competitiveness is another of the highly influential factors, in order to be able to compete with growing international competition. Based on experience, it is considered vital that the cooperative's products are able to compete in the international market based on quality and price, and differentiate themselves through ecological and biodynamic certification.

3.2.3. Creation of R + D + i Alliances

Table 2 shows the organization's strategies relating to this dimension. The level of perception amongst members reflects the strengths of its development as an Agricultural Society. An important indicator is the continuous innovation through R + D + i, which is a differentiator within the food and agriculture industry. A farmer with more than 40 years of experience in this field expresses his confidence in the innovation "*Camposeven is a leader, it is an exception within the sector, it is an example which should be followed*". In 2009, the Organic Cooperative integrated with companies in the sector, creating different organizations (Food and Agriculture Platform with the UPM and companies in the sector, Food for Life European Platform). The objective of these actions is to have a greater presence in the food and agriculture market. Its strategic R + D + i links with the UPM's (Universidad Politécnica de Madrid) GESPLAN Group created the "Ingenuity Foundation Chair" project in 2013 with the objective of creating technological innovations in the efficient use of energy and with the vision of reducing fossil fuels, linked to the ever complicated use of the region's water sources and improving ecological crop techniques, whilst ensuring their activities contribute day-by-day to a more profitable company with the vision of making the natural environment a social property for communal enjoyment.

3.2.4. Self-Management

A characteristic of the Organic Cooperative is the aim of self-sufficiency, which is reflected in its search for energy efficiency and profitability. The cooperative has the perception that agricultural companies should be based on competitiveness and should not be dependent on the public sector. Two member farmers mention that "*public support make the organized groups less competitive, because society should be self-sufficient*" [38]. There is currently public support from the European Union. This support represents an average of 4.5% of the incomes from the commercialization of fruit and vegetable products. The support is applied to activities such as research for innovation in production systems, environmental improvements amongst others [84]. The ecological cooperative participates in this program by complying with ecological certification rules [54,56], which have allowed it to successfully introduce its ecological products in countries within the European Union. The Cooperative's objective is to be innovative, improve energy efficiency and make use of natural resources with a sustainability vision.

3.3. Technical-Entrepreneurial Dimension Strategies

One of Organic Cooperative's fundamental indicators its ability to transform as an organization, highlighting its ability to take action and create a new system, when the current situation is not sustainable [46,85]. Within this dimension, strategies are aimed at improving its business function [78], through improvements in the sustainable management of natural resources, technological innovation and the efficient use of energy. The main strategies used (Table 3) from a technical-entrepreneurial point of view are linked to the activities aimed at the sustainable use of natural resources, optimizing energy usage, eliminating chemical supplies and differentiating their ecological and biodynamic products in the market.

Table 3. Technical-entrepreneurial dimension strategies [38].

Strategies	Importance (1–4)	Application by Farmers (%)
Restructuring towards ecological products	3.9	100
Diversification of products	3.9	100
Technological renewal of operations	3.3	90
Use of fuels and energy reduction	3.3	80

3.3.1. Restructuring towards Ecological and Diversified Products

The technical-entrepreneurial strategies implemented by the farmers are based on more than 30 years of experience and social learning processes. Following the incorporation of the Organic Cooperative, significant changes were made in the way crops are grown. The report created by the European Commission [38] details the farmers' decision to make Camposeven a 100% ecological agricultural development. The conventional system of producing agricultural food products is abandoned in favor of 100% of crops becoming properly certified as ecological, whilst carrying out conservation work [6].

Greenhouses convert their conventional production systems to ecological ones, adjusting their teams' operational processes. The amount of energy required to develop each crop is calculated. Double covers and thermal screens are used in order to lose less heat during the night. The temperature of the nighttime heating is reduced from 19° to 12° (making more efficient use of energy). Varieties are used which are less sensitive to the cold. The idea is to use less and less heating. Biodynamic agriculture certification does not allow the use of heating [54], unless the nocturnal temperature reaches a level that could harm the crops. All the efforts are dedicated to minimizing a loss of heat at night which has been accumulated throughout the day, with the objective of making efficient use of heat energy.

The consumers of ecological products demand a diverse range of quality organic products. Several researchers in America state that since 2000, consumers purchase organic products through conventional channels such as supermarkets, rather than through other means [86]. It is common for supermarkets to offer a wide range of ecological products. The use of greenhouses is able to accelerate metabolism and/or protect various crops so that they can take them to the market before any other producers in the region. The diversity of products out of season is an opportunity to provide international customers with confidence.

The Organic Cooperative's range of products has enabled it to establish itself in the market. Its mixed crop operations mean it can offer this diversity. In order to offer high quality diversified products, its basic activities (sowing, growing, harvesting, preparation, packaging and marketing) need to be part of a highly coordinated process [38]. The fundamental activities required to produce a finished product need to make efficient use of water resources, greenhouses, research and technological development areas, the implementation of conservation agriculture tasks and regeneration of natural resources as well as reducing energy and using fossil fuels more efficiently. This results in reduced costs and a direct increase in profitability [87]. These actions have resulted in an improvement in the quality of life amongst the members, individuals and groups linked to the company's operations.

Finally, by differentiating ecological and biodynamic products in the international market, it has enabled the Organic Cooperative's products to be widely accepted. Currently, over 90% of its products are exported, with this market being key to its success.

3.3.2. Technological Renewal, Use of Fuels and Energy Reduction

The strategy of technological renewal in terms of operations is an inherent part of the change from a conventional production system to an ecological system. Changes were not only made in open-air crops, but also in greenhouses. The technology used for greenhouse crops is completely different; it requires more attention, especially in terms of temperature control. Technological renewal involves changing from a conventional system to an ecological or conservation system. As one farmer and Organic Cooperative member expresses, "*The majority of operations are experiencing a modernization and renewal process, in this sector adapt or die*" [38].

The Company has 65 hectares of greenhouses, with 100% being ecologically certified. Seventy percent have the ecological seal for biodynamic agriculture or DEMETER certification. *Biodynamic agriculture* is characterized by the restricted use of fossil fuels and a significant reduction in energy use. Point 3.4.5 of this certification states the following:

> *Production under Glass and Plastics: The energy usage for heating crops under glass or plastic should be kept as low as possible. Energy saving techniques, such as the use of special heating systems (e.g., ground or vegetation heating) must be introduced to the enterprise wherever possible*. [54]

EA tasks, which include the addition of the other crops and compost prepared according to ecological certifications, in greenhouses, show the results of a more efficient use of energy and ongoing costs reductions, making the system profitable. The data from 2002 to 2014 show the impact of making more efficient use of natural resources, by giving agricultural tasks a conservationist focus.

Farmers have traditionally tried to ensure the success of greenhouse crops by using heating. Traditional heating systems are fueled by carbon, wood, organic materials or diesel oil and, since 2005 in the Murcia region, by natural gas. Heating systems demonstrate the inconvenience arising from a lack of uniformity in terms of radiation and maintaining temperature. These systems are very useful and economical and they use widely available fuels. Another system that has been very useful for the Organic Cooperative in 14% of its greenhouse operations is a water vapor heating system (Figure 6) through 1.5-inch diameter steel tubes (Figure 7).

Figure 6. Boilers and water vapor injectors.

Figure 7. Steel plumbing system for distributing water vapor.

The system radiates energy to the structure's surroundings, with 25% of this energy reaching the ground. This system has provided positive results, with reduced costs observed during each production period (Figure 8). Based on the information obtained from the farmers regarding the greenhouses' costs per square meter (Table 4 and Figure 8), the change from a conventional to an ecological agricultural production system is quantified. A direct decrease in fossil fuels is observed (by 80%) as well as a decrease in operational costs in ecological greenhouses (2.48 Euros/m^2) compared to conventional ones (3.35 Euros/m^2), with an overall cost reduction of 26%. This cost reduction arising from the change to an ecological production system impacts the farmers' financial benefits. Furthermore, the integral transformation of the ecological cooperative and the decrease in fuels and supplies, enable a more efficient use of resources, with environmental effects and a direct impact in terms of reducing greenhouse gas emissions, as well as reduced contamination of soil and aquifers [24].

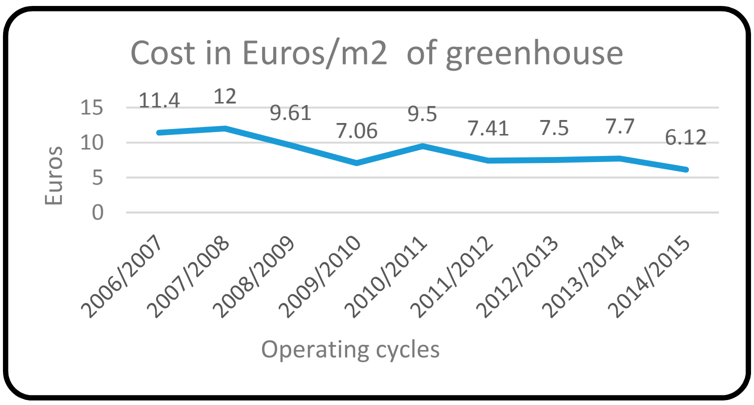

Figure 8. Greenhouse costs. Source: fieldwork.

Table 4. Average operational costs in greenhouses 2002–2015. Source: fieldwork.

Variable	Costs per Greenhouse (Euros/m^2)		Difference	%
	Conventional Greenhouses	Ecological Greenhouses		
Agricultural tasks	2.00	2.97	0.97	48%
Water	0.05	0.15	0.10	198%
Fuels	3.24	1.43	−1.82	−56%
CO_2	1.18	-	−1.18	−100%
Production supplies (fertilizers, seeds, etc.)	3.35	2.48	−0.87	−26%
Amortization (farm equipment, pumping equipment, heating equipment)	0.34	0.29	−0.05	−15%
Administrative expenses	1.23	1.06	−0.17	−14%
Total	11.39	8.37	−3.01	−26%

Table 5 shows additional data on average productivity, demonstrating that ecological greenhouses are less productive compared with conventional ones, which is in line with other studies [87]. However, it is shown how the prices obtained for products from ecological greenhouses are higher than those from conventional ones. These higher sale prices for ecological products, which are linked to reduced operating costs, create a positive impact on the overall benefits received by ecological farmers.

Table 5. Benefits in greenhouses 2002–2015. Source: fieldwork; * PV/m^2 = (Production/m^2)(Prices/kg); ** Benefit/m^2 = PV/m^2 − TC/m^2.

VARIABLE	Benefits per Greenhouse (Euros/m^2)		Difference	%
	Conventional Greenhouses	Ecological Greenhouses		
Production/m^2	14.32	9.00	5.32	−37%
Prices/kg	1.14	1.70	0.56	49%
* Production Value/m^2	16.32	16.65	0.33	2%
Total cost/m^2	11.39	8.38	3.01	−26%
** Benefit/m^2	4.93	6.92	1.99	40%

A characteristic of the boilers is their versatility in terms of fuel usage. The boilers are adapted for the use of different fuels, fuel or natural gas. Since 2005, the use of fuel was based on the prices offered in the production area. The decision to use different fuels between 2005 and 2014 is linked to the more accessible pricing during the required period.

These greenhouses benefit from modern installations. The heating system is by radiation through pipes with a dual purpose, they help transport workers for day-to-day work (internal tracks) (Figure 2) and generate internal heat in the greenhouse (Figure 7).

The farmers' initiatives are linked to seeking efficiencies and profitability. The design of these installations enables agricultural tasks to become more efficient. The physical efforts of farmers is limited to manual work, moving and loading produce is carried out using wheelbarrows which have been adapted to the rails, making the production activities more efficient (Figure 2).

3.3.3. Use of Fuels and Energy Reduction in Greenhouses

In order to discuss energy efficiency, it is necessary to analyze all of the energy sources in the system. In this case, only the use of fossil fuels will be analyzed. With regards to efficiency, only the use of fuels in greenhouses (natural gas and fuel) will be referred to. Table 6 shows the intermittence and percent of the type of fuel used between 2002 and 2014. The use of natural gas by farmers became prominent in 2005, a year in which gas pipelines were installed in the region. In the period between 2002 and 2006, the Organic Cooperative was not yet incorporated. The region's suppliers invoice the farmers for fuel by kilogram (kg). The producers use the cheapest fuel available to them when they need it. The variation in use of fuel from the period 2006/2007 is a result of the difference in price in each production period. The equipment installed in the greenhouses enables the use of any type of fuel. Figure 4 shows the amount of fuel in tones used since 2003. By starting to work with EA, farmers are able to reduce the use of fossil fuels and optimize the amount used.

Table 6. Type of fuel used between 2002 and 2015. Source: Field work.

Fuel/Period	2002/2006	2006/2007	2007/2008	2008/2009	2009/2010	2010/2011	2011/2013	2013/2014
Fuel	100%	5%	25%	100%	50%	-	100%	-
Natural gas	-	95%	75%	-	50%	100%	-	100%

The different proportion of fuels used (Figure 9) is a decision made by farmers when they purchase the fuel. The decisions are based on the price differences between fuels. The objective is to use the type of fuel efficiently and make the system more profitable. This group of farmers can be characterized by their continuous analysis of income and expenditure. Less fuel is used, or more efficient use of the fuel is possible, as a result of changing to ecological conservation work.

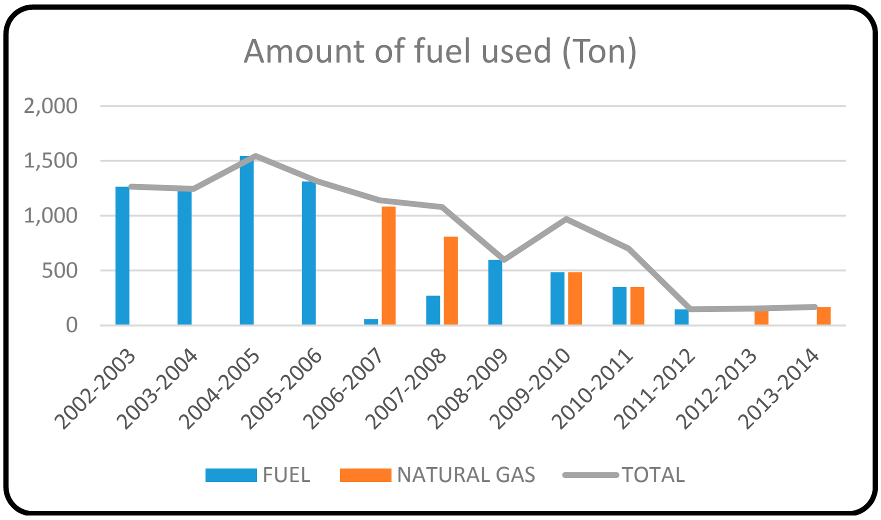

Figure 9. Fuels used in greenhouses. Source: Fieldwork.

The information presented in Table 7 includes fuel (fuel and natural gas), converted in order to calculate the energy used, in toe, an indicator which is defined as 10^7 kcal (41,868 GJ), the equivalent energy released by burning one ton of crude oil [8]. The opportunity is taken to differentiate the use of each of the fuels. The market's influence on the price of fuel does not allow farmers to use 100% natural gas (a fuel which has less contamination impact on the environment). Despite this, the Organic Cooperative farmers make efficient use of each type of fuel and the energy itself. This efficient usage refers to the strict use of fuel for the crop's most pressing needs in critically cold periods.

Table 7. Toe by type of fuel. * 1000 kg fuel = 0.96 toe; ** 10 m^3 Natural gas = 0.928 toe.

Product	2002–2003	2003–2004	2004–2005	2005–2006	2006–2007	2007–2008	2008–2009	2009–2010	2010–2011	2011–2012	2012–2013	2013–2014
Fuel *	1213	1193	1483	1259	55	259	573	465	-	141	146	-
Natural gas **	-	-	-	-	1243	928	-	556	402	-	-	191
Total toe	1213	1193	1483	1259	1297	1187	573	1022	402	141	146	191

The important aspects of Table 7 and Figure 10 are the way in which non-renewable resources are managed. Ecological conservation works [6,16,45] allow for a more efficient use of fossil fuels. The focus on efficiency and profitability is effective, resulting in an 84.2% decrease in fuel in 12 years. The farmers in the Organic Cooperative who have ecological greenhouses are an example of the opportunity that exists in improving the conventional production system through changes to basic agricultural tasks focused on conservation.

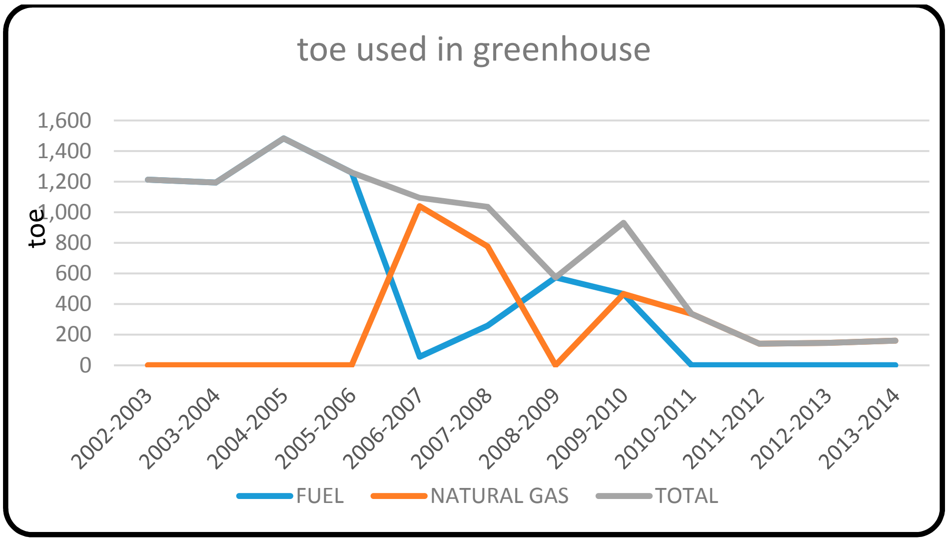

Figure 10. Toe by type of fuel. Source: Fieldwork

Table 8 is the record of energy used in ecological greenhouses. The 84% decrease in energy has a positive impact on the environment, improves profitability for investors and improves the quality of life for the organization and the individuals and groups who are linked to the integrated process of producing, preparing, packaging, marketing and distributing ecological food.

Table 8. Energy used in MWh * between 2002 and 2014. * 1 MWh = 0.086 toe; Source: Field work.

Product	2002–2003	2003–2004	2004–2005	2005–2006	2006–2007	2007–2008	2008–2009	2009–2010	2010–2011	2011–2012	2012–2013	2013–2014
Fuel	104	103	127	108	5	22	49	40	0	12	13	0
Natural gas	0	0	0	0	107	80	0	48	35	0	0	16
Total	104	103	127	108	112	102	49	88	35	12	13	16

The results shown in Figure 11 are the Organic Cooperative organization's objectives: moving away from CA towards EA; eliminating chemical and oil supplies; reducing fossil fuel usage; making more efficient use of the energy in greenhouses; making EA in greenhouses profitable; improving the quality of life for members and workers; and improving the environment as a result of better soil and water sources.

Greenhouses have been, and continue to be, instrumental in increasing fruit and vegetable production at a global level. Their high usage of energy from fossil fuels is discussed, as well as their high greenhouse gas emissions. The results presented here create the possibility of resuming activities involving the use of EA in protected agriculture, whilst in parallel reducing expenditure by shifting from CA to EA.

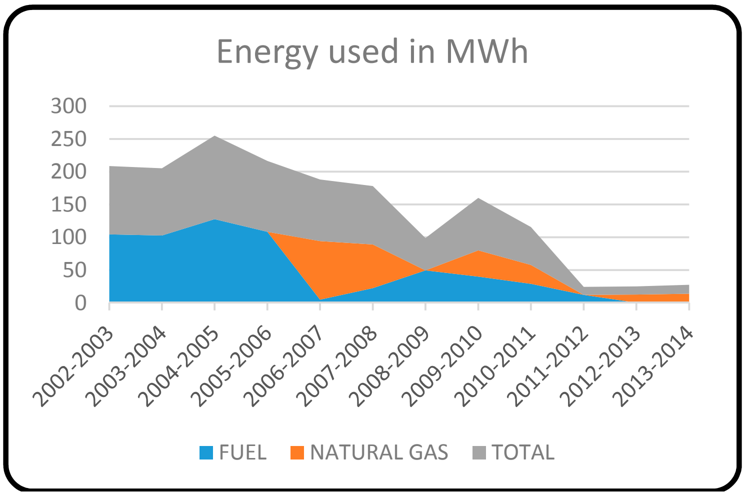

Figure 11. Energy use in Organic Cooperative greenhouses. Source: Fieldwork

4. Conclusions

The Organic Cooperative is an organization dedicated to the production of ecological fruit and vegetable crops. Following its change in production activity, from CA to EA, it has created innovative tools which have enabled it to be efficient in the use of fuels, reduce the use of energy from fossil fuels and contribute to environmental improvements. Based on a social learning process, across more than 30 years of experience, there has been a change from a conventional production system to an ecological one, which has not only impacted farmers' financial benefits, but presumably also has positive environmental effects as a result of using less fuel and agricultural supplies.

The factors in the ethical-social dimension have influenced the outcomes of the company's vast transformation. The conduct of individuals within the Organic Cooperative means that their skills and abilities are improved, creating total confidence and teamwork, with ethics and values being fundamental aspects. The activities within this dimension have led to a complete acceptance of the use of ecological production systems. This change led to the implementation of new agricultural tasks (conservation and regeneration of natural resources) and a more rational use of fossil fuels. These are factors that the European Commission itself outlines as important ethical and social considerations, in particular in relation to agriculture and related food production [88].

The regional and international strategic vision, influenced by the political-contextual dimension, enables it to specifically plan its activities and implement the necessary strategies in order to improve the management of natural resources. Based on this political-contextual dimension, the ecological cooperative commits to the EU's objectives for reducing energy consumption [11,37,66], and making more efficient use of energy by reducing the use of fossil fuels. Their production activities are clearly linked to the EU's 20-20-20 strategy: use 20% renewable energy, reduce greenhouse gas emissions by 20% and improve energy efficiency by 20%.

The farmers' competencies create strategies within the Organic Cooperative's technical-entrepreneurial dimension. Technological change leads to modifications in the production systems in 100% of operations, as well as in all of the greenhouses. By moving towards ecological production, it enables it to access the main ecological product markets within the European Union. Ecological product export activity is its main source of income (it currently exports over 90% of its products). The importance of this change has been the wide acceptance of its ecological products offered, combined with the profitability from its efficient production process, with the withdrawal and efficient use of fossil fuels also being an important factor in its success.

Technological innovation creates experience and knowledge in terms of the efficient use of fossil fuels. Greenhouses are the production strategy that consumes the most energy within the agricultural system. Training farmers in new technology is the basis on which they are able to decide how much and which type of fuel to use in the greenhouses, making use of them in an efficient and profitable manner. The organic cooperative's ecological greenhouses create products in greater volumes and with higher quality. Their products are used strategically as they are harvested out of season and can be taken to market before competitor products. The changes in the ecological system led to a more rational and efficient use of fuels. The organic cooperative's ecological greenhouses have reduced the use of fossil fuels by more than 80% over 12 years. A clear success of the strategies adopted by the farmers in the Organic Cooperative is the reduced total operating costs (by 26%) as a result of transforming the conventional system to an ecological one in greenhouses.

The Organic Cooperative's experience with regards to the ecological system and the use of greenhouses creates a new vision in the field of fossil fuel usage. The design used within EA, implementing crop conservation tasks contributes to the efficient use of energy required in the greenhouses. The experience of these farmers is a result of social integration. The group's inclusive vision is a product of the social learning process and improved confidence in the decisions made.

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References

1. Darnhofer, I.; de los Rios, I.; Knickel, K.; Koopmans, M.; Lamine, C.; Almored, G.; Tisenkopfs, T. *Rethinking the Links between Farm Modernization, Rural Development and Resilience in a World of Increasing Demands and Finite Resources*; RURAGRI: Brussels, Belgium, 2014.
2. *Horizon 2020 Work Programme 2016–2017*; European Commission: Brussels, Belgium, 2016.
3. Canning, P.; Charles, A.; Huang, S.; Polenske, K.R.; Waters, A. *Energy Use in the U.S. Food System*; United States Department Agriculture: Washington, DC, USA, 2010.
4. Woods, J.; Williams, A.; Hughes, J.K.; Black, M.; Murphy, R. Energy and the food system. *Philos. Trans. R. Soc.* **2010**, *365*, 2991–3006. [CrossRef] [PubMed]
5. *La Energía en España 2014*; Ministerio de Industria Energía y Turismo: Madrid, Spain, 2015.
6. Pimentel, D.; Hepperly, P.; Hanson, J.; Douds, D.; Seidel, R. Environmental, Energetic, and Economic Comparisons of Organic and Conventional Farming Systems. *BioScience* **2005**, *55*, 573–582. [CrossRef]
7. Lamb, A.; Green, R.; Lan, B.; Broadmead, M.; Bruce, T.; Burney, J.; Carey, P.; Chadwick, D.; Crane, E.; Field, R.; et al. The potential for land sparing to offset greenhouse gas emissions from agriculture. *Nat. Clim. Chang.* **2016**, *6*, 488–492. [CrossRef]
8. Algor, S.L. *Energía 2015*; Foro Nuclear: Madrid, Spain, 2015.
9. Fischer, T.; Byerlee, D.; Edmeades, G. *Crop Yields and Global Food Security: Will Yield Increase Continue to Feed the World?*, 1st ed.; Twofoot Consulting Group: Canberra, Australia, 2014; pp. 462–467.
10. Shannon, K.L.; Kim, B.F.; McKenzie, S.E.; Lawrence, R.S. Food System Policy, Public Health, and Human Rights in the United States. *Annu. Rev. Public Health* **2015**, *36*, 151–173. [CrossRef] [PubMed]
11. Pereira, V.J. Energy consumption across European Union farms: Efficiency in terms of farming output and utilized agricultural area. *Energy* **2016**, *103*, 543–556.
12. Pelletier, N.; Audsley, E.; Brodt, S.; Garnett, T.; Henriksson, P.; Kendall, A.; Kramer, K.J.; Murphy, D.; Nemecek, T.; Troell, M. Energy Intensity of Agriculture and Food Systems. *Annu. Rev. Environ. Resour.* **2011**, *36*, 223–246. [CrossRef]
13. *El Estado de la Inseguridad Alimentaria en El mundo 2015*; Food and Agriculture Organization of the United Nations (FAO): Roma, Italy, 2015. (In Italian)

14. *World Agriculture: Towards 2015/2030*; Food and Agriculture Organization of the United Nations (FAO): Roma, Italy, 2002.
15. Willer, H.; Lernoud, J. The World of Organic Agriculture—Stadistics and Emerging Trends 2016. Available online: https://shop.fibl.org/fileadmin/documents/shop/1698-organic-world-2016.pdf (accessed on 30 June 2016).
16. Pimentel, D.; Berardi, G.; Fast, S. Energy efficiency of farming systems: Organic and conventional agriculture. *Agric. Ecosyst. Environ.* **1983**, *9*, 359–372. [CrossRef]
17. Scialabba, N.E.; Müller-Lindenlauf, M. Organic agriculture and climate change. *Renew. Agric. Food Syst.* **2010**, *25*, 158–169. [CrossRef]
18. Seufert, V.; Ramankutty, N.; Foley, J.A. Comparing the yields of organic and conventional agriculture. *Nature* **2012**, *485*, 229–232. [CrossRef] [PubMed]
19. Haas, G.; Wetterich, F.; Köpke, U. Comparing intensive, extensified and organic grassland farming in southern Germany by process life cycle assessment. *Agric. Ecosyst. Environ.* **2001**, *83*, 43–53. [CrossRef]
20. Dalgaard, T.; Halberg, N.; Porter, J.R. A model for fossil energy use in Danish agriculture used to compare organic and conventional farming. *Agric. Ecosyst. Environ.* **2001**, *87*, 51–65. [CrossRef]
21. Hoeppner, J.; Entz, M.; McConkey, B.; Zentner, R.; Nagy, C. Energy use and efficiency in two Canadian organic and conventional crop production systems. *Renew. Agric. Food Syst.* **2006**, *21*, 60–67. [CrossRef]
22. Muhammad, S.; Fathelrahman, E.; Tasbih, R.U. Factors Affecting Consumers' Willingness to Pay for Certified Organic Food Products in United Arab Emirates. *J. Food Distrib. Res.* **2015**, *46*, 37–45.
23. Nguyen, M.; Haynes, R. Energy and labour efficiency for three pairs of conventional and alternative mixed cropping (pasture-arable) farms in Canterbury, New Zealand. *Agric. Ecosyst. Environ.* **1995**, *52*, 163–172. [CrossRef]
24. Pimentel, D. *Impacts of Organic Farming on the Efficiency of Energy Use in Agriculture. An Organic Center State of Science Review*; The Organic Center: New York, NY, USA, 2006.
25. Belloti, B.; Rochecouste, J. The development of Conservation Agriculture in Australia—Farmers as innovators. *Int. Soil Water Conserv. Res.* **2014**, *2*, 21–34. [CrossRef]
26. Wood, R.; Manfred, L.; Dey, C.; Lundie, S. A comparative study of some environmental impacts of conventional and organic farming in Australia. *Agric. Syst.* **2005**, *89*, 324–348. [CrossRef]
27. Longo, S.; Mistretta, M.; Guarino, F.; Cellura, M. Life cycle assessment of organic and conventional apple supply chains in the North of Italy. *J. Clean. Prod.* **2016**. [CrossRef]
28. Aravindakshan, S.; Rossi, F.; Krupnik, T. What does benchmarking of wheat farmers practicing conservation tillage in the eastern Indo-Gangetic Plains tell us about energy use efficiency? An application of slack-based data envelopment analysis. *Energy* **2015**, *90*, 483–493. [CrossRef]
29. Rhodes, C.J. Fossil fuel use is limited by climate, if not by resources, and "Peak Soil". *Sci. Prog.* **2015**, *98*, 73–82. [CrossRef] [PubMed]
30. Stern, P.; Janda, K.; Brown, M.; Steg, L.; Vine, E.; Lutzenhiser, L. Opportunities and insights for reducing fossil fuel consumption by households and organizations. *Nat. Energy* **2016**, *1*. [CrossRef]
31. Brosch, T.; Sander, D.; Patel, M.K. Editorial: Behavioral insights for a sustainable energy transition. *Front. Energy Res.* **2016**, *4*. [CrossRef]
32. Glaser, M.; Krause, G.; Ratter, B.; Welp, M. Human/Nature interaction in the anthropocene potential of social-ecological systems analysis. *Dtsch. Ges. Hum.-Okol.* **2008**, *17*, 77–80.
33. Holling, C.S. Two Cultures of Ecology. 1998. Available online: http://www.consecol.org/vol2/iss2/art4/ (accessed on 30 June 2016).
34. *OECD Factbook 2015–2016: Economic, Environmental and Social Statistics*; The Organisation for Economic Co-operation and Development (OECD): London, UK, 2016. Available online: http://dx.doi.org/10.1787/factbook-2015-en (accessed on 24 June 2016).
35. Sartori, L.; Basso, B.; Bertocco, M.; Oliviero, G. Energy Use and Economic Evaluation of a Three Year Crop Rotation for Conservation and Organic Farming in NE Italy. *Biosyst. Eng.* **2005**, 245–256. [CrossRef]
36. Haberl, H.; Fischer-Kowalski, M.; Krausmann, F.; Weisz, H.; Winiwarter, V. Progress towards sustainability? What the conceptual framework of material and energy flow accounting (MEFA) can offer. *Land Use Policy* **2004**, *21*, 199–213. [CrossRef]
37. *Communication from the Commission European 2020 a Strategy for Smart, Sustainable and Inclusive Growth*; European Commission: Brussels, Belgium, 2010.

38. De los Ríos, I.; Garcia, C.; Herrera, A.T.; Rivera, M. *Innovation and Social Learning in Organic Vegetable Production in the Region of Murcia, Camposeven, Spain*; RETHINK Case Study Report, GESPLAN; Technical University of Madrid: Madrid, Spain, 2015.
39. Hernánz, J.; Girón, V.; Cerisola, C. Long-term energy use and economic evaluation of three tillage systems for cereal and legume production in central Spain. *Soil Tillage Res.* **1995**, *35*, 183–198. [CrossRef]
40. Gomieroa, T.; Paolettia, M.; Pimentel, D. Energy and environmental Issues in Organic and Conventional Agriculture. *Crit. Rev. Plant Sci.* **2008**, *27*, 239–254. [CrossRef]
41. Qu, M.; Lin, Y.; Liu, C.; Yao, S.; Cao, Y. Farmers' perceptions of developing forest based bioenergy in China. *Renew. Sustain. Energy Rev.* **2016**, *58*, 581–589. [CrossRef]
42. Deike, S.; Pallutt, B.; Christen, O. Investigations on the energy efficiency of organic and integrated farming with specific emphasis on pesticide use intensity. *Eur. J. Agron.* **2011**, *28*, 461–470. [CrossRef]
43. De los Rios, I.; Cadena, J.; Diaz, J.M. Creating local action groups for rural development in México: Methodological approach and lessons learned. *Agrociencia* **2011**, *45*, 815–829.
44. Smith, L.G.; Williams, A.; Pearce, B. The energy efficiency of organic agriculture: A review. *Renew. Agric. Food Syst.* **2015**, *30*, 280–301. [CrossRef]
45. Clark, S.; Khoshnevisan, B.; Sefeedpari, P. Energy efficiency and greenhouse gas emissions during transition to organic and reduced-input practices: Student farm case study. *Ecol. Eng.* **2016**, *88*, 186–194. [CrossRef]
46. De los Rios, I.; Becerril, H.; Rivera, M. Ecological agriculture and its influence on rural prosperity: An agricultural company's vision (Murcia, Spain). *Agrociencia* **2016**, *50*, 375–389.
47. De los Rios, I.; Rivera, M.; Garcia, C. Redefining rural prosperity through social learning in the cooperative sector: 25 years of experience from organic agriculture in Spain. *Land Use Policy* **2016**, *54*, 85–94. [CrossRef]
48. Cazorla, A.; De los Ríos, I. *Rural Development as "Working with People": A Proposal for Policy Management in Public Domain*, 1st ed.; Universidad Politecnica de Madrid (UPM): Madrid, Spain, 2012; pp. 6–18.
49. Cazorla, A.; De los Ríos, I.; Salvo, M. Working With People (WWP) in rural development projects: A proposal from social learning. *Cuad. Desarro. Rural* **2013**, *10*, 131–157.
50. *Enfoque LEADER Guia Basica*; Comisión Europea: Bruselas, Belgium, 2006.
51. Benson, D.; Lorenzoni, I.; Cook, H. Evaluating social learning in England flood risk management: An individual-community interaction perspective. *Environ. Sci. Policy* **2016**, *55*, 326–334. [CrossRef]
52. Tàbara, J.D.; Pahl-Wostl, C. Sustainability Learning in Natural Resource Use and Management. 2007. Available online: http://www.ecologyandsociety.org/vol12/iss2/art3/ (accessed on 30 June 2016).
53. De los Rios, I.; Becerril, H.; Rivera, M.; Garcia, C. Managing for the Sustained Success of Organic Food Associations: A Sustainable Management Approach from "Working with People" Model. In *Food Science, Production, and Engineering in Contemporary Economies*; IGI Global: Hershey, PA, USA, 2016; Volume I, p. 473.
54. Demeter Internacional e.V. *Normas Internacionales de Producción Agraria*; Asociación de Agricultura Biodinamica de España: Madrid, Spain, 2015.
55. Szeremeta, A.; Ball, K.; Blake, F.; Schlüter, M.; Tuszynski, L. *An Evaluation of the First Three Years Looking for Further Development*; No. 834/2007, 889/2008 and 1235/2008; IFOAM EU GROUP: Bruselas, Belgium, 2012.
56. NASAA Organic. NASAA Organic and Biodynamic Standards. 2016. Available online: http://www.nasaa.com.au/data/pdfs/NASAA%20Organic%20Standard%20Feb%202016.pdf (accessed on 30 June 2016).
57. Sanders, J. *Evaluation of the EU Legislation on Organic Farming*; Study Report; Thünen Institute of Farm Economics: Braunschweig, Germany, 2013.
58. Canakci, M.; Akinci, I. Energy use pattern analyses of greenhouse vegetable production. *Energy* **2007**, *31*, 1243–1256. [CrossRef]
59. Esen, M.; Yuksel, T. Experimental evaluation of using various renewable energy sources for heating a greenhouse. *Energy Build.* **2013**, *65*, 340–351. [CrossRef]
60. D'Arpa, S.; Colangelo, G.; Starace, G.; Petrosillo, I.; Bruno, D.E.; Uricchio, V.; Zurlini, G. Heating requirements in greenhouse farming in southern Italy: Evaluation of ground-source heat pump utilization compared to traditional heating systems. *Energy Effic.* **2015**, *9*, 1065–1085. [CrossRef]
61. Kumar, A.; Singh, A.; Singh, I.; Sud, S.K. Prototype greenhouse environment monitoring system. In Proceedings of the International MultiConference of Engineers and Computer Scientists, Hong Kong, China, 17–19 March 2010.

62. Sun, S.; Zhan, C.; Yang, G.; Yu, Y. Research on A New Technology Integrated Low-Cost, Near-Zero-Energy Solar Greenhouse. *Proc. Eng.* **2016**, *145*, 188–195. [CrossRef]
63. Zhang, H.; Burr, J.; Zhao, F. A comparative life cycle assessment (LCA) of lighting technologies for greenhouse crop production. *J. Clean. Prod.* **2016**. [CrossRef]
64. Cuce, E.; Harjunowibowo, D.; Mert, C.P. Renewable and sustainable energy saving strategies for greenhouse systems: A comprehensive review. *Renew. Sustain. Energy Rev.* **2016**, *64*, 34–59. [CrossRef]
65. Marucci, A.; Cappuccini, A. Dynamic photovoltaic greenhouse: Energy efficiency in clear sky. *Appl. Energy* **2016**, *170*, 362–376. [CrossRef]
66. Sutherland, L.A.; Peter, S.; Zagata, S. Conceptualising multi-regime interactions: The role of the agriculture sector in renewable energy transitions. *Res. Policy* **2015**, *44*, 1543–1554. [CrossRef]
67. Portugal-Pereira, J.; Soria, R.; Rathmann, R.; Schaeffer, R.; Szklo, A. Agricultural and agro-industrial residues-to-energy: Techno-economic and environmental assessment in Brazil. *Biomass Bioenergy* **2015**, *81*, 521–533. [CrossRef]
68. Fiksel, J. Designing Resilient, Sustainable System. *Environ. Sci. Technol.* **2003**, *37*, 5330–5339. [CrossRef] [PubMed]
69. Peters, R. New realities, more diverse farms RETHINK promotes innovative strategies to make rural areas more vibrant. *Agrinnovation* **2016**, *3*, 18–19.
70. Knickel, K. Trajectories of agricultural modernization and rural resilience: Some first insights derived from case studies in 14 countries. *Appl. Stud. Agribus. Commer.* **2016**, *10*, 31–34. [CrossRef]
71. Cairol, D.; Coudel, E.; Knickel, K.; Caron, P.; Kroger, M. Multifunctionality of agriculture and rural areas as reflected in policies: The importance and relevance of the territorial view. *J. Environ. Policy Plan.* **2009**, *11*, 269–289. [CrossRef]
72. Bryden, J.; Efstratoglou, S.; Ferenczi, K.K.; Johnson, T.; Refsgaard, K.; Thomson, K. *Towards Sustainable Rural Regions in Europe*, 1st ed.; Routledge: Abingdon/Oxford, UK, 2011; pp. 1–50.
73. Olssone, G.; Rönningen, K.; Hanssen, S.; Wehn, S. The interrelationship of biodiversity and rural viability: Sustainability assessment, land use scenarios and norwegian mountains in a european context. *J. Environ. Assess. Policy Manag.* **2011**, *2*, 251–284. [CrossRef]
74. Milone, P.; Ventura, F. *Networking the Rural: The Future of Green Regions in Europe*; Royal Van Gorcum: Assen, The Netherlands, 2010; pp. 150–165.
75. Knickel, K.; Brunori, G.; Rand, S.; Proost, J. Towards a Better Conceptual Framework for Innovation Processes in Agriculture and Rural Development: From Linear Models to Systemic Approaches. *J. Agric. Educ. Ext.* **2009**, *15*, 131–146. [CrossRef]
76. *Agricultura Ecologica Estadisticas 2014*; Ministerio de Agricultura Alimentacion y Medio Ambiente: Madrid, Spain, 2015.
77. Singh, A.S.; Masuku, M.B. Sampling techniques & determination of sample size in applied statistics research: An overview. *Int. J. Econ. Commer. Manag.* **2014**, *2*, 1–22.
78. Friedman, J. *Planning in the Public Domain. From Knowledge to Action*; Princeton University Press: Princeton, NJ, USA, 1987; pp. 182–200.
79. De los Rios, I.; Turek, A.; Gallegos, A. Project Management Competencies for Regional Development in Romania: Analysis from "Working with People" Model. *Procedia Econ. Financ.* **2013**, *8*, 614–621. [CrossRef]
80. Porter, M.E. *Competitive Strategy: Techniques for Analyzing Industries and Competitors*; Free Press: New York, NY, USA, 1980; Republished 1998.
81. Crowder, D.W.; Reganold, J.P. Financial competitiveness of organic agriculture on a global scale. *Proc. Natl. Acad. Sci. USA* **2015**, *12*, 7611–7616. [CrossRef] [PubMed]
82. Bravo-Monroy, L.; Potts, S.; Tzanopoulos, J. Drivers influencing farmer decisions for adopting organic or conventional coffee management practices. *Food Policy* **2016**, *58*, 49–61. [CrossRef]
83. Suh, J. Communitarian cooperative organic rice farming in Hongdong District, South Korea. *J. Rural Stud.* **2015**, *37*, 29–37. [CrossRef]
84. *España Comunica a la UE Unas Necesidades de Fondos de 235 Millones de Euros Para Los Programas Operativos de Las Organizaciones de Frutas y Hortalizas en 2016*; Ministerio de Agricultura, Alimentación y Medio Ambiente: Madrid, Spain, 2016. (In Spanish)
85. Ridder, D.; Mostert, E.; Wolters, H.A. *Aprender Juntos para Gestionar Juntos. La Mejora de la Participación Publica en la Gestion del Agua*; Instituto de Investigac, Universidad de Osnabrück: Osnabrueck, Germany, 2005.

86. Dimitri, C.; Greene, C. *Organic Food Industry Taps Growing American Market*; Economic Research Service; The United States Department of Agriculture (USDA): Washington, DC, USA, 2002.
87. Reganold, J.P.; Wachter, J.M. Organic agriculture in the twenty-first century. *Nat. Plants* **2016**, *2*. [CrossRef] [PubMed]
88. Sachez, E.; Ragucci, M.; Vassarotti, A. *Ethical, Legal and Socio-Economic Aspects of Agriculture, Fisheries and Food Biotechnology*; An Overview of Research Activities; European Commission, Directorate-General for Research: Luxembourg, 2002.