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23rd International Trade Fair of Material & Energy Recovery and Sustainable Development, ECOMONDO, 5th-8th November, 2019, Rimini, Italy

Selected papers (2)

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Selected papers (2)

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Aims and Scope

Procedia Environmental Science, Engineering and Management (P - ESEM) is a journal focusing on publishing papers selected from high quality conference proceedings, with emphasis on relevant topics associated to environmental science and engineering, as well as to specific management issues in the area of environmental protection and monitoring.

P - ESEM facilitates rapid dissemination of knowledge in the interdisciplinary area of environmental science, engineering and management, so conference delegates can publish their papers in a dedicated issue. This journal will cover a wide range of related topics, such as: environmental chemistry; environmental biology; ecology geoscience; environmental physics; treatment processes of drinking water and wastewater; contaminant transport and environmental modeling; remediation technologies and biotechnologies; environmental evaluations, law and management; human health and ecological risk assessment; environmental sampling; pollution prevention; pollution control and monitoring etc.

We aim to carry important efforts based on an integrated approach in publishing papers with strong messages addressed to a broad international audience that advance our understanding of environmental principles. For readers, the journal reports generic, topical and innovative experimental and theoretical research on all environmental problems. The papers accepted for publication in *P – ESEM* are grouped on thematic areas, according to conference topics, and are required to meet certain criteria, in terms of originality and adequacy with journal subject and scope.

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GUEST EDITOR

Fabio Fava, born in 1963, is Full Professor of "Industrial & Environmental Biotechnology" at the School of Engineering of University of Bologna since 2005.
F. Fava published about 240 scientific papers, 170 of which on medium/high IF peer-review international journals of industrial and environmental biotechnology. He has 5733 overall citations, a H-index of 46 and an i10 index of 123 (Google Scholar) along with 180 papers quoted by Scopus. He is actively working in the fields of environmental, industrial and marine biotechnology and of the Circular Bioeconomy in the frame of a number of national projects and collaborative projects funded by the European Commission. Among the latter, he coordinated the FP7 collaborative projects NAMASTE, on the integrated exploitation of citrus and cereal processing byproducts with the production of food ingredients and new food products, and BIOCLEAN, aiming at the development of biotechnological processes and strategies for the biodegradation and the tailored depolymerization of wastes from the major oil-deriving plastics, both in terrestrial and marine habitats. He also coordinated the Unit of the University of Bologna who participated in the FP7 collaborative projects ECOBIOCAP and ROUTES (on the production of microbial and biodegradable polymers from different organic waste and food processing effluents), MINOTAURUS and WATER4CROPS (on the intensified bioremediation of contaminated waste- and ground- water and the integrated valorization and decontamination of wastewater. coming from the food processing industry and biorefineries), and ULIXES and KILL SPILL (on the development of strategies for intensifying the *ex situ* and *in situ* bioremediation of marine sediments contaminated by (chlorinated)hydrocarbons and microplastics and the isolation and industrial exploitation of microbes from such contaminated matrices). Dr. Fava served and is serving several national, European and international panels, by covering the following positions:

• Italian Representative in the Horizon2020 Programme Committee of Societal Challenge 2: European Bioeconomy Challenges: Food Security, Sustainable Agriculture and Forestry, Marine, Maritime and inland water research" (European Commission, DG RTD) (2013-);
• Italian Representative in the "States Representatives Group" (SRG) of the Public Private Partnership "Biobased Industry" (PPP BBI JU) (Brussels) (2014-); he is chairing the SRG since October 2018;
• Italian Representative in the BLUEMED WG of the EURO-MED Group of Senior Officials (EU Commission DG RTD and Union for Mediterranean) (2017-);
• Italian Representative in the initiative on sustainable development of the blue economy in the western Mediterranean the "Western Mediterranean Initiative" WEST MED, promoted by the EU Commission (DG MARE) in close cooperation with 10 countries of the area (2016-);
• Member of the "Working Party on Biotechnology, Nanotechnology and Converging Technologies" of the Organization for Economic Co-operation and Development (OECD, Paris) (2008-);
• Chair (2011-2013) and currently Deputy Chair of the "Environmental Biotechnology section" of European Federation of Biotechnology (EFB) (2013-).

Finally, he is the scientific coordinator of the International Exhibition on Green and Circular economy ECOMONDO held yearly in Rimini (Italy)

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Procedia Environmental Science, Engineering and Management **6** (2019) (2) 149-290

23th International Trade Fair of Material & Energy Recovery and Sustainable Development, ECOMONDO, 5th-8th November, 2019, Rimini, Italy

CONTENTS

Procedia
Environmental Science, Engineering and Management
http://www.procedia-esem.eu

Procedia Environmental Science, Engineering and Management **6** (2019) (2) 149-157

23th International Trade Fair of Material & Energy Recovery and Sustainable Development, ECOMONDO, 5th-8th November, 2019, Rimini, Italy

INDUSTRIAL SYMBIOSIS-BASED RENEWABLE ENERGY: A SUSTAINABLE WAY TO DRAW ADVANTAGES FROM SICILY'S SUN AND WIND*

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Abstract

The use of solar and wind energy has represented a sustainable solution ever since energy has become a pollution issue, but how does a wind farm or photovoltaic system impact the environment? A traditional plant uses concrete and a massive amount of steel, both high impact for the environment. Through the principles of circular economy and industrial symbiosis, a new way of producing and installing Solar and Wind plants has been developed. The use of renewable wood and recycled metal, introduced by Sigvald Harryson's project, the "Giraffe 2.0", is the solution for both landscaping and polluting issues.
This hybrid plant allows energy to be obtained in a natural way and it allows the structure to be used as a charging station or directly as an energy source to power citizens' homes. The structure is developed to store and produce energy more efficiently than a traditional solar panel and its peculiarity consists in being able to capture energy all-day, 365 days a year. Also, it is designed to be 100% renewable.
The use of the Sicilian potential is fundamental for the development of sustainable energy.

Keywords: circular economy, industrial symbiosis, Giraffe 2.0, Sicily, sustainable source.

1. Introduction

With the advent of the machine, and therefore of industrialization, energy has become the cornerstone of modern life. Without it, the consumer society would find itself paralyzed,

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unable to carry out the simplest actions of everyday life. Nowadays, cities are one of the major producers of environmental impacts in terms of resource and energy consumption and greenhouse gas (GHG) emissions (Grimm et al., 2008; Yang et al., 2018). Furthermore, the role of cities as pollutant is more and more relevant: nowadays urban areas use the 60-80% of global energy (https://ec.europa.eu). In this regard, the consumption of world energy is increasing exponentially from the 18th century, with a +2.3% boost in 2018 (www.yearbook.enerdata.net). As a result of this continuous increase, global energy-related CO_2 emission in 2018 amounted to 33 Gigatons (Gt), 10 of which generated by the exploitation of coal (www.iea.org).

It is certain that one of the worse problems of the modern world is the climate change and its effects to the environment, mainly caused by energy consumption (IPCC, 2007). It appears necessary to develop new technologies, along with economic and financial strategies; in order to follow the warning sent by the World Summit on Sustainable Development in Johannesburg (September, 2002), where was agreed that the contribution of renewables to world energy use should be substantially increased ''with a sense of urgency.''

One of the most promising tools in order to fulfill the global increase of demand for energy is the development of novel solar energy (Kim et al., 2018). In fact, nearly 613 PW/h (1 PW = 1015W) of solar energy reaches the earth annually (Korfiati et al., 2016). Although, Italy can rely on the availability of strong winds and sun rays. Moreover, the exploitation of the renewable energy sources is fundamental for achieving the targets established by the Paris Agreement. Despite the substantial increase in common awareness of pollution resulting from the use of conventional energy sources, social acceptance represents a potential but powerful barrier to the achievement of renewable energy targets (Wüstenhagen et al., 2007). The first scholar that detected the problem of social acceptance for Aeolic plants was Carlman. She stated that siting wind turbines was ''also a matter of public, political, and regulatory acceptance" (Carlman, 1984). The increase in demand and supply of renewable energy not only leads to environmental benefits, but it implements economic advantages deriving from the maximum exploitation of free resources such as solar rays or the force of the wind.

In this paper we are going to introduce a valid alternative to the use of current energy sources, proposing a case study which solves both the landscaping and polluting issue.

2. Material and methods

As stated in the European Regulation of 2018, the main and binding objective of energy and climate policies on the horizon of 2030 is the internal reduction in all economic sectors of at least 40% of greenhouse gas emissions (GHG) compared to 1990. In addition, the possibility of achieving economic growth through innovation and a sustainable and competitive energy policy has been recognized. The production of energy from renewable sources often depends on local or regional SMEs (small and medium-sized enterprises) (EC Directive 2001, 2018).

The growing concerns on the pollutant impact of CO_2, produced and discharged from energy consumption, underline the importance of the exploitation of renewable sources and the development of Renewable Energy Technologies (RET) (Watanabe, 1995). In fact, most GHG is produced by sectors such as energy supply (29.3%) and transport (19.5%) (www.eea.europa.eu). Thus, 48.+8% of greenhouse gases released into the atmosphere come mainly from sources directly linked to the exploitation of fossil-derived energy sources.

The environmental damages caused by energy supply affect not only global warming, but also air pollution, rain acidification and emission of radioactive substance (Dincer, 1999). The RETs are efficient tool for the implementation of sustainable development (Stiglitz, 2002), able to avoid the issues caused by the exploitation of classical energy sources. Nevertheless, only three renewable energy sources (i.e., biomass, geothermal, and solar) are able to yield enough heat energy for generating power. Of these three, Solar Energy holds the highest

potential since geothermal sources and the supply of biomass are not evenly spread across the world (Holm-Nielsen and Ehimen, 2016; Sampaio and González, 2017).

Solar Energy is a renewable, eco-friendly and the Sun is a freely available energy source. Its use ensures the conservation of fossil-derived sources and simultaneously respects the environment. In this regard, the emission of 696,544,000 metric tons of CO_2 have been avoided trough the installation of 113,533 household solar systems in California, USA (Arif, 2013). Furthermore, PV energy is aiming to become the most cost-effective, as evidenced by the will of the Los Angeles Department of Water and Power to seek approval a two phase 25-year power purchase agreement (PPA) priced at $20/MWh (www.analysis.newenergyupdate.com). The one settled by this PPA is a much lower price if compared to the Italian National Power Price, equal to €61,31/MWh in 2018 (www.mercatoelettrico.org).

The employment of renewable sources represents both an opportunity to reduce the environmental impact and for an economic and social follow-up (Mistretta et al., 2007). In particular, the strategy 1.17 of the Sicilian Government ROP (2003) (Regional Operative Plan) encourages to power the island with sustainable energy, with a view to reduce the primary energy consumption and the GHG emissions (ROP 2000-2006). To achieve this objective, a case study has been proposed in Ambiens S.r.l. through the installation of Giraffe 2.0. The draft we are proposing is the right answer to the environmental problem, in line with the reduction of the production of GHG imposed by the EC Directive.

3. Experimental

Ambiens S.r.l. is located in Piazza Armerina (EN), in Contrada Rasalgone. Its geographical position makes it optimal for open field analysis and researches, at a latitude with temperatures and solar radiation that can otherwise only be searched in the laboratory.

In fact, the choice to settle this innovative plant in the territory of Piazza Armerina derives from two reasons: on the one hand there is the enterprise of Ambiens S.r.l. , which has always held out its hand in favor of environmental sustainability; on the other hand, we find the perfect weather and climate spot. In this regard, thanks to the data collected by the National Aeronautical Centre for Meteorology and Climatology, it has been demonstrated that the Enna station has the highest wind power of all the Sicilian region. In this territory, the wind velocity range is situated between the cut-in and rated wind speeds for typical wind-turbines, where the exploitation occurs in the most efficient way (Pallabazer, 1995). In Enna has been registered the highest wind speeds and the frequency of calms is very low. Moreover, circa 60% of the recorded wind velocities are situated in a range between cut-in and rated speed. Therefore, Enna may be considered the most promising locations in Sicily, where wind machines may be installed (Bivona et al., 2003).

Ambiens S.r.l. is an engineering company founded in 2006 that operates in the field of environmental protection. In particular, the firm deals with design of waste treatment plants, hydrological and climate studies and design and management of renewable energy production plants. It also provides advice for public and private bodies in the fields of environment, regional development, safety and quality. Ambiens S.r.l. operates according to UNI ISO 26000 (2010), and is directed by UNI CEI 11339 (2009) (http://store.uni.com/catalogo/uni-iso-26000-2010?josso_back_to=http://store.uni.com/josso-security-check.php&josso_cmd=login_optional&josso_partnerapp_host=store.uni.com).

In 2011, the company meets the German group ASA Energy, that works in the renewable energies field. The firms cooperate in a symbiotic process, currently configured as a spin-off of ASA Energy, that allows them to operate on the international field. With regard to renewable energies, Ambiens S.r.l. has an extensive experience in design, construction and management of PV plants, as a performer of technical and legal verification for medium- and high voltage systems, as well as developer and builder of the above.

Ambiens S.r.l. has also a scientific laboratory, called E&E LAB. Its aim is the study and at the applied research for the technologies that deal with the production of electricity from renewable sources and the protection of the environment. Due this laboratory, the company pays attention to climate and climate change researches, and the resulting processes. This workshop covers areas such as climatology, solar energy, wind energy and hydroelectric power. Finally, it is equipped with tools for the verification of the efficiency of the different components of a renewable source power plant.

4. Results and discussions

4.1. The Giraffe 2.0

As said before, our study is focused on the project named Giraffe 2.0. It is a prefabricated wooden structure, patented by the company Innoventum AB, which serves as a support for a hybrid solar-wind system. This hybrid system is composed of a photovoltaic system, with a power of 8.88kWp, and a wind turbine, with a power of 5.5 kW, with a total power of 14.38 kW. Some specifications are given in Fig. 1. Moreover, the particular positioning of the PV panels of the Giraffe 2.0 allows the production of energy for at least 4h more per day than a normal positioning of the panels PV (Fig. 2).

Parking space	Two cars/EVs
Annual production*	20 000 kWh
EV mileage per year	45 000 km x 2 cars
Footprint	24.6 m^2
Structure dimensions (W x L x H)	4.1 m x 6.0 m x 11.9 m
Energy density	813 kWh/m^2

Fig. 1. Giraffe 2.0- Technical specifications

Even the method of attachment is extremely eco-friendly, because it avoids the use of concrete. In fact, the wooden structure is fixed by means of iron ballast anchored to the ground with hot galvanized iron screws of the Krinner type (Fig. 3).

The energy produced after the conversion in AC is collected inside a cabinet, where also the monitoring system is installed. With this project, Innoventum AB. obtained, in 01.02.2016, the certification of the European Commission under the Horizon 2020 project, which defines the Giraffe 2.0 structure as an innovative project, suggesting its use in projects financed within the Community framework. Giraffe 2.0 is a perfect combination of unique design, ecological materials, and great performance, also the components comply with the directives: EN 55014-1, (2008); EN 55014-2, (2016); EN 61000-6-1, (2007); EN 61000-6-3, (2013); EN 61000-6-5, (2015); EN 60335-1, (2013); IEC 61400-12-1, (2017), in addition to IEC 61400-2, (2013), and IEC 61400-13, (2015).

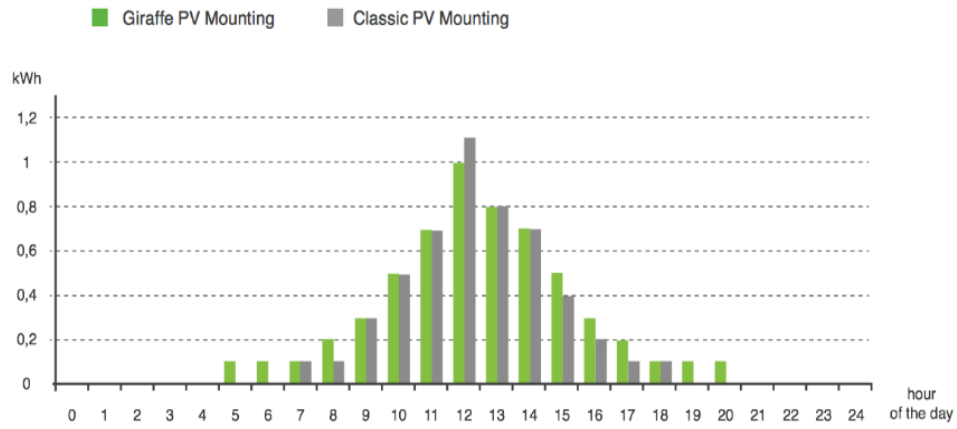

Fig. 2. Comparison between a classical PV Mounting and the Giraffe 2.0. energy production

	KSF M 89x3000-M24	KSF M 89x2100-M24	KSF M 89x1600-M24	KSF M 89x1300-M24
a	Length (mm) (±25 mm)			
	3070	2080	1580	1280
b	Shaft outer diameter (mm)			
	88,90	88,90	88,90	88,90
c	Inner diameter (mm)			
	81,70	81,70	81,70	81,70
d	Thread			
	M24	M24	M24	M24
e	Pitch circle diameter (mm)			
	150	150	150	150
f	Pitch circle holes (mm)			
	6 x Ø 14	6 x Ø 14	6 x Ø 14	6 x Ø 14
g	Flange wrench size (mm)			
	160	160	160	160
h	Flange outer diameter (mm)			
	182	182	182	182
i	Flange thickness (mm)			
	10	10	10	10

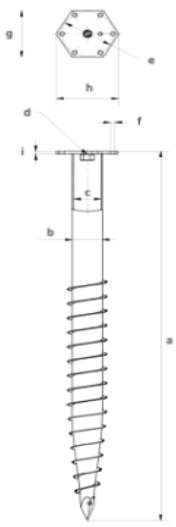

Fig. 3. Iron screws technical data (a) and drawing of the iron screw (b)

4.2 Photovoltaic system

The photovoltaic system consists of 24 modules in monocrystalline silicon, with a power of 370Wp and dimensions equal to 1640x992x40mm, positioned on the "back of the giraffe" with different orientation and inclinations, occupying an area of about 39 m^2, connected to each other using the so-called "optimizers", that allow maximum producibility. In relation to the calculations made, based on the irradiation data provided by UNI 10349, the maximum energy produced by the photovoltaic plants of the system in question can be estimated in about 42,000 kWh /year. Other characteristics of the generator are presented in Fig. 4.

N° poles:	4(3F+N)	Differential protection:	Type A
Nominal tension:	400 V	Sensibility:	300 mA
Rated current:	16 A		
Type of curve:	C		
Breaking capacity:	6 kA		

Fig. 4. Generator characteristics

4.3 Sustainability of the plant

The plant, fulcrum of our case study has a bearing structure made entirely of wood that, compared to the construction and realization of a classic steel structure, allows to reduce substantially the CO_2 emissions. Another peculiarity of the wooden towers is that they absorb the vibrations produced by the rotor, reducing massively the noise (Fig. 5). Moreover, wood is a renewable material, so it is a choice made in favor of environmental sustainability.

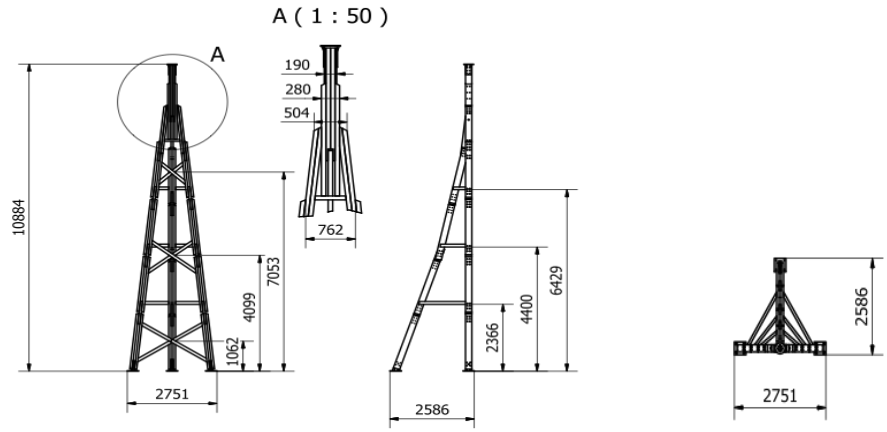

Fig. 5. Drawing of the pieces of the wooden structure by InnoVentum AB

In addition to the reduction of CO_2 emissions, as a result from the exploitation of renewable sources, the eco-sustainability of the project is also guaranteed by some constructive measures that concern the regimentation of the meteoric waters. The photovoltaic roof is, in fact, equipped with a system of water collection, conveyed in two tanks of 15.000 liters each.

The collected water can be reused for washing the modules themselves or for agricultural use. As well as being an element of innovation, wood works are a factor of high environmental value and the use of these materials is an example of landscape-environmental mitigation. So, the high cost of wooden structures is therefore compensated by the authenticity of the environmental mitigation effect, unique in its kind in the Italian territory (Fig. 6). To complete the project, it will be implanted a plant barrier to shield the photovoltaic roof. All these measures avoid the social issue, introduced by Carlman, considering that they turn the structure itself into a work of landscaping art.

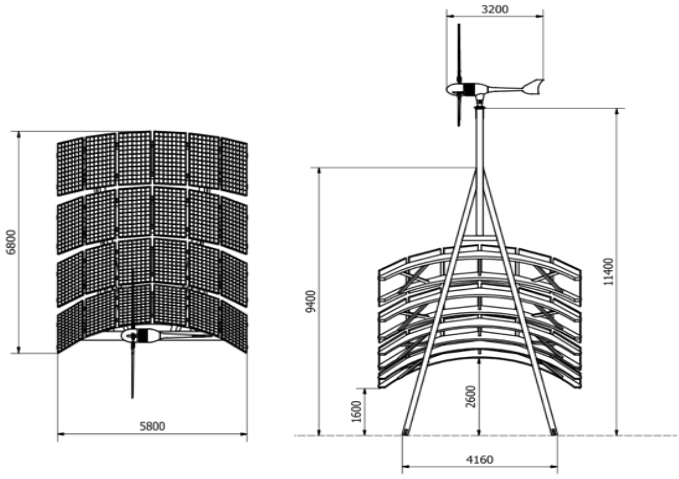

Fig. 6. Drawing of the assembled wooden structure and PV panels by InnoVentum AB

EVs (Electric Vehicles) are becoming more and more popular as the vehicle of the future, offering a clean, efficient and noise-free means of transport. In this regard, the Giraffe 2.0 also has an e-charging system for electric vehicles. Moreover, the combination of EV and PV represents a way to maximize the efficiency of the system through the direct use of the energy created by the implant, avoiding the release of energy during transportation (Fig. 7).

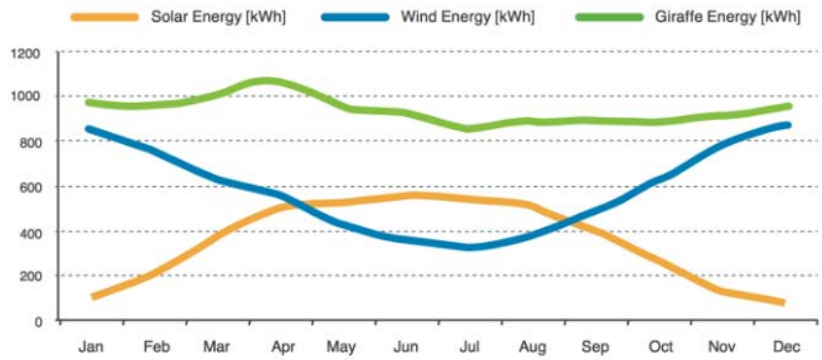

Fig. 5. Flat energy curve

Finally, Wind and Solar energy are highly complementary: wind power is generated mainly during the nights and in the coldest months, when the air is denser and the winds are stronger and stable; while solar energy is generated during the day, especially in the warmer seasons. In this way, the energy produced by a hybrid Solar-Aeolic power plant has a flow much more uniform than a pure wind or pure solar installation, thus solving the inevitable problem of sinusoidal curve which is considered the disadvantage of renewable energy. Such complementarity is the main principle used in a hybrid construction such as the Giraffe 2.0.

6. Conclusion

Despite the great potential represented by Sun and Wind power, the percentage of solar and wind energy within the total energy production is still neglectable.

Through the case study carried out in this paper, it is hoped to raise the awareness among people about the importance of the diffusion of renewable energy production in order to achieve the objectives prefixed by the Paris Agreement.

This paper aims to spread this consciousness especially in Sicily, where the implementation of the Giraffe 2.0 can maximize its efficiency and effectiveness, in order to both raise the local economy and combat the common problem of pollution.

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Procedia Environmental Science, Engineering and Management **6** (2019) (2) 159-167

23th International Trade Fair of Material & Energy Recovery and Sustainable Development, ECOMONDO, 5th-8th November, 2019, Rimini, Italy

PREVENTION AND CONTROL OF EMISSIONS IN INTERMODAL TRANSPORT: THE IMPORTANCE OF ENVIRONMENTAL PROTECTION*

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Abstract

Air pollution is one of the main problems that many companies and public bodies discuss in order to find a solution to protect the environment. This phenomenon is defined as a state of alteration of the natural conditions of the air and can be caused by various factors known as pollutants. A large part of polluting emissions is due to urban traffic and in particular because of the circulation of cars.
The object of this paper is to study the emissions of harmful substances, through the use of the "Carbon Footprint" tool, in the intermodal transport sector. This is a very powerful and useful tool that represents the gas emissions attributable to a product, an individual or an organisation. The impact that these emissions have on anthropogenic climate change is thereby measured and expressed in terms of kg of CO_{2eq} (CO_2 equivalent).
The quantification phase of the carbon footprint becomes an opportunity for company management, by understanding the impact of each stage there is the chance to gather further efficiencies throughout the production cycles and take actions in order to improve those indicators. Therefore, the objective set by the following study is to analyse how to make the transport sector more efficient both in economic terms and in terms of polluting emissions starting from a case study.
"F.LLI DI MARTINO S.P.A.", founded in Catania (IT) in Eastern Sicily in 1969 and operating in the intermodal transport sector, was chosen because it boasts certifications such as ISO 9001 and ISO 14001. Over the years it has also adopted a proactive behaviour, proving to be very sensitive towards the environmental issue.

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The innovation proposed with the use of Carbon Footprint is that of accounting for the quantity of polluting emissions released during the transport phase, favoring a reduction in impact, greater transparency and information for customers.

Keywords: air pollution, carbon dioxide, decarbonization, efficiency, intermodal transport

1. Introduction

The paper structure is based on the analysis of the used tool, Carbon Footprint, and the consequent certification needs to be obtained; the description of core business and history of the company, the results deriving by the use of the tool, conclusions, suggestion and references. Intermodal transport is a methodology based on the use of different means (ship, rail and road) which can bring several advantages: (sustainable and environment friendly, goods security, energy, reduction in road traffic, a smart system, more security on the road) from the moment it is used as the reduction of the impression.

Feature and assumption of this type of transport is that the goods are placed at the factory or at the warehouse of a shipper in a specific container (container) or rather Intermodal Transport Unit (UTI), from where it is not removed until the achievement of the final destination. This lack of intermediate manipulations obviously guarantees a lower risk of damage to the contents, a lower cost of transfer between different types of media and often also guarantees greater speed in delivering the goods.

The maritime transport's points of strength are low environmental impact, security (less damages and theft) and reliability. At the same it can't compete with the road transport in short distances, because it's important the flexibility of the transport. The principal weakness points are represented by the fact that routes are obligated being this type of transport less flexible. Other weak points are the low speed (for a lot of different operations of loading and unloading of goods in the ports and the loss time to enter and exit from there), the less development of integration between maritime activities and other kinds of logistic.

In last years is developing the idea of "sustainable mobility" like a system that is capable to conciliate the use of mobility with the reduction of negative externalities produced by the mobility (greenhouse emissions, smog, acoustic pollution, urban traffic improves).Those externalities create a social cost that weighs on the population sustainable mobility aims to transform this negative factor into an element of social qualification such as to induce the establishment of virtuous processes capable of stopping its effects (Marfoli, 2013).

To reach these goals its necessary make the use of a rail system more efficient and the use of and intermodal system and prefer it to the use of road transport. These are two solution to improve the performance and the quality of road-rail combinations. six different objectives have been identified that are able to define six possible fields of action to increase volumes moved and quality of services related to intermodal transport: infrastructure development; modal integration (intramodal and intermodal); degree of opening of the market for freight transport services; reduction of environmental impact; increased security; improving the efficiency of multi zone transport operations (Vaghi and Grea, 2007).

Freight transport today has a much more complex and critical function than in the past, as such today it is not a simple transferring of goods from a point to another, it's a phase of the production system. Focusing the attention on all segments of an itinerary, the systemic approach aims to optimize costs, times and quality of the service. In the last few years a new conceptual model has spread which, starting from new criteria in the transport of people and goods, is now traduced into a new approach to transport systems planning.

The phase of planning should focus on the opportunity to connect different transport methods (road, ship and rail), considering friction costs connected to the change from a transport mean to another. The systemic approach aims to optimize the three main aspects of the transport offer so intermodality becomes an indispensable prerequisite resulting a key concept of the distribution chain (Iannone, 2002).

Intermodal transportation may be defined as the transportation of a person or a load from its origin to its destination by a sequence of at least two transportation modes, the transfer from one mode to the next being performed at an intermodal terminal. The concept is very general and thus and can have different meanings: transportation of containerized cargo by a combination of truck, rail, and ocean shipping, dedicated rail services to move massive quantities of containers and trailers over long distances, main transportation mode for the international movement of goods (Cranic and Kim, 2009).

The objective assumed to be achieved through the study applied in the paper is that of being able to achieve a reduction in fuel consumption and consequently a reduction of the production of CO_2 emissions through the implementation of the Carbon Footprint so as to achieve a double advantage in terms of environmental impact and reduction of costs that affect the company's core business. To achieve this goal, a case study implemented within the company F.lli Di Martino S.P.A.

2. Material and methods

2.1 Description of the case study

Depending on its business name, the F.lli Di Martino Company is classified as a S.P.A. The product sector in which the company operates is intermodal transport, along national, international and intercontinental routes (Road Freight, Sea Freight, Rail Freight). The company was born in 1969 and is located in the industrial area of Catania in Oriental Sicily. It does three different kind of activities: logistic; distribution; freight forwarding. The company has an important group of customers, national and international ones: “Campari Group”; “Heineken”; “Dolfin”; “Leroy Merlin”; “Nestle”; "La Rinascente"; “Alcott”; “Monge”; “Balocco”.

The F.lli Di Martino S.p.A. in the time, obtained a lot of different international certification: ISO 9001 quality certification; SQAS (safety and quality assessment); ISO 14001 environment certification; HACCP (Hazard Analysis and Critical Control Points). The company under study is highly sensitive to the issue of environmental pollution and has been investing for some time to reduce the impact of its production process. For some time now he has begun to map and track all the activities in order to find new ways to optimize the process without sacrificing efficiency and reliability.

2.2. Methodology application

The LCA approach was developed according to the specific International Standards 14040-44: 2006, to estimate climate change impacts of logistics activities. Therefore, the study was articulated as follows: Goal and Scope definition; Life Cycle Inventory (LCI); Life Cycle Impact Assessment (LCIA); and Life Cycle Interpretation. Each of those phases was discussed in the following of the text.

2.2.1. Goal and scope definition

The study was conceived with the aim of environmentally comparing a set of transport scenarios providing a combination of different routes (i.e., road, rail and water) from an

intermodal logistics perspective on an equal base of producer/user locations. In particular, four transport scenarios were explored, as shown in Fig.1.

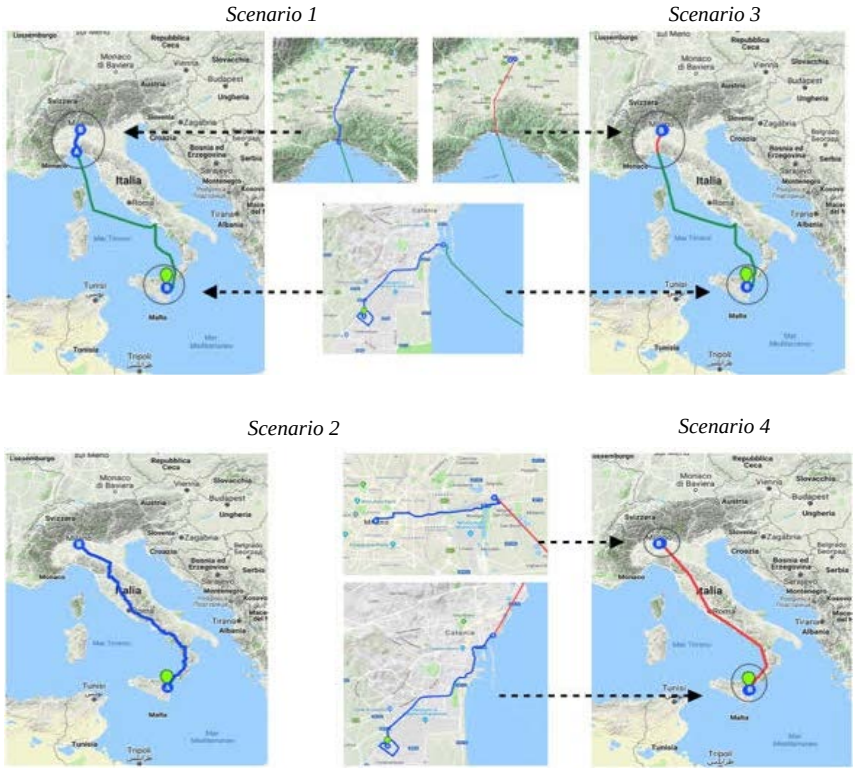

Fig.1. The four scenarios investigated in the assessment: different colours were used to represent the transport systems implied: road (blue); rail (red); and water (green)

The image shows the freight transport from Catania (Italy) to Milan, Lombardy (IT). The preference has fallen on this route because it is representative of the company activity and it is lent to be operated with the use of different means of transport such as by road, ship and train. By analyzing the possible paths, four possible scenarios were created.

- first scenario is composed by road transport from the warehouse to the port of Catania (IT) and from the port of Genoa (IT) to the destination Milan (IT); the ship for transport from the port of Catania (IT) to the port of Genoa (IT).
- second scenario is entirely by road.
- third scenario is like the first one, but with variation of the use of the train from the port of Genoa to the Station of Milano Smistamento (IT) and the use of road transport from the station of Milano Smistamento (IT) to the destination Milan (IT).
- fourth scenario: road transport from the warehouse to the Catania station (IT) and from the Segrate station (IT) to the Milan destination (IT); and train for intermediate transport.

In addition to this, Fig. 2 shows length distribution based upon the mean utilized, with respected to the total distance travelled.

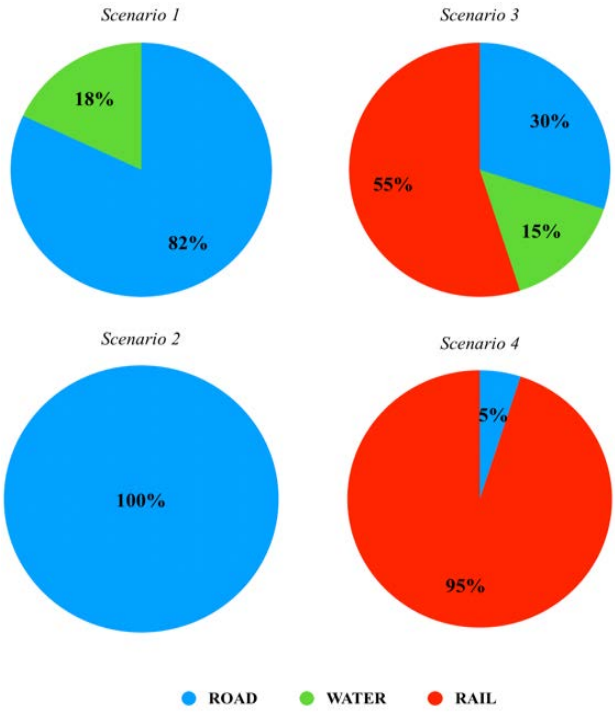

Fig. 2. Transport options in each scenario considered as percentage contribution to each scenario total transport

Attention was paid upon the logistics sector was investigated as it is accepted globally to be a large contributor to the economic and environmental burdens associated with life cycles of products and services, and so can negatively influence the related sustainability levels. Therefore, sustainable solutions for distribution of material commodities need to be found and pursued: this study wants to contribute this specific research field and, indeed, was conducted to find the less GHG-emitting scenario among those considered. For this purpose, the Carbon Footprint (CF) associated with the logistics scenarios considered was computed following the LCA framework. Attention was focalized upon the CF because it is recognized worldwide as a key indicator to measure the environmental performance of services like the logistics one as studied here.

As a part of this phase the functional unit and the system boundaries were defined, to represent the investigated process and be consistent with the aim of the study. The FU represent the unit of the product and provides a reference trough which inputs are linked to outputs and to the resulting impacts and damages: in this case the functional unit was 1 p corresponding to a transported product amount of 25 tons. With regard of the system boundaries they were defined to include the following steps:

- manufacturing of the transport means utilized from row material production and acquisition;
- maintenance of the means and fuel consumption and related emissions during the transport means operations
- end of life of the means
- auxiliary services and equipment

2.2.2. Life Cycle Inventory

This phase plays a key role in any LCA and related studies as being about compilation, qualification and quantification of input and output streams as connected with a given product or service. Specifically, for this case study, the input streams consisted in the transport flows calculated as discussed in the following, while the output streams were limited just to the GHG emissions as required for the CF assessment. Those flows represent, therefore, the primary data used for the assessment in combination with secondary data extrapolated from databases of acknowledged scientific value and relevance, like Ecoinvent v.2.2, as available in the SimaPro 7.3.3 that was used for the CF computation.

The transport flows were calculated from route lengths within the scenarios considered, with reference to a 25t transported amount (FU of the study labelled as 1p): values were reported in Table 1.

Table 1. Values of the transport flows calculated for each route identified as part of the scenario considered

Scenario	***Functional unit***	***Transport system***		
		Road	***Rail***	***Water***
		tkm		
1	1 p	5037.5	0	23125
2		1665	31250	0
3		1887.5	3500	925
4		35000	0	0

Secondary data were represented by the transport life cycle modules contained in Ecoinvent and referred to one tkm transport flow: they were reported in Table 2, along with the related dataset description as of Ecoinvent v.2.2, in line with the defined system boundaries.

Table 2. Dataset description related to the modules use for the assessment was reported

Transport module	***Dataset description***
Transport, lorry, 16-32 t, EURO 5/RER	Included processes are the followings: operation of vehicle; production, maintenance and disposal of vehicles; construction and maintenance and disposal of road.
Transport, freight rail/IT	The following steps were considered: production, maintenance, operation, and disposal of the train; and construction and maintenance and disposal of railway tracks
Transport, freight ship/OCE	The module calls the modules addressing: operation of vessel; production of vessel; construction and land use of port; operation, maintenance and disposal of port.

2.2.3 Life Cycle Impact Assessment

This phase was limited to the Carbon Footprint, so assessing the climate change impact. The CF is one of the most popular "impact category indicators", in the category of climate change. Different emissions of greenhouse gases are weighted based on their global warming potential (GWP) relative to carbon dioxide (e.g., one kg of methane has a much greater GWP than one kg of carbon dioxide).

This weighting is technically called "characterization" of the inventory results, and the GWPs of different greenhouse gases are the characterization factors. The resultant CF is expressed in terms of CO_2 equivalent ($CO_{2\,eq}$) (Maalouf, 2018).

In this study, among the need-point approaches the IPCC 2007 GWP 100A method (IPCC, 2007) was used, which was developed by the Intergovernmental Panel on Climate Change and it contains the climate change factors of IPCC with timeframe of 100 years.

According to Eq. (1) by Maalouf et al. (2018):

$$CF_i = \sum_i GWP_i * e_i \quad (1)$$

where:

- e_j is the emission (in mass unit) of the j-th GHG associated with the given process;
- GWP_j is the Global Warming Potential of the j-th GHG for a 100-year temporal horizon (GWP100), which is required for any CF assessment. In this regard, Table 4 reports the GWP100 of the GHGs that were considered by the authors to be most representative of the investigated system.

Table 3. Global Warming Potential of relevant GHGs. Conversion factors from IPCC (2007).

GHG	***Formula***	***GWP_{100} [$gCO_{2eq}/gGHG$]***
Carbon dioxide	CO_2	1
Methane	CH_4	25
Nitrous oxide	N_2O	298

3. Results and discussions

As shown in Fig. 3, the scenario 3 is the less impactful so it is preferable for the environment. However, is important to take into account the economic component and search a sustainable scenario for both aspects. The decision about the best type of transport must be subject to some rules dictated by costs, time and "control capacity" (the firm can only control road transport, ship and train are commissioned to third parties). For this reason, the scenario 3 can be considered as an economically unsustainable hypothesis.

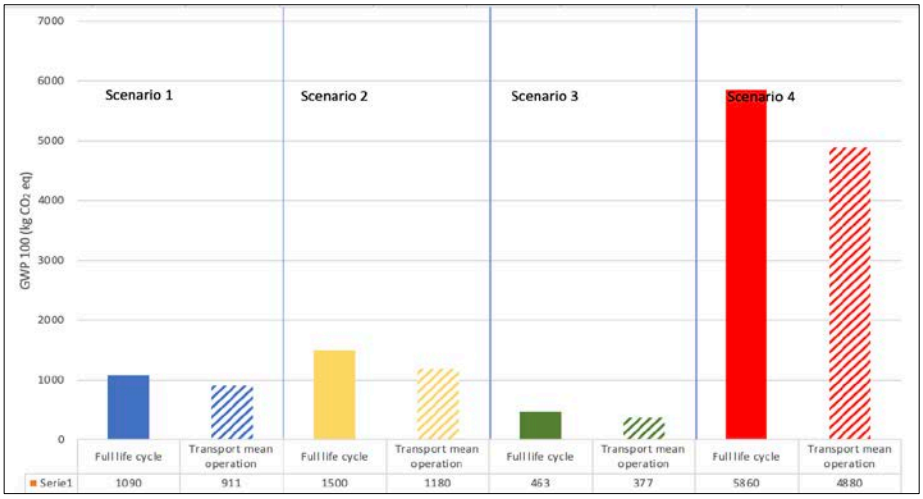

Fig. 3. Emissions in 4 scenarios for full life cycle and for transport mean operation

As emerged from meetings with the company, scenario 2 is the most used and, in light of the results obtained, it can be considered as a good compromise. The worst-case scenario is clearly scenario 4 which presents a high quantity of emissions. The graph also shows the difference between the impact of the entire life cycle, including construction, maintenance and disposal of vehicles ancillary services, and that connected only to the operational transport phase which has a variable incidence from 78% to 84% depending on the scenario. Finally, as can be seen in next tables the most significant gas, as it generates greater impacts on climate change, is carbon dioxide with an incidence of approximately 95% of the total.

Table 4. Amount of main GHGs emission for each scenario

Scenario 1	Output inventory (kg)	GWP 100 (kg $CO_{2\ eq}$)
CO_2	1.04E3	1.04E3
CH_4	1.25	31.25
N_2O	0.0372	11.08
Other GHGs		7.67

Scenario 2	Output Inventory (kg)	GWP 100 (kg $CO_{2\ eq.}$)
CO_2	1.43E3	1.43E3
CH_4	2.12	53
N_2O	0.0457	13.62
Other GHGs		3.38

Scenario 3	Output inventory (kg)	GWP 100 (kg $CO_{2\ eq.}$)
CO_2	441	441
CH_4	604	15.1
N_2O	0.02	4.71
Other GHGs		2.19

Scenario 4	Output inventory (kg)	GWP 100 (kg $CO_{2\ eq.}$)
CO_2	5.58E3	5.58E3
CH_4	7.4	185
N_2O	215	64.07
Other GHGs		30.93

4. Conclusions

The study highlighted the possibility of making the environmental and economic variables coexist within the company choices, in order to achieve customer satisfaction taking into account the social responsibility that large companies have today.

With a view to continuous improvement, this paper aims to be a starting point for all companies operating in the transport sector and, more generally, intermodal transport, in order to be able to take decisions that contribute to environmental protection.

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CRITICAL BARRIERS FOR PLASTIC RECYCLING. A CC CASE-STUDY IN TURIN*

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Abstract

Waste accumulation is one of the most discussed environmental issues which is jeopardizing our planet from an environmental, economic and social point of view. In this context, plastic plays a pivotal role, because its accumulation and persistence is becoming a matter of great concern. In 2017, 43% of plastic packaging is recycled.. In order to understand the barriers and the criticisms which hamper the development of a more efficient recycling pathway for plastics, one of the most important material recovery plants of Turin has been selected as case of study. The plants belongs to Amiat, the multi-utility working in waste collection on the behalf of Turin Municipality. This plant can treat up to 66 ktons/year of plastic packaging. Its function is to pre-select the materials coming from the separate collection, in order to guarantee the necessary level of quality to allow the recycling process. In fact, pre-selection is required for different reasons: a non-efficient separation performed by the citizen, as well as administrative and legal constraints on plastics treatment, such as recycling plastic packaging only. Hence, this work is willing to identify the key-actors involved in the plastic recycling process as well as to analyse the role of the selected plant using a case study methodology, assessing the key barriers and suggesting possible solutions for future scenarios of plastics recycling.

Keywords: circular economy, plastic market, plastic recycling

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1. Introduction

From 1950 onwards, it is estimated that about 6'300 Mtons of primary and secondary plastic waste have been produced on the planet. Furthermore, it is estimated that 79% of plastic waste has been accumulated in landfill or discarded in the environment, whereas only 9% has been recycled (Geyer et al., 2017). Although public opinion has recently been affected by impactful media exposition, such as the dissemination of news and data about the island of plastics in the Pacific Ocean (Lebreton et al., 2018) called *Pacific Trash Vortex (Great Pacific garbage patch)*, environmental policies in developed countries are struggling to reach effective results. In the developed areas supposed to be keen on environmental awareness, such as Europe, policies to optimize and improve plastic recovery are unable to take off the ground (DESA, 2013). Thus, the awareness of the issue is not consistent with data about plastic recycling. For instance, European citizens declared themselves aware about the environmental impact of plastics, and concerned about the management of this kind of waste (Syberg et al., 2018). On the other hand, according to Eurostat Report (2018), each European citizen produces 31 kg of plastic packaging waste every year, which leads to a total of 15.8 Mtons in the European Union (EU). Nevertheless, in European countries, only 40% of plastic packaging is currently recycled (EC, 2015). In Italy, the amount of plastic packaging actually recycled is around 43% (PlasticsEurope, 2018). This dynamic is consistent with the continuous growth in the rate of separate collection, by now close to 55%, which led to the progressive increase of the plastic percentage transported to recovering and recycling centers (ISPRA, 2017).

In the City of Turin, the rate of separate collection is only around 45% and the quantity of plastic addressed to material recovery plants is constantly growing (Commune di Torino, 2018). The plant selected for this case-study stores and sorts the plastic waste coming from the separate collection of the City of Turin. It represents a preliminary step for plastics before going into the recycling process to guarantee suitable plastic waste for the recycling process.

The main objective of this work is to investigate the barriers for plastic recycling starting from the case-study of the selected plastics recovery plant in Turin. The analysis of the material and money flows, the study of plastic materials and the examination of the normative led to the identification of relevant key barriers which might hamper the already "complex" recycling process of plastics. In this research, we aim to identify whether the selected plant is necessary to guarantee an efficient recycling process or why it might not be in the next future.

The authors rebuilt the whole plastic recycling framework through the definition of plastics as polymeric materials (3.1) with their specific characteristics and the main categories for the recycling (3.2). The Italian situation (3.3), the stakeholder analysis and the plastic ecosystem are explained afterwards (3.4). Finally, the plant is analyzed (3.5) as well as an exploration of the relevant regulations including the birth of CONAI is done, providing the starting point for potential future scenarios (3.6).

2. Methodology

The methodology chosen is the case-study analysis. The choice of the plant is relevant because dynamics of CCs (*Centro Comprensoriale*-Plants of recovering materials) are not explored at all, because their value is often underestimated due to their small dimension. In fact, this research wants to analyze their role, considering their work of pre-selection is fundamental for the whole plastic recycling value chain. It is acknowledged that CCs are complex systems and it is worth investigating why they are necessary and whether they might not be in the next future. In order to reach this purpose, official documents of COREPLA are used, as well as information provided on COREPLA website.

3. Results and discussion

In this section, the definition of plastic is presented, in order to give clarity to the concepts involved. Then a quick excursus about different kinds of plastic recycling is proposed. Afterwards, the Italian packaging ecosystem is analyzed, identifying the most relevant actors involved, as well as the case study of the selected CC is taken into careful consideration, in terms of money and materials flow, highlighting pros and cons of the actual existing Italian plastic recycling network. Finally, the enactment of Ronchi Decree is discussed, explaining the reasons and the perspectives after the birth of CONAI.

3.1. Plastic: one definition for a plethora of materials

The International Union of Pure and Applied Chemistry defines plastic as a "*polymeric material that may contain other substances to improve performance and/or reduce costs*" (Vert et al., 2012). Actually, there are a plethora of different plastics whose our products are made of and there are codes (Table 1) to help the identification of the type of plastic in order to facilitate the recycling process according to international standards.

Table 1. Classification of plastics according to the International Standards (adapted from Wong, 2010)

Symbol	***Type of Plastics***	***Main Use***
	Polyethylene Terephthalate (PET)	PET is used for containers for foods and liquid, soft drink bottles, fibers for clothing.
	High Density Polyethylene (HDPE)	HDPE is used for bottles, piping for water and sewer, milk jugs, detergent bottles, nursery pots, oil containers, snowboards, boats and chairs
	Polyvinyl Chloride (PVC)	PVC (or vinyl) is common for products such as plumbing products, medical tubing, pressure pipes, electrical cable insulation, outdoor furniture, liquid detergent containers, etc.
	Low Density Polyethylene	This polyethylene is ductile and, thus, used for shopping bags, food containers, films or bags and stretch wrap
	Polypropylene (PP)	PP is a thermoplastic polymer and one of the worldwide most common used plastic. It is used for laboratory equipment, automotive parts, medical devices, etc.
	Polystyrene (PS)	PS is commonly used for yoghurt pots, foodservice containers, CD cases, envelope windows, video cassettes, appliance housings as televisions.
	Other types of plastics	Various usages.

3.2. Plastics recycling

Plastic recycling process can be mechanical or chemical: the former consists of the re-melting and the re-extrusion of the polymer. The latter one is the chemical break of the polymer in smaller

molecules which can be re-used either to produce a new polymer or another material. In any case, each process requires resources, such as water, and energy: thus, the golden rule, i.e. the most efficient solution to the waste accumulation issue, it must always be the minimization of waste. It is relevant to know that plastics are divided in two main classes. Each class of plastics exhibits different properties and different behaviors towards the recycling processes. Plastics that are solid materials obtained through the melting and subsequent cooling of the polymer are called *thermoplastics*. The recycling of these plastics is easy enough: it is sufficient to heat and reshape these materials. It is important to highlight that repeated processing may alter the properties of the polymers. Plastics having their set properties and shapes obtained through the so-called crosslinking reactions are called *thermosetting plastics*. These plastics are more difficult to recycle because the heating process leads to their chemical degradation. There are four different classes of plastic recovering processes (Elias, 2003):

1. *Primary mechanical recycling*: uncontaminated plastic is directly recycled (usually for industrial waste);
2. *Secondary mechanical recycling*: post-consumer plastics are sorted and purified and then recycled;
3. *Chemical recycling*: plastics are broken into smaller molecules. In this way, it is possible to obtain the starting material, a new plastic or another different product;
4. *Incineration*: plastic is burnt. The released heat is used to produce energy.

Another kind of plastic disposal is composting: the material is broken through a biodegradation process into smaller molecules, carbon dioxide and water without the formation of toxic substances, within the time and with the conditions described by the regulation. In Italy, the characteristics for compostability are defined in the UNI EN 13432 (2002). Not all plastics can be recycled and the first step to correctly recycle in an efficient way is the proper separation of plastic waste from other materials. Each recycling process exhibits its own criticisms due to different reasons: citizens' awareness, technology readiness, economic feasibility, lack of policies. In Table 2 the criticisms, from a chemical point of view, for the different kind of disposal are listed (presented). From Table 2, it is possible to observe that there are some issues which need to be overcome yet. From a chemical point of view, it is important to consider the strategies adopted to have a good quality final material (conditions of the process), as well as the energy and the resources exploited in the recycling process.

It is relevant to notice that, when discussing about chemical recycling, materials, and not products, are taken into account. On the contrary, the Italian law, with the establishment of CONAI (2015), regulates the recycling of packaging; thus, it is based on products and not on materials. Indeed, in Italy, certain products made of recyclable materials are not collected only because they don't act as packaging. The in-use Italian normative is discussed in details in next sections. A sound idea to simplify the entire process might be to regulate the collection of all plastics based on material types instead of product types.

In this way, the rate of recyclable plastics could be improved as well as the separation between plastic and non-plastic materials could be easier both for citizens and for a plant as the case-study considered. In addition, chemistry must innovate materials at the first stage of production, i.e. when they are synthesized, to make them more recyclable and it must continue to study new processes to recycle the plastics that are not yet recycled and to make the already existent ones more efficient.

The re-design of materials with the purpose to make them easier to recycle and following a production process closer to the Green Chemistry Principles (Anastas and Warner, 1998) is, nowadays, one of the main challenges for a chemist. To sum up, it is worth highlighting that materials must satisfy a certain function, comply with the legislation and be economically viable at the same time.

Table 2. Plastic recycling processes: criticism and solutions

Plastic recycling process	***Criticisms***
MECHANICAL RECYCLING	Loss of qualities. Use of energy and resources. The presence of additives or mixed materials can jeopardize the recycling.
CHEMICAL RECYCLING	Difficult for some plastics to recover *selectively* the starting materials. Use of energy and resources. The presence of additives or mixed materials can jeopardize the recycling.
INCINERATION	The material cannot be re-used in the production cycle but energy is recovered. Life Cycle Assessments are necessary to evaluate which way is the most sustainable.
COMPOSTING	Misunderstanding of right collection rules by citizens. Lack of effective campaigns of information on key-terms as "biodegradable" and "compostable".

3.3. The Italian situation

In the last decade, every year around 2'200 ktons of plastic packaging are introduced by the Italian market (PlasticsEurope, 2018). The recycling system allows to recover 87.5% of post-consumer plastic packaging: 44.5 % was used to produce new raw material, while 43% was destined to energy recovery. According to PlasticsEurope (2018), from 2006 to 2016 the volumes for recycling increased by 46%, while energy recovery increased by 53% and landfill decreased by 49%.

The Italian plastic packaging supply chain is regulated, at national level, by a unique actor, COREPLA. COREPLA is the national consortium intended for collecting, recycling and recovering plastic packaging and it contributed to collect the 51% of plastic packaging in 2018. It collected 1'219'571 tons, whose 110'823 tons consisted of outer fraction, allowing to avoid the production of around 900 ktons of CO_2. The outer fraction, according to the Italian laws, is the part of waste coming from the separated collection, not homogeneous with the type of material collected (e.g.: glass in the paper bin). Generally, the outer fraction reduces the purity of the collected material, decreases its value and must be disposed of separately (ETRA, 2011). The Italian plastic packaging ecosystem is composed by several private and public stakeholders. The simplified material flow is depicted in Fig. 1.

The plastic packaging value chain starts along with production, distribution and utilization. On the left side, indeed, there is the Plastic Packaging Recovering Chain, i.e. the packaging producers, the product companies and the retailers, who produce the packaging, the products and sell them to the consumers. On the right side, instead, the Plastic Waste Recovering Chain is represented. The recycling process takes place in different phases: (i) the separate collection of waste (citizen); (ii) the collection of separated waste from a company (public or private) and the pre-sorting and cleaning of plastics; (iii) the sorting of different plastics and, (iv) the recycling, i.e. the sorted plastics are processed in order to have materials suitable for a new use.

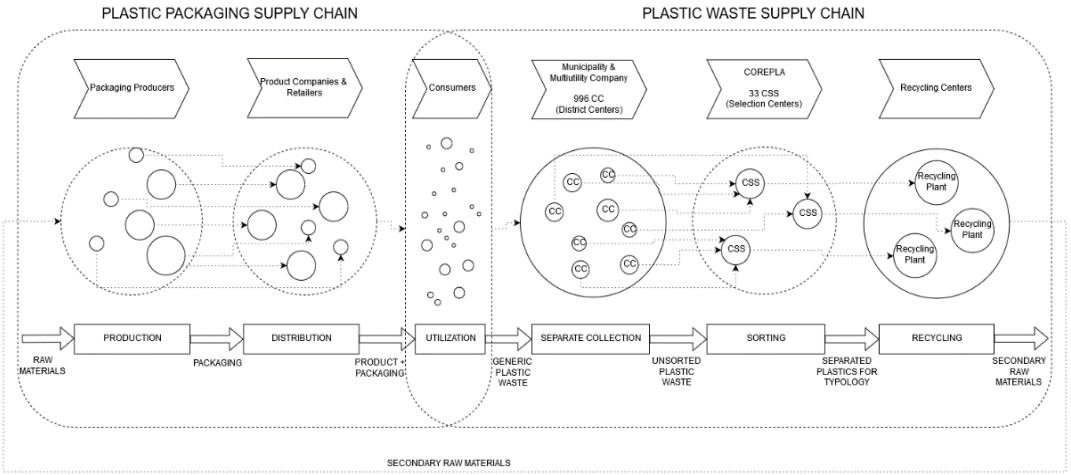

Fig. 1. Simplified plastic packaging value chain in Italy

3.4. The plastics ecosystem

Figure 2 represents the national Money and Material Flow (MMF) for the plastics recycling supply chain. The dashed lines represents the money flows, where the direction of the arrows means who pays who, while the filled lines represent the materials flows. The plastic packaging ecosystem, in terms of materials flows, starts from the producers, i.e. packaging and product producers, who use raw (primary or secondary) materials to produce the plastic packaging. Consequently, they sell the products, and the packaging, to the consumers.

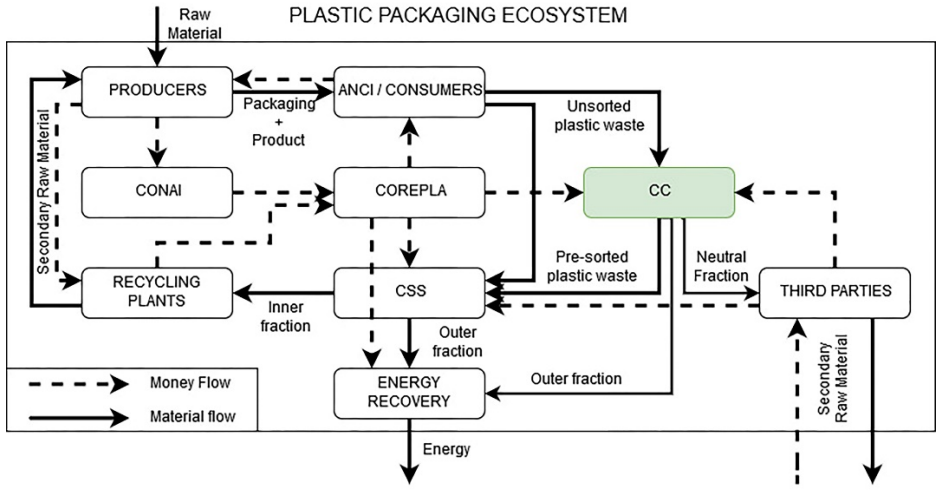

Fig. 2. Money and Material Flow for the plastic packaging supply chain in Italy

In the graph it is represented by ANCI ("Associazione Nazionale dei Comuni Italiani / National Association of Italian Municipalities") and consumers' box. Then the municipalities (i.e.

ANCI) collect the plastic waste with separate collection, generally through a private or public multi-utility service company, and bring the waste to the CC (the District Center), owned by a third party company or by the municipality/multiutility itself, for the pre-sorting and cleaning process, or directly to the CSSs (the Sorting Centers) owned by COREPLA's subcontractors. The CCs, and the CSSs, sort the plastic waste dividing them into 1) an inner fraction, i.e. the recyclable plastics; 2) an outer fraction, the waste part composed by other materials (glass, paper and not-packaging plastics) and 3) a neutral fraction, products not recognized by CONAI-COREPLA (Consorzio Nazionale Imballaggi, National Packaging Consortium). In Italy there are 996 CCs held by municipalities and local multiutilities while COREPLA holds 33 Sorting Centers (CSSs), scattered throughout the national territory (MISE, 2018): the choice of center happens according to a territorial proximity principle, in order to reduce both costs and transportation environmental impact. At this point, the material is ready to be recycled.

The outer fraction, generally, ends to District Heating (DH) plants, in order to recover the energy of the plastics by incineration, or to landfill. The neutral fraction is sold to third parties who recycle the materials and resell it on the materials' market. Finally, the inner fraction, the most valuable fraction of the plastic waste is brought to recycling plants which transform the waste into secondary raw materials, ready to be sold either again to packaging producers or for the production of other products. Although the Material Flow seems to be decentralized, involving several private and public stakeholders, from the municipalities to the citizens, include private companies, the Money Flow is completely centralized and guided by a unique actor, COREPLA, as member of the CONAI system of consortia which manages the whole post-consumer packaging material in Italy. COREPLA signs contracts directly with municipalities or operators, as District Centers or Sorting Centers, who receive the approval for the treatment by local public administrations. Indeed, the packaging ecosystem Money Flow can be read again starting from the packaging producers who pay a fee for each packaging sold on the market to CONAI, the general packaging Italian consortium. CONAI pays directly COREPLA for each plastic packaging. COREPLA, with the fees received by the private companies, pays 1) the municipalities, or the local multiutilities who collect plastic waste and 2) the owners of the District Centers who pre-sort and clean the unsorted plastic waste, 3) the subcontractors who own the Sorting Centers and the owners of the District Heating systems for Energy Recovery. Finally, the Recycling Plants, who receive the final sorted and split plastic materials, pay again COREPLA to receive the inner fraction of the plastic wastes and sell the secondary raw materials, after the recycling process, to the producers.

3.5. A case-study in Turin: a starting point to understand the complexity of plastics recycling chain

The selected plant is classified as a CC; it is a district center from which the selected plastics will be moved to the CSS, the Sorting Center. It deals with plastic packaging and other kinds of bulky waste, in fact in this case-study the authors choose to focus only on plastic waste. The plant holds ISO9001 (2015), ISO14001 (2015) and OSHAS 18001 (1999), certifications and it has the main goal of storing and selecting non-dangerous waste to facilitate the selection process to generate secondary raw materials to reintegrate in products' life-cycle.

The plant is authorized to treat up to 66.5 ktons per year of waste. In 2018 it treated 23 ktons of waste, fulfilling around 34.6% of its potential. This is an encouraging figure, as in the previous years the amount of generic plastic waste collected was lower. Piedmont increased from 2017 its amount of generic plastic collected by 14%. On the other hand, only around 19 ktons consisted of plastic packaging, while around 4 ktons made up the outer and the neutral fraction. According to the quantity of plastic packaging given to the CSS, COREPLA gives to the CC an economic reward. The price per ton varies according to the kind of packaging given to the CSS as described by Table 3.

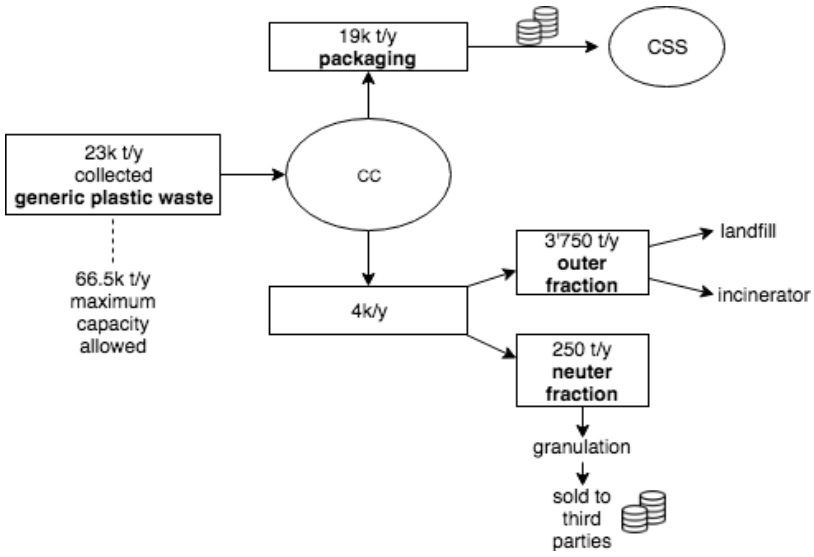

Fig. 3. Plant's Material Flow

Table 3. Flow of plastic materials and reward per tons on material (ANCI-COREPLA, 2014)

Flow	***Euro per ton***	***Description***
A	303	mono-material of urban origin
B	80	mono-material of non-domestic origin with a relevant quota of tracers
C	394	mono-material of urban origin, mainly CPL ("Contenitori Per Liquidi / Beverage Container")
D	295	multi-material of urban origin

Each flow has a maximum percentage of allowed outer fraction (FE - "Frazione Estranea"), in order to be accepted by the CSSs and COREPLA according to the national ANCI-CONAI agreement for the period 2014-2019: A) FE < 20%, B) FE < 20%, C) FE < 10% and D) $\%FE_{Plastic}$ < 22%. For the Flow D, $FE_{Plastic}$ is quantified according to Eqs. (1, 2):

$$\%FE_{Plastic} = \frac{PlasticPackaging * \%FE_{tot}}{PlasticPackaging + OtherPackaging} \quad (1)$$

where:

$$\%FE_{Tot} = \frac{FE * 100}{PlasticPackging + OtherPackaging + FE} \quad (2)$$

PlasticPackaging and *OtherPackaging* represent the amount of plastic and of other materials in tons. When only mono-material is given to the CSS the formula to calculate the economic reward is while, when the flow is multi-material, the economic reward is given by the

formula where CN is the net fee, Cu the unitary fee per ton, IC the quantity of packaging in tons, FE the outer fraction in tons and Cfes and Cfer the unitary cost for selection and recovery of outer fraction, respectively. The COREPLA reward constitutes the main source of income for the plant.

On the other hand, the plant deals with different stakeholders, who influence the flows of incoming materials, as well as the end market of recycled plastics. The first actor which influences the plastic cycle is composed by the citizens who decide whether or not to respect the separate collection. Secondly, Amiat, the local multi-utility of the City of Turin, plays a key-role as the company which steers waste management, in which the plant plays an active role. Amiat collects waste, including plastics, which reaches the plant on a daily basis, taking it from selected areas of the city. Once treated by the plant, specific plastics are sent to specific CSSs. Specifically, the consortium buys plastic bales from the selected plant. Afterwards, in the CSS the bales of plastic material would be treated and separated in diverse types such as: colourless PET bottles (mineral water, soft drinks, etc.), blued PET bottles, PET bottles of other colours, high-density polyethylene bottles-HDPE; polyethylene film (bags, bottle packs, appliance packs, etc.) and mixed packaging (mainly rigid and flexible polyethylene or polypropylene). The complex network of stakeholders created by the plastic packaging ecosystem is depicted in Figs. 1 and 2.

3.6. Establishment of CONAI: an important actor for the recycling system of plastic packaging.

The regulation relating to the management and recycling of plastic packaging dates back to Legislative D.Lgs 22/97, the so-called "Ronchi Decree". This decree gave rise to CONAI, which manages exclusively the packaging waste. It clarified the current collaboration between public and private sectors: Ministries, Authorities and Public Administration, on one side, and Material Consortia like COREPLA (for plastics) on the other (CONAI, 2017). On the other hand, it led to the creation of a private market for the recycling of packaging (Pierobon, 2012). After that legal framework, several laws disposed by national and European institutions determined the conditions of work of COREPLA and CCs as the case-study.

As mentioned before, COREPLA only accepts plastics from packaging as it is under CONAI regulation (CONAI Environmental Declaration) which obliges packaging producers to pay a fee to guarantee the collection and the recovery of the packaging sold in the Italian market (extended producer responsibility). Thus, the recycling potentiality in Italy is not fully disclosed, as many plastic products are not accepted by CONAI (2018) and, consequently, they are discarded during the sorting and the selection processes within the CC and, afterwards, within the CSS plants. In the case of the selected plant, pre-sorting is useful to separate the plastic packaging from the non-packaging. These conditions and constraints depend on the legal and administrative barriers which regulate the whole process.

Currently, CCs as plants of plastic treatment receive compensation linked with the amount and the quality of separate collection. It decreases as the "outer fraction" increases with respect to the plastic packaging, i.e. the inner fraction, on the basis of the provisions of the ANCI-Conai Framework Agreement (Ciotti and Paravidino, 2018). As declared in the Agreement, the plant works on sorting only plastics from packaging into material to recycle and to use other potentially recyclable plastics for energy recovery. Although the amount of packaging flows is considerable, as COREPLA offers a financial compensation for 14 types of flows, the packaging constraint prevents a larger proportion of plastics from being sent for recycling. The Agreement defines as outer fractions, objects of daily use that are very common: plastic cutlery, toys, construction products and, more generally, any object that is not intended to be used as a packaging. For this reason, the 16% of the total amount of plastics received by the plant is considered by the Agreement as outer fraction, and it is actually sent to incinerator or to landfill.

At European level, the legislation seems to have taken a step forward, with the entry into force of Directive 2018/852, which provides for an extension of the responsibility of the packaging

producer to ensure high quality and recyclability. This action could influence the future quality of input flows received by the plant; however it does not boost the recyclability of other plastic products.

To sum up, at legislative level there is a clear need to improve another aspect: the reusability and durability of plastic products. To reach these goals, four main administrative challenge are identified to improve the legislation about plastic reuse and recycling. They involve different policy fields: 1) taxes on the use of virgin plastics or differentiated value added taxes for recycled plastics; 2) reform of support for fossil fuel production and consumption; 3) introduction of recycled content standards, targeted public procurement requirements, or recycled content labelling; and 4) education and awareness campaigns in order to stimulate demand for products containing recycled plastics (OECD, 2018). The first step for plastic reusability is actually represented by Deposit Return System (DRS): 10 European countries have allowed more than 130 million citizens to return and reuse empty beverage containers (CM Consulting, 2016). However, this plan should be shared by all EU Member States, including Italy, to guarantee significant outputs. These aspects explain not only the quality of the work of the selected plant, but also its purpose in the current Italian plastics management ecosystem.

4. Conclusion

The plant considered in this case-study plays a relevant role in the plastic value chain. After an analysis of the flows (materials and money) from the plant and a careful regulations' evaluation, some interesting conclusions can be drawn. From an administrative and legal point of view, the renewal of the current legislation on management might be able to improve the whole recovery system; at the same time, it could open new scenarios for the plant. If this legal update took place, the plant would work with a wider amount of plastics which would be sold to recycling public and private companies. In particular, the D.lgs 22/97 should be updated, in order to include products different from plastic packaging, thus enlarging the range of recyclable products; the ANCI-CONAI agreement should be revised as well, in order to allow municipalities to bring to the CCs not only plastic packaging but other kinds of plastic as well. A relevant aspect which comes up from this research is that plastic recycling system is based on a material and product selection instead of only on a material one, indeed. Hence, from a recycling point of view, the material is the subject and not the product. Opening the access to the recycling process to all the products made of plastics could simplify the separation operations both from the citizen and the CCs, or more in general, the separation plant perspective. The regulation on products should be applied more to the recycle field, such as the Deposit-Return System for beverage containers, e.g. for glass bottles or plastic cups, while for the recycling field we should focus the attention on materials.

On the one hand, Chemistry and more in general the technological field, should continue its effort towards the innovation of materials that are easier to recycle. The challenging work in the research addressing an increasing sustainability for a pivotal material like plastic is jeopardized by the high performances required for this material. These requirements lead to a change in our behavior as consumers and this is an interesting challenge.

On the other hand, this "material" approach might be difficult for economic reasons because the payment for the recycling system should be made by the companies which produce plastic and not by the packaging producers. This could further hamper the cost-effectiveness of recycled plastic because, considering the cost of virgin plastic is influenced by the cost of oil, any additional cost bore by companies might be reflected in the final price of recycled plastic. A possible solution might consist in the introduction of tax relieves for the companies but the complex cost structure of plastic production should be further deepened to provide more insightful suggestions. Furthermore, the case study points out how plants as the CC considered continue to play an important role in the plastic waste treatment.

In conclusion, this research shows the future challenges which are going to be faced by every actor who want to change the process with a circular perspective. A circular approach might deeply change the function and the work of CCs in the plastic value chain and opens new scenarios of study.

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SMART ENERGY DISTRIBUTION SYSTEM BASED ON A CIRCUIT OF SOLAR PANELS APPLIED TO STRAW-INSULATED WOODEN DWELLINGS*

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Abstract

Important progress has been made in the field of photovoltaics and biostructures, in particular on the intelligent distribution of energy from solar panels. This research focuses on the key role of this system, applied to condominium structures built entirely of wood and insulated with biomaterials such as straw, in order to intelligently and effectively distribute the energy derived from solar panels, based on the utilities required by the structures themselves. According to the European Directive of 2008/28/EC, this article highlights the way in which the application of photovoltaic systems can make biostructures even more sustainable, trying to make them self-sufficient in terms of energy. The synergy between the systems is guaranteed by the partnership of two companies: Prefabbricati di Martelli Salvatore & C. S.a.s, specialized in the design and construction of wood structures, placing environmental sustainability first, and F.E.R. S.r.l., which operates in the design and promotion of Renewable Energy Sources, particularly in the field of photovoltaic energy. The aim of this project is to develop energy through solar panels managed by an intelligent energy distribution system that, applied to condominium biostructures, allows you to make these structures almost zero-impact. This research shows how the implementation of an intelligent energy distribution system and the construction of structures that use materials from nature, offer both economic and environmental benefits, such as the reduction of dependence on non-renewable energy resources, a reduction in energy waste from solar panels and finally the creation of a biostructure that is in complete harmony with the environment.

Keywords: biobuilding, renewable energy resources, straw, smart system, wood construction

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1. Introduction

The following work aims to focus attention on new ways of intervening on the territory in an environmentally friendly way, taking stock of the best techniques of eco-innovation, underlining the role of the actors involved in the protection of the environment, quality of life and energy saving in the field of construction and urban redevelopment. The building sector is called upon to meet the new requirements in terms of energy saving and climate change. This can only be achieved with the correct choice of materials, systems and technologies that today, allow us to build buildings with significant results in terms of energy consumption (Bolletta and Della Rocca, 2008). The primary purpose of sustainable construction is to reduce the use of non-renewable energy, trying to significantly minimize, through the use of eco-friendly materials, the effects that traditional structures have on the health of humans and the surrounding ecosystem trying to achieve a perfect marriage between man and nature.

New buildings are asked to contribute to the development and dissemination of the concept of energy efficiency with an ethical and structural approach that, starting upstream and at the design stage from energy analysis, leads to the identification and implementation of energy-saving measures based on the best solutions available on the market, so as to optimize energy consumption, maximize economic savings, greater environmental comfort and less pollution. Sustainable construction is based on five fundamental principles: sustainable planning of the project starting from the choice of the site; protection of water resources and efficient use of water through recovery systems; rational use of resources, conservation of materials and reuse; quality of the internal environment; energy efficiency both in times of intelligent management of electricity and in terms of self-production of energy (Campiotti et al., 2012).

Today, a company's commitment to sustainability, which is its primary point, is a competitive key for any business sector. Companies operating in the field of green building have the opportunity to meet environmental problems by creating structures capable of reducing CO_2 emissions compared to the traditional ones, which are one of the main sources of pollution. Studies conducted by ENEA and Cittalia show that 37.8% of the sources of CO_2 emissions generated by Italian citizens between 2000 and 2009 can be attributed to the use of the building's air conditioning and heating system (Desideri et al., 2009). If on the one hand the first source of renewable energy is energy saving, on the other hand the main resource that replaces the various non-renewable energies is solar energy. The use of solar plants allows to produce energy with low environmental impact, since it does not require fossil raw materials to trigger combustion processes and therefore does not release harmful substances into the atmosphere. When there will be solar systems with yields such as to exploit 70/80 % of our planet, photovoltaics will be the most widely used method of energy production (Carrotti and Made, 2006). But we must be careful how we use, in fact, a recent research published in Nature Sustainability, and coordinated by the ecologist Rebecca Hernandez, of the University of California in Davis, reveals that: the photovoltaic, if installed without any other criterion than economic convenience, can be harmful to the environment, or, at least, sees greatly reduced its potential benefits. On the contrary, if it is used correctly, integrating it with ecosystems, agriculture and the urban environment, it multiplies its advantages, becoming even more important in achieving energy sustainability (Rizzi, 2016).

2. Materials and methods

Significant progress has been made on energy efficiency, in particular on the possibility of energy recovery from renewable energy sources. With increasing attention to the environment, standards and regulations have also been introduced in the building sector, in order to reduce pollution and energy waste. EU emissions were reduced by 23% between 1990 and 2016, resulting in a 9.8% increase in production from renewables. According to the EU's 2030 climate and energy framework, a binding target is set to reduce emissions into the EU by at least 40% below 1990

levels by 2030. The framework sets a binding EU-wide target to increase the share of renewable energy consumption to at least 27% by 2030 (Piraccini and Fabri, 2018). Renewable energy production has represented a strong energy potential growth in recent years. In particular, wind and photovoltaic power plants have seen a considerable increase, especially in the southern and island regions of our country. The solar photovoltaic / thermal collectors sector is one of the fastest growing industries in the world, to maintain this growth rate it is necessary to start new projects based on the most modern technologies in order to increase energy efficiency by reducing waste. The EC Directive (2008) highlights the way in which the application of photovoltaics makes buildings in green building even more sustainable, trying to make them self-sufficient in terms of energy. The EnergyHub system proposed by this research offers a new way to integrate the production of energy from small-scale photovoltaics using the production and direct collection within a residential system of 20 villas. This model allows the meeting of energy demand and supply in a building following a certain aggregation of energy converters and allows to estimate the energy consumption, pollutant emissions, installation and operating costs.

The photovoltaic system offered by F.E.R. S.r.l. is an Energy Hub. This research focuses on the key role of this system, applied to houses structured entirely in wood and insulated with sustainable materials such as straw, in order to distribute in an intelligent and effective way the energy obtained from solar panels, according to the energy needs of each user. The synergy between the systems is guaranteed by the partnership of two companies: Strutture in legno Martelli s.a.s., specialized in the design and construction of wooden buildings, and F.E.R s.r.l., which operates in the design and promotion of Renewable Energy Sources, in particular in the photovoltaic energy sector. The object of this research is the hypothesis of being able to install an inverter system, an electronic input/output device capable of converting an input direct current into an output alternating current, for residential buildings. The solar energy storage system consists of a series of batteries, which combined with an inverter and a charge controller, stores the excess energy produced by the photovoltaic system. The wooden houses proposed by Prefabbricati Martelli, are based on the standards of Passive House, with the aim of offering an efficient and economically sustainable solution combined with renewable energy (www. ideegr een.it). The introduction of the so-called almost zero energy buildings is an effective solution to mitigate CO_2 emissions and reduce energy consumption in the building sector, which currently accounts for about 40% of the world's energy. In addition to high efficiency, the Passive House Standard provides excellent cost-benefit ratios when lower overall energy costs are taken into account. Moreover, another significant aspect of this empirical study based on the implementation of a photovoltaic inverter system with an almost zero impact residential model is the reference to the circular economy.

3. Experimental

3.1. Case study: Martelli Prefabricated Salvatore & C. s.a.s.

The sector of wood construction according to the standards of green building in Sicily has made significant progress with the emergence of greater awareness and sensitivity to the issues of environmental protection. The company involved is Prefabbricati di Martelli Salvatore & C. s.a.s., whose family has been working in the wood sector since 1955. In 2006 the original company was split and transformed into today's "Prefabbricati di Martelli Salvatore &C. S.a.s". It was in that year that the company expanded with the construction of a factory located in the industrial area of the municipality of Bronte. Over the years, its activity has increased, becoming a reference point in the construction of structures entirely of wood and in the restoration and renovation works. The company deals with every single phase of the production cycle: from the design to the construction of any type of wooden structure Prefabbricati di Martelli is in possession of SOA certificate for the category OS32 which certifies the quality in the execution of public works and Ministerial

Authorization in accordance with the Ministerial Decree 14/01/2008 for the processing of structural elements. It is also certified UNI EN ISO 9001:2015 to ensure strict compliance with quality in the management of business processes and UNI EN ISO 14001:2015 to underline the concrete commitment to monitor the environmental impacts of its activities and to systematically seek continuous, consistent, effective and above all sustainable improvement of its environmental performance (www.struttureinlegnomartelli.it).

3.2. Case study: F.E.R. S.r.l.

In Sicily, in the photovoltaic sector, there are few companies that present a wide range of high quality and reliable products and that continuously follow the new emerging technologies such as F.E.R. s.r.l. F.E.R. s.r.l. was born from the synergy of managers, technicians and designers passionate about photovoltaics and the world of renewable energy that, since 2007 to date have contributed to the construction of numerous photovoltaic systems and feasibility studies. F.E.R. s.r.l. has its registered office in Catania and operational headquarters in Caltagirone, and has tools for plant design in energy recovery at the forefront. The company operates in the field of renewable energy driven by a strong sense of responsibility towards the environment and the territory, is able to offer different services from consulting and assistance to design and construction, so focused on the needs of each project. The company's organisational chart is composed of a Chief Administrative Officer, a Commercial Manager and a technical manager who coordinates the personnel and technical engineers. F.E.R. S.r.l. certifications in the green economy sector are: KHC ESCO UNI CEI 11352:2014 N.104/17, SMC ISO 9001:2015.

4. Results and discussions

The analysis of the company's business plan has shown that the total production of energy produced by the photovoltaic system with power 130.00KWp amounts to 14047kWel / year, considering a li-ion battery storage system. The maximum productivity is found in the summer months with an increase in May and June and a corresponding decline from August. The maximum energy produced is 23,649.2 kWh in July. The respective consumption is constant for all months at 650 kWh/month for an annual total of 7800 kWh/year. Of the energy produced by this system, 90% of the total energy is fed into the grid and only 10% is used for domestic consumption. The total costs incurred for this investment, considering 2019 as the year of introduction of the photovoltaic system amount to € 275,500.00 (VAT included) to which must be added the annual costs of ordinary and extraordinary maintenance, respectively of € 1300.00 and € 130.00. Following a preventive analysis carried out over 20 years of operation, revenues are estimated at a total of € 592,443. Through the analysis of the Breakeven point, point in which the total revenues and total costs are equal and the profit of the company is equal to zero, you can see how you get positive values from 10 years of operation with a break-even point of 33,320 €. The values obtained before the tenth year of the financial year involve negative performance in terms of both break event points and cash flows, since this investment for the first ten years absorbs the liquidity generated and is unable to cover the costs incurred.

Installing a photovoltaic system means, in addition to saving money on your electricity bill, doing good to the environment. By installing photovoltaic modules on your roof, you produce electricity that would otherwise have been produced from highly polluting fossil fuels. To better understand how much carbon dioxide we avoid releasing into the atmosphere if we choose to switch to photovoltaics and self-consumption of clean electricity, we must use the data "emission factor of the electrical mix" which represents the average value of CO2 emissions due to the production of electricity used in Italy. The figure is made public by the Ministry of the Environment and the one updated to date is 0.531kg of CO_2/kWh (https://www.minambiente.it/).

To produce one kilowatt hour of electricity, on average the equivalent of 2.56 kWh is burned in the form of fossil fuels and consequently about 0.53 kg of carbon dioxide is emitted into the air. It can therefore be said that every kWh produced by the photovoltaic system avoids the emission of 0.53 kg of carbon dioxide. The carbon dioxide emission avoided in one year is calculated by multiplying the value of the electrical energy produced by the systems by the emission factor of the electrical mix. To estimate the emission avoided in the life time of the plant, simply multiply the annual emissions avoided by the estimated 30 years of life of the plants (www.woodysolution.it)

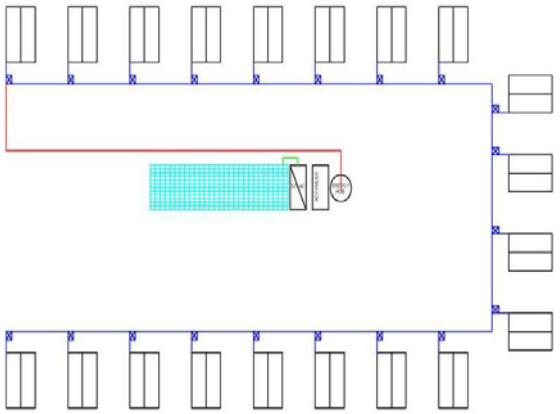

Fig. 1. Villette with photovoltaic system

Fig. 2. Frame system with straw panels

Straw was chosen as insulation material because it is a material with excellent insulating characteristics, both from a thermal and acoustic point of view. It ensures low heat dispersion and considerable energy savings. Straw is an excellent hygrometric regulator, taking into account the good vapour permeability. It has good elasticity, good resistance to seismic vibrations. The value of thermal conductivity of the straw varies from the density, the position of the stems (parallel or perpendicular to the direction of propagation of heat), the moisture content of the same and the type, but the values are between $\lambda = 0.0337$ W/mK and $\lambda = 0.086$ W/mK. Straw guarantees good sound insulation, the value of which is all the greater the greater its weight and therefore its mass. (www.struttureinlegnomartelli.it)

5. Conclusions

The continuous technological development aimed at environmental protection has allowed, today, the construction of an entire building in a short time with a considerable interest in the green building sector. The wooden structures preserve the environment as much as possible because they use materials that do not harm nature in any way. Moreover, it is well known that in Italy too, the European Directive 2010/31/EU requires Member States to reduce the consumption of buildings responsible for 40% of overall energy consumption, will come into force at full capacity: to be precise for Italy, the obligation to build only buildings with "almost zero energy", better known as buildings NZEB (Nearly Zero Energy Buildings), starts from January 1, 2019 for public buildings, and from January 1, 2021 for private buildings newly built or subject to specific renovation.

Considering the new targets set by the EU, which provide for a binding target of 32% of renewable energy by 2030, in fact, the use of a photovoltaic system, will be a key element in order to achieve the goal set.

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APPLICATION OF ZERO WATER WASTE MODEL IN THE BREWING INDUSTRY BY USING REVERSE OSMOSIS *

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Abstract

Only about 2.5% of earth's water is freshwater, including 1.75% in glaciers, which are quickly melting, 0.75% in groundwater and soil moisture and only 0.01% in rivers, lakes and swamps. Recently many companies, operating in the agrifood sector, are investing in technologies capable of reducing water waste, especially considering the amount of water required to sustain this kind of economies. Still, many small businesses cannot afford to implement systems capable of reaching both an environmental effectiveness and an economic efficiency. The goal of this paper is to show the results of Reverse Osmosis' implementation in the brewing industry, enabling it to reach a circular economy model, that if implemented will help industries get closer to a Zero Water Waste Model. We evaluated a possible investment in this technology, focusing on Birrificio dell'Etna S.r.l. dynamic brewing company that wants to reduce water waste without sacrificing the income aspect. The real benefit of this technology is its inexpensiveness and effectiveness, capable of outclassing other obsolete filtration systems, such as Micro, Ultra and Nano filtration. Reverse Osmosis exploits a natural chemical process, making it possible to filtrate external substances between 0,001 and 0.0001 microns. With such discernments companies will finally be in line with consumer's needs, increasingly leaning on environmental issues.

Keywords: agrifood sector, brewing industry, freshwater, reverse osmosis, zero wastewater

1. Introduction

With the phenomenon of industrialization and the consequent increase of the population, the demand for resources has increasingly increased, causing changes in the surrounding environment. So much so, that on July 29, 2019, was declared the Earth

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Overshoot Day, that is the day when the Earth ended its natural resources for 2019. Among these resources are also considered water resources where 97% is made up of saltwater and 3% of freshwater, of which 2/3 is represented by glacier water. It has been analyzed that the average inhabitant of the planet consumes 1,240 m^3 of water in an year, it is estimated that in Italy a citizen consumes 380 liters of water only for domestic purposes, a value that must be multiplied 17 times if we consider the water used by the companies for the production of what we eat and wear (www.WWF.it). Consequently to the succession of the event that are being manifested the society has become more sensitive on the use that is made of the freshwater resources so as to sensitize not only citizens but also companies, which try to adopt solutions for the treatment of freshwater, which are exploited in the process of production and cleaning of machinery.

Particular attention has been taken by the brewing industry that due to their production find themselves consuming large quantities of water, just think that water constitutes 85% as the final component of a beer, and the company is unable to reuse the water used. For this reason, the main companies are moving towards the circular economy to adopt solutions that can be ecologically and economically sustainable (Fernandez-Labrador et al., 2018; Greenlee et al., 2009). A solution that turns out to be optimal is constituted by reverse osmosis.

Reverse Osmosis works by using a high-pressure pump to increase the pressure on the salt side of the RO and force the water across the semi-permeable RO membrane, leaving almost all (around 95% to 99%) of dissolved salts behind in the reject stream. The amount of pressure required depends on the salt concentration of the feed water. The more concentrated the feed water, the more pressure is required to overcome the osmotic pressure. The desalinated water that is demineralized or deionized is called permeate (or product) water. The water stream that carries the concentrated contaminants that did not pass through the RO membrane is called the reject (or concentrate) stream (Puretec Industrial Water, 2019). Reverse Osmosis membrane are constructed from a membrane flat sheet. It is comprised of three layers: a polyester basic support base; a micro porous polysulfone and a 0.2-micron thick polyamide barrier layer.

Reverse Osmosis can remove up to 99%+ of the dissolved salts (ions), particles, colloids, organics, bacteria and pyrogens from the feed water (although a RO system should not be relied upon to remove 100% of bacteria and viruses). A RO membrane rejects contaminants based on their size and charge. Any contaminant that has a molecular weight greater than 200 is likely rejected by a properly running RO system (for comparison a water molecule has a MW of 18). Likewise, this is why a RO system does not remove gases such as CO_2 very well because they are not highly ionized (charged) while in solution and have a very low molecular weight. Because a RO system does not remove gases, the permeate water can have a slightly lower than normal pH level depending on CO_2 levels in the feed water as the CO_2 is converted to carbonic acid.

Reverse Osmosis is very effective in treating brackish, surface and ground water for both large and small flows applications. Some examples of industries that use RO water include pharmaceutical, boiler feed water, food and beverage, metal finishing and semiconductor manufacturing to name a few.

Reverse Osmosis is used all around the world to desalinated water, so much so that roughly 50% of desalinated water globally is obtained through Reverse Osmosis (Qasim et al., 2019). This technology is the main alternative in terms of clean water production, being able to minimize costs associated to desalinization, and overtaking more conventional thermal technologies (such as Multi-stage flash distillation). Improvements in membrane materials and module design, process design, feed pre-treatment, and energy recovery, or reduction in energy consumption, in turn lead to important reductions in costs. These factors draw more and more commercial interest in Reverse Osmosis technology and pave the road

for alternative applications other than seawater desalination. The positive effects in terms of resources and capital optimization can, of course, be also applied to wastewater treatment.

The objective of this paper is to show the advantages of implementing the reverse osmosis in the brewing industry to get closer a Zero Waste Water Model.

2. Materials and methods

Our goal is to study the effects of reverse osmosis by focusing on the brewing industry. To reach the goal, is proposed a case study implemented in the Birrificio Dell'Etna (L.T.D). In order to re-use the water that is exploited. Not having specific data, if we consider that the company has to take care of 100 cubic meters of water per day, or 100.000 liters, and a single RO plant can depurate 1000-2000 lt/h, if the machines work for 10 hours per day, that means that we would need between 5 and 10 plants. Since the cost of one reverse osmosis plant is around 5,000 euros, this would mean that the initial investment would fluctuate between 25,000 and 50,000 euros, which is a small price if compared with other water depuration systems, such as (Fig. 1):

• Ion exchange (IX) resin systems: at the low end, a simple 20 GPM IX system would likely cost around $100,000, while a system of similar capacity but greater chemical complexity might double or even quadruple the cost. At the high end, a complex IX system with a capacity of 2000 GPM might cost as much as $7 to $10 million.

• Microfiltration (MF) and ultrafiltration (UF) systems. A basic 10 to 20 GPM MF/UF system would likely cost less than $100,000, while a larger 100 to 200 GPM unit would run between $150,000 and $450,000 depending upon the quality of materials used. (Samco Technologies, 2017). This is very important, not only in the specific application of this technology in our case study, but for the brewing industry in general, to better understand why, let's take a look at the current state of the beer industry.

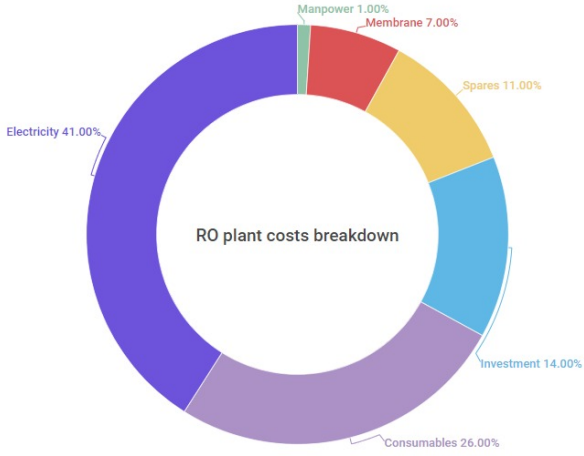

Fig. 1. The chart explains in detail the different costs that arise from the installation of RO plants

In recent years there has been a stagnation of the brewing market following the emergence of stricter regulations, greater competition and a change in consumer habits that lead companies to adopt innovative strategies to maintain their returns and margins. Nevertheless, it was noted that demand for this product is increasing in the main developing countries such as Latin America, whose demand grew by 1.2%, led by Mexico, where demand is expanding to a CAGR of the 3.4%, the fastest in the region. In terms of global

consumption, China takes gold as the largest beer market with 22.4%, followed by the United States, which represents 13%, and Brazil with 6.8% (Chase & Co., 2018).

In addition to testing different strategies and releasing different products, several leading brands have begun experimenting with new forms of technology, such as the aforementioned reverse osmosis, which not only helps in terms of cost reduction, but also gives value to companies in terms of green economy, a kind of value that customers are starting to look for more and more. While beer can be one of the oldest and most popular beverages in the world, tradition also needs innovation.

3. Experimental

The history of birrificio dell'Etna L.T.D. starts in 2014 when Delfio Faraci and Leo Biasi decided to commute their passion and their love for the beer in a job. The Etna Brewery was born from a common passion that binds Delfio Faraci and Leonardo Biasi, two entrepreneurs with a spirit of innovation and creativity and both connoisseurs and connoisseurs in various ways of the world of beer. The company is located on the slopes of Etna, the highest active volcano in Europe, where you can admire splendid lava eruptions and attractions for all tourists in the world. The idea of Faraci and Biasi is to create something unique linked to the Sicilian territory, an artisan reality capable of enhancing the aromas and flavors of its own land. This led them to the production of unique and excellent beers capable of transmitting to those who savor them the same emotions as those who produce them with dedication and energy.

The brewery's location was a cultural choice, Faraci and Blasi both love Sicily and her history. The beer's labels recall the characters of Greek mythology, this was also a cultural choice because Sicily is deeply tied to Greece and its mythology. Their beer schedule consists of 7 beers: Juno, Ulysess, Ephesto, Polyphemus, Heracles, Prometheus and Cyclope. The Etna Brewery to demonstrate its sensitivity and the love it has towards its territory has implemented a circular economy system with the aim of reducing production costs and safeguarding the environment. In fact, photovoltaic panels have been installed to have renewable energy and the company used raw materials of the territory such as the ancient wheat Sicilian Perciasacchi, the must of Nerello Mascalese and the green pistachio from Bronte D.O.P. added. Finally, the company consists of a young and dynamic team. You can take guided tours of the structure and tasting of products accompanied by typical dishes of the area. The brewery performs direct sales to the public, resale through distributors and sales by agents.

The etna brewery is equipped with a 1000-liter steam system prepared for double cooked, 20 hl fermenters and automatic washing cip, the rooms size is 500 square meters and the dimensions of the cooking room is 100 square meters. They also have an Automatic bottling line complete with bottle rinser, vacuum and injection nitrogen before filling and before capping. The "Birrificio Dell'Etna" is a symbol of initiative for the whole Sicilian territory. In an island where everyone prefers to escape to seek their fortune elsewhere, the etna brewery decides to stay and enhance their land.

4. Results and discussion

Not having available real data representative of the production and therefore of the flows that are used and discharged into the sewer system, literature data have been used that indicate for a medium-sized industrial reality of this category a discharge to be discharged of about 100 m^3/day. The flow rate value is very significant because it is estimated that around 85% of the total (corresponding to the average value of the purification yield assumed for the type of plant envisaged) can be reused within the production system means that there would

be a reduction in supply annual water supply of approximately 31000 mc. This constitutes a first important environmental advantage given the scarcity of water resources and the implementation of this purification plant would also help to moving towards a more sustainable policy.

Further environmental advantage deriving from the introduction of reverse osmosis which is a natural process does not alter the "structure" of the water and effectively eliminates all pollutants such as heavy metals, nitrates, bacteria, the arsenic and phosphates. This allows the company to be able to take advantage of safe water without therefore there being substances potentially dangerous for human health not only for washing but also for other purposes.

In addition to environmental benefits, the main advantage that comes from an economic point of view is that considering that the cost of the water resource is estimated at 0.28 euros per cubic meter means that a saving of around 9000 euros per year is obtained in addition to the reduction of the quota due to the discharge into public sewers. This data therefore constitutes a key performance indicator because it helps us to understand the amount of value that the company could save if it no longer uses running water. Furthermore, these devices are equipped with simple vital parts "designed" to last over time. In fact, the components do not require particular control interventions and the membrane that is used must be replaced every 2-4 years, with a simple replacement of these particular filters a new equipment is guaranteed. This is another important economic advantage in that maintenance-related costs are low, given that the only part of the plant that must be controlled is the membrane, whose replacement does not represent an excessive cost. The cost for the realization of the plant is estimated to be around € 50,000, it is estimated because it is closely linked to a plant that produces a discharge of 100 m^3/day. Another economic advantage is the fact that it would no depend on a specialized company to occupy of the waste water, as is done at this time.

After comparing the different types of filtration it was decided to propose the use of Nano Filtration processes at membranes to the detriment of Micro Filtration (always with membranes) since, in the industrial field, the membranes of the Nano Filtration find great use due to their versatility, ease of installation and maintenance as well as high purification yields. In fact, comparing the Nano Filtration with the Micro Filtration it was noticed that the membranes used in Nano Filtration are able to remove particles of 0.001- 0.1 μm, while the membranes used by the Micro Filtration have a pore size of 0.1-10 μm, this translates into that the Nano Filtration membranes guarantee a better filtration so as to avert possible occasions in which particular harmful bacteria can pass to the human health when the water is filtered.

5. Conclusion

The implementation of this type of plant turns out to be the best system that can be built inside a company and not only, due to its great flexibility. In fact, it can be applied for the reclamation of marshy areas. This plant is also used by some of our Italian countries such as the Island del Giglio, the Island of Elba and the city of Agrigento with the aim to dispose of a sweet and healthy water.

It can also be applied to particular industries such a plant as the chemical-pharmaceutical industry, in agriculture and its exploitation is not limited only to them but also to other companies that carry out different economic activities than to those mentioned.

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REUSE OF SECONDARY RAW MATERIALS (BREWER'S YEAST AND GRAINS) FOR ANIMAL FEEDING TO IMPROVE CIRCULAR ECONOMY*

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Abstract

The new studies concerning the field of waste treatment technologies tend to exploit refuse materials with the aim of minimizing the quantities of unusable waste. One of these innovative technologies concerns the recovery of by-products from the processing of Barley Malt and Hops, the main ingredients of beer. Brewer's grains and yeast can be used as a feeding for animal nutrition on farms located in the Sicilian region. The aim of the paper is to analyze and spread the exploitation of Sicilian brewer's grains and yeast production waste. The phases that compose the production cycle of brewers beer are: Grinding of the Barley; Mashing using hot water; Filtration through special membranes; Boiling; Whirpool; Cooling down; lastly, Fermentation. During the Whirlpool phase, a mixture called brewers of grains and yeast is obtained which can be used as a feeding for animal added into the diet: as previously mentioned, in the form of livestock feed thanks to its 26% of protein content.

Keywords: animal nutrition, circular economy, industrial symbiosis, raw materials

1. Introduction

Today's society is increasingly observant to the issue of ecology, in particular to everything concerning the life of waste. In this period, in fact, awareness towards the territory is increasingly strong through good practices of environmental protection

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implemented by the population. In this regard, numerous studies have been carried out on the search for new methods for the reuse of waste materials coming from the production cycles of the different product sections (Olajire, 2012). It is therefore important to analyze the "strategies" of eco-sustainable cooperation adopted by small and large pro-active companies which, with a "Green" perspective, aim to minimize the pollution of the Sicilian region. Consistent is now the number of companies that deal with of Craft Beer production, from which it is possible to recover an important quantity of by-products as a feed for animal. Barley malt is the principal raw material in the brewing of malt beverages such as beer, ale, stout and por ter. In the processing of barley malt to produce such beverages, the malt is mashed with others cereals and hot water. This results is an extract which is then separated from coagulated and insoluble grain residue. The insoluble grain residue gathered is referred to as "spent grains' or brewer's grains which have a commercial value and can be used for animal nutrition. The nutritional value of spent grain represent an important sources of protein, with a higher digestibility of fiber. The amount of spent grains is normally 14 kg/hL wort with a water content of 80% (Fillaudeau et al., 2006).

It is also possible to recover a part of the brewer yeast used during processing: in brewing, surplus yeast is recovered by natural sedimentation at the end of the second fermentation and maturation. Only part of the yeast can be reused as new production yeast. Surplus yeast is very high in protein (50%) and B vitamins, and may be given to animal feed industry as a feeding supplement. These brewing by-products haves dry matter content close to 10% w/w and generates beer losses (or waste) of between 1.5 and 3% of the total volume of produced beer (Fillaudeau et al., 2006).This type of cooperation is an important example of industrial symbiosis aimed at safeguarding the local territory: in this case, in fact, the company collaborates with a cattle farmer who, on time, is on the farm to pick up the brewers waste material for animal feeding after the chemical and microbiological characterization (Lombardi and Laybourn, 2012). As far as the industrial symbiosis and its territorial implementation are concerned, the ENEA, Italian public research center, which deals with research in the sectors of industry, the environment and new technologies in support of competitiveness policies, has had a great importance for sustainable development (Cutaia et al., 2016; Mirata and Emtairah, 2005). In 2015 ENEA established the first Italian Industrial Symbiosis Network (SUN: Symbiosis Users Network; www.sunetwork.it). This network aims at being the Italian reference point in the field of Industrial Symbiosis through the support of scientific/research bodies as well as the participation of operative stakeholders (companies and institutions) and the cooperation with the General States of the Green Economy. Local stakeholders' involvement is carried out through contacts with Sicilian Region (Regional waste Agency), meetings and specific framework agreement signed between ENEA and Confindustria Sicilia (Sicilian association of Industrials) and ENEA and University of Catania (dos Santos Mathias et al., 2014).

The framework agreement signed with Confindustria Sicilia aimed at involving local productive sectors, enterprises and institutional partners, whereas the framework agreement signed with University of Catania aimed at collaborating in research activities in the field of eco innovation strategies, with the perspective of mutual exchange of research experience and buildings and equipment provision (Tseng and Bui, 2017; Tseng et al., 2018). In this paper we want to identify and analyze the types of instrumental symbiosis that exist between the various companies of the Sicilian region through good practices based on environmental protection, on minimizing the environmental impact and on reusing waste materials reinserted in a further cycle productive. In animal nutrition probiotic are used to increase the performance and the healthy status for livestock animal (Chiofalo et al., 1992). Saccharomyces cerevisiae derived from residue of beer determine positive effects on animal performances (Stockland, 1993). Brewer's yeast are able to increase the efficiency of digestion of fiber in monogastric animal. Fantuz et al. (1995) showed positive effects on cow

milk production and quality (Arambel and Kent, 1990). The aim of this study in collaboration with the University of Messina is to study the effects of the addition into the diet, dosages, healthy status and the performances of the use of brewers grains and yeast for animal production and to control the quality of animal products, to reducing the environmental impact and at the same time to reduce the costs of feeding.

2. Material and methods

To achieve this goal, a case study has been proposed in Etna Brewery, where for years the reuse of waste materials is promoted as a feed for the livestock sector. The approach we will follow is the one that aims at developing a circular economy (EC), where the life cycle of the second raw material is extended through a different use thanks to which the waste is recovered (Cutaia et al., 2015). From previous studies, the LCA (Life Cycle Analysis) has proved to be an essential tool for quantifying the environmental performance produced by Industrial Symbiosis, thoroughly studying all the elements of environmental performance, despite the absence of agreed rules, methods and indicators, therefore, consequent evaluation limits of environmental sustainability, the SI appears as the conceptual model, and almost cultural, to be followed since the fields of application are quantitatively and qualitatively wide. The concept of waste has evolved over time, the current conception is that which prefers the recovery of waste, no longer seen as something unusable, but as an opportunity to obtain other forms of energy and sustenance, the push towards (Ellen MacArthur Foundation, 2014).

The application of the closed cycle as an alternative to the classic linear model of production systems has arrived at an international level with the spread of the broader concept of resource efficiency through the International Resource Panel and in the various G7 / G8 / G20. If the linear economy, by continually repeating the "extraction - production - consumption - disposal" scheme, is characterized as a system in which the life cycle of a product ends when it is consumed, becoming a waste (cradle to serious), in the circular economy, on the other hand, activities, starting with extraction and production, are organized in such a way that someone's waste becomes resources for someone else. The evolution mentioned above took place to meet those that are now the obvious necessities of our planet, the continuous exploitation of the present resources meant that we approached a point of no return. More and more in today's companies, the green approach is favored, using as a model to follow and a point of reference that culture present in other parts of the world for more than 30 years, just think of Kalundborg, a city in Denmark where it already applies from 70s an industrial symbiosis composed of increasingly interdependent parts, connected by exchange and reuse relationships of waste materials.

In industrial symbiosis (SI) the exchange variables are: waste and energy, we analyze in depth the first variable seeing how environmental problems are transformed into economic opportunities. The product sector referred to in the case study is that of craft beer production, a sector that has been growing for years in the Sicilian region, represented by many small and medium enterprises. The production involves many scraps judged in the past irretrievable that thanks to the innovative optics of the industrial symbiosis find application in a completely different sector, but that can potentially become first connection between all the companies of production of the craft beer and the sector of the animal production in which that which in the first sector was an unused waste becomes a means of support for high-protein livestock. This innovative approach in Sicily that aims to expand as a true "culture of re-use" is an example of the potential for work in the complete implementation of the SI model that must not be an end in itself, but projected towards a future in which all companies, working in different product sectors, strive to find what are the possible ways of extending the Life Cycle of the parts that make up their production cycle (Goedkoop, 2006).

Through the application of these methods it is possible to subsequently collect data and compare the benefits deriving from the single company related to the total system. The aforementioned data collection is one of the cornerstones of the SI, in 2015 ENEA opened the first Industrial Symbiosis Network (Symbiosis Users Network), which aims to be the main point of reference and connection between companies wishing to apply the SI.

3. Experimental

The case study that is exposed concerns the company BIRRIFICIO DELL'ETNA s.r.l., located in str.8, Carruba CT 95018, Italy, which deals with the artisanal production of beer, this process can also be called "brassa" and requires numerous processing steps. The first phase, as well as one of the most important, is the grinding during which the grains of barley malt and other cereals are ground to make their starch content available. This is followed by the water-malt mixing phase at different temperature and time steps, called mashing, during which the starch contained in malts is broken down into simple sugars. These require particular temperature and acidity conditions, in fact this operation consists in raising the temperature of the mixture to 52/78°C for a certain period of time. Subsequently the mixture is transferred inside the filter vat consisting of a double bottom, which allows the separation of the solid part (brewers grains) from the liquid part (must). This phase is technically referred to as filtration: through this step the Brewers Trebbia are placed in containers and after destined to farm for animal and used this by-product integrated into the diet of cattle, beef etc. (Fig. 1). Then it must be boiled for about an hour, during which time hops and any spices are added. This phase is of considerable importance, since it allows: sterilizing the must, concentrating the must by evaporation and favoring the coagulation and precipitation of proteins and polyphenols.

Fig. 1. Machinery for the production of beer and containers destined to farm for animal

Next step is the Whirpool or a mechanical procedure through which a circular motion is imparted to the must in order to collect hop residues and insoluble substances at the bottom of the vat (Fig. 2). The must is cooled and oxygenated, so as to create an optimal environment for the subsequent inoculation of the yeast in the fermenter. The must created from the raw materials is turned into beer by the yeast, this produces all the compounds related to the alcohol, the taste and the aroma that are found in the beer.

After about 30 days from primary fermentation, the bottling phase proceeds, adding a small amount of sugar and yeast to the product in order to restart the fermentation in the bottle. This phase lasts for 15 days, during which the bottles are kept at a controlled temperature. At this point the product is ready for consumption.

Fig. 2. Machinery for the production of beer with a circular motion

As it can be seen from the description of the production process, the company, in addition to normally performing its own processing cycle, also has a special focus on environmental issues and therefore towards an increasingly open concept in terms of the green economy. In fact, during the filtration phase, beer waste does not become waste, but a second raw material defined brewers grains and yeast are destined for animal production, therefore it becomes feed for animal able to generate food as a meat, milk etc.

4. Results and discussion

The addition of brewer's yeast and grain into the diet of fattening pig not influenced negatively the healthy status and the performances of animals and no problem resulted as regard the digestion and sanitary problems. In particular the addition of brewer's yeast increased the digestibility of the diet with an improvement of fermentation activity into the gut of pig regarding protein ad fiber. No negative effect were showed by using brewer's yeast as regards the intake of the diet.

Brewer's yeast (8.81% DM) added into the diet increased ($P<0.05$) body weight of pig in comparison with control group of pig (119,58 kg vs 111.52 kg), in particular body weight gain of pig fed with brewer's yeast increased ($P<0.05$). The index conversion rate of fed improved ($P<0.05$) by using brewer's yeast. We planned the analysis of sustainability of C&DW waste management scenarios, identifying the purpose of the study, and the issues to be solved, meaning the direction of the study and the benchmarks (PE International, 2011).

5. Conclusions

The use of brewer's yeast as a residue of beer industry represent a good solution when added into the diet of pig. Brewer's yeast improved the body weight gain of pig, the final body weight and the index conversion rate. No negative effects were showed as regards the

quality of carcass of pig. The use of secondary raw materials as a brewer's yeast can be an important way to reducing environmental impact ad at the same time to reduce the costs of animal diets.

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RISK ASSESSMENT OF A METHANE OXIDIZING BIOFILTER FOR REDUCING LANDFILL GAS EMISSIONS FROM A POST-CLOSURE LANDFILL*

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Abstract

This study focuses on the assessment of volatile organic compounds (VOCs) and odor compounds emissions from a post-closure landfill. A human health risk assessment and an air quality evaluation were performed to compare two different landfill gas management scenarios and to assess whether a methane oxidizing biofilter mitigates the risk from inhalation exposure to VOCs and odor emissions. Three specific monitoring campaigns were performed: one sample of raw biogas at the biofilter inlet and three air samples from the biofilter surface were collected and analyzed to determine the concentration levels of VOCs, H_2S and odor compounds accordingly to US EPA, 1995 and US EPA TO-15, 1999, NIOSH 6013:1994, and dynamic olfactometry (EN 13725:2003), respectively. Concerning the raw biogas, five odor compounds were selected from the mixture and then the odor activity value (OAV) was evaluated. CALPUFF dispersion model was used to evaluate the VOCs concentration in air at eleven sensitive receptors. In the risk assessment, cyclohexane, n-hexane, 2-methylpentane, 3-methylpentane, benzene, xylenes, toluene, dichlorodifluoromethane, vinyl chloride were selected to evaluate the hazard index (HI) for non-carcinogenic compounds and the cancer risk (R) for carcinogenic compounds (benzene). The results showed that for both LFG management scenarios HI and R resulted negligible ($HI \leq 1$ and $R < 10^{-6}$) and the odor concentration resulted always below 1 UO m^{-3} at each sensitive receptor. Furthermore, emerged that the biofilter reduce HI and R on average by 93% and 17%.

Keywords: risk assessment, methane oxidation, VOCs, odor compounds

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1. Introduction

In 2015, the Circular Economy Action Plan was adopted by the European Commission. One of the key goals was to reduce landfilling of municipal solid waste (MSW) to the maximum of 10% by 2035 as indicated in Directive 2018/850 of the European Parliament (EC Directive, 2018) and Council amending the Landfill Directive 1999/31/CE (EC Directive, 2010). One of the main issues related to landfilling is disposal of biodegradable waste. In fact, the organic fraction of MSW (OFMSW) under anerobic conditions produces leachate and landfill gas (LFG), posing negative impacts on the environment. In particular, methane (CH_4) and carbon dioxide (CO_2), that are the main components of LFG, are greenhouse gases. Specifically, CH_4 has a Global Warming Potential (GWP) 28 times higher than CO_2. Furthermore, the biological degradation of OFMWS produces many types of VOCs: aliphatic compounds, that are typical of LFG from old sections of a landfill (Parker et al., 2002); aromatic compounds, that are generally released from the volatilization of plastics, foam and boxes (Cheng et al., 2019); oxygenated compounds, that are originated from the degradation of proteins and organic matter (Wu et al., 2018); sulfur compounds and terpenes. Among these compounds, there are both toxics and malodorous pollutants and concern of inhabitant living near a landfill site is arising (Belgiorno et al., 2012).

The composition of LFG varies in time due to the degradation stage of OFMSW within the landfill body. In particular, during the stable methanogenic stage internal combustion engine (ICE) are used to recover energy and produced electric power, but a recent study, even if applied on anaerobic digestion process, indicates that micro-turbine can replace ICE and improve the energy recovery efficiency of 10-20% (Baccioli et al., 2018). However, the quality and quantity of LFG is reduced when pre-treated MSW is landfilled (Pecorini et al., 2012), and when the landfill is at the post-closure stage. Consequently, the current techniques, that are imposed by CE, 1999 to avoid untreated emissions of LFG, became technically inefficient because of the low calorific value of LFG. For this reason, to treat low calorific value LFG both physicaL/chemical and biological processes are studied. With the reference to the former, open flares and non-catalytic thermal oxidation were identified as possible alternatives to traditional flares (EPA, 2011) but also some pilot tests were developed to increase CH_4 content by removing CO_2 from the LFG stream using bottom ash (Lombardi et al., 2016). On the other hand, many studies rely on CH_4 oxidation process to biologically convert CH_4 to CO_2 in proper designed biofilter (Cassini et al., 2017; Scheutz et al., 2009; Schulte et al., 2017). Few studies investigated the efficiency of CH_4 oxidation in full-scale biofilter both actively or passively loaded (Cassini et al., 2017; Rossi et al., 2018). However, CH_4 oxidation efficiency increased up to 100% in passively loaded biofilter (Rossi et al., 2018) and furthermore, VOCs and odor compounds emissions were reduced up to 100% for H_2S in both active and passive biofiltration systems (Pecorini et al., 2017). For these reasons, biological methane oxidation, both in actively and passively loaded biofiltration systems, represents an emergent and environmentally sustainable technique (Bacchi et al., 2018) to reduce CH_4, VOC and odor emissions.

The main objective of this study is to perform a site-specific risk assessment and an air quality evaluation in the area of Podere il Pero landfill. In particular, we want to evaluate the reduction on risk exposure to inhaled contaminants, in the surroundings of the landfill site, due to the installation of an active biofilter for the treatment of low calorific value LFG.

Focusing on the human health risk assessment, the landfill and the biofilter surface were identified as primary pollutants emission sources. Despite, emissions from the flare was not taken into account because of the impossibility to characterize this emission source. VOCs and odor compounds were the pollutants assessed and two different LFG management scenarios were considered:

- *Reference Scenario*: the LFG is collected by the active extraction systems and is combusted in the flare; the landfill surface is the only pollutants emissions source.
- *Biofilter Scenario*: the fraction of LFG with low calorific value is treated in a methane oxidizing biofilter; the landfill and the biofilter surface were considered as pollutants emissions sources.

This work is divided in four main parts:

- the first part deals with the site characterization and the main pollutants emissions sources are identified following the health risk assessment approach;
- the second part focuses on the characterization of pollutants emissions sources. In particular, describes the collection and the analysis of LFG samples, the evaluation of VOCs and odor compounds emission rate, and the dispersion model that was used to predict the concentration of the pollutants at each receptor;
- the third part focuses on the assessment of the risk and air quality;
- the fourth part presents results and conclusions.

2. Materials and methods

2.1 Site characterization

The case study of this work is Podere il Pero landfill, a post-closure landfill located in the province of Arezzo (Italy). Mainly municipal solid waste (MSW) were disposed at the landfill and the plant reached a final disposal volume of 674000 m^3. As imposed by the EC, 1999, the LFG produced inside the body of the landfill is first collected by means of an active extraction system and then burnt in a flare. Nevertheless, mainly because of the low organic content within the waste disposed at the plant, the calorific value of LFG decreased with a consequent improper and inefficient functioning of the flare. As a result, to avoid untreated emissions of LFG in the atmosphere, a biofilter for the biological methane oxidation, was built in the frame of LIFE RE Mida Project.

The LFG is collected from the oldest cells of the landfill. A blower conveys the low calorific value LFG to the biofilter while the high-calorific value LFG is burnt in the flare. During the monitoring period, the biofilter was actively loaded with 251 $gCH_4\ m^{-2}d^{-1}$ on average. Briefly, the biofilter is made of concrete wall with a length of 18 m and a width of 15 m. A series of 9 slotted pipes distribute the LFG in a gravel bottom layer of 0.4 m. Then, in the upper layer CH_4 is biologically converted in CO_2. In fact, this layer is made of compost and sand, in a volume ratio of 5:1, which is a suitable material for the development of methanotrophic bacteria (Huber-Humer and Lechner 2009). Furthermore, an irrigation system was installed and was set to achieve an optimal moisture content of 30% for the filter media.

2.2. Emission sources characterization

To characterize the two emission sources in terms of VOCs and odor compounds emission rates were performed three monitoring campaigns in March 2017, August 2017 and March 2018. The biofilter was not classified neither passive nor active source. In fact, is a passive source in accordance to D.G.R. 15 febbraio 2012 - n. IX/3018 (D.G.R., 2012) because of the outward volumetric flow that is less than 50 $m^3/m^2/h$, but, the biofilter surface, equally to a landfill surface, is crossed by a low flow and forcing convention (wind) is not the only driving force of surface emissions. For this reason, accordingly to Lucernoni et al., (2017) and US EPA (1995), the samples were collected using the dynamic flux chamber method. The chamber, was made of PTFE with an inner diameter of 50 cm, and the sweep air flow (nitrogen -N_2-), was set at 4.5 L/min. The sampling device was located in

correspondence of the three maximum outward flow and then was sealed with sand to avoid the entrance of atmospheric air. Then, the samples were analyzed accordingly to USEPA TO-15, (US EPA, 1999), NIOSH 6013:1994, and EN 13725 (2003) to determine VOCs, hydrogen sulphide (H_2S) and odour concentration. Finally, VOC and H_2S emission rates were evaluated in accordance to Liu et al. (2015), while the Specific Odour Emission Rate (SOER) was calculated as suggested by Lucernoni et al. (2017).

The landfill, as previously stated and equally to the biofilter, was not classified neither passive nor active source. However, in this case, it was not possible to perform direct measurements on the landfill surface and emission rates were evaluated indirectly. Specifying, during each monitoring campaign, a raw LFG sample was collected from the biofilter main pipe in a PVC bag and then was analyzed. Concerning the VOCs, the emissions rates were evaluated by multiplying the VOCs concentration to the average biogas surface emission flux. The latter was evaluated using the static flux chamber method that is performed twice a year (spring and winter), to assess the diffusive emissions from the landfill. Concerning the odor emissions, because of the high concentration levels of toxic compounds within the mixture, the odor concentration was assessed indirectly. In particular, the chemical composition of the mixture was related to the odor proprieties evaluating the so-called odor activity value (OAV). The OAV within the literature is defined as the sum of the concentration of each malodorous compound weighted with its odor threshold (OT) (Capelli et al., 2013) and is considered as a theoretical odor concentration of a mixture (Wu et al., 2016). Ethylmercaptan, dimethyl sulphur, ethanol, limonene and H_2S and their OT reported in D.G.R., 2012 were selected to calculate the OAV.

2.3. Dispersion modeling

The maximum concentration levels of VOCs, H_2S and odor were considered to evaluate emission rates to use as input data for CALPUFF dispersion model. CALPUFF is a non-stationary, puff dispersion model that can be applied in complex terrain settings. In addition to emission data, meteorological and topographical data were used as input data to the dispersion model. The former (wind speed, wind direction, ambient temperature, atmospheric pressure and rainfalls) were acquired by a meteorological station located at the plant for the calendar year 2015 that had the most complete meteorological data set in the period 2013-2017. CALMET meteorological model was used to develop the wind field in a spatial domain of 10x10 km^2 with a horizontal resolution of 200 m, and a vertical resolution of eight elevation levels (0-20-50-100-200-500-1000-2000-4000 m). To take into account the orography in the spatial domain were considered the spatial area and the elevation of each emission sources (biofilter 270 m^2, landfill 54153 m^2) and the elevation of each receptor in the simulation grid.

The simulation domain was set to 6x6 km^2, and eleven sensitive receptors were identified in a radius of 3 km from the centre of the landfill. CALPOST processor was used to evaluate the average hourly concentration at each receptor and CALRANK was used to evaluate the 98° percentile of the average hourly concentration. Finally, the odor simulation maps were developed considering a peak to mean ratio of 2.3 to evaluate the maximum odour concentration and to take into account the peak oscillation around the mean (Capelli et al., 2013; Capelli and Sironi, 2018; D.G.R, 2012).

2.4. Health risk assessment and odor impact evaluation

The health risk assessment was performed following the methodology Risk Assessment Guidance for Superfund recommended by USEPA (US EPA, 2009). In

particular, based on the properties of VOCs and on a previous study (Liu et al., 2016), inhalation was the only exposure route assessed in this study.

At first, following the *Inhalation Dosimetry Method*, exposure concentrations (EC) were estimated as follows:

$$EC = \frac{CA \cdot ET \cdot EF \cdot ED}{AT} \quad (1)$$

where *CA* is the concentration of the pollutant in air (mg m^{-3}), ET is the exposure time (hours/day), EF is the exposure frequency (days/year), ED is the exposure duration (years), AT is averaging time (hours). Concerning non-carcinogenic compounds, the risk is evaluated considering a chronic exposure scenario for each substance trough the hazard quotient (HQ), that is calculated by dividing EC to the inhalation toxicity value – *RfC* - (mg m^{-3}). By summing the HQ previously evaluated for each single substance we estimated the hazard index (HI) at each receptor (Table 1). Concerning carcinogenic compounds, the risk is assessed by multiplying EC to the Inhalation Unit Risk (IUR).

Table 1. Parameters for EC calculation (USEPA, 2009)

Parameter	***Value***	***Unit***
ET	24	hours/day
EF	350	days/year
ED	24	years
AT	52560* or 613200°	hours

*non-carcinogenic compounds, °carcinogenic compounds

With regard to the odour emissions, the odour concentration of 1, 3 e 5 OU_E m^{-3} accounting respectively for the 50%, 85% and 90-95% of the population that detects the odour were considered to evaluate odor impact (D.G.R, 2012).

3. Results and discussion

3.1. Raw biogas and emissions characterization

In the raw biogas, among the 117 VOCs under investigation, 51 compounds were detected at least once in the samples. Six types of VOCs were detected: aliphatic, aromatic, oxygenated (alcohols, ketones, ethers), sulfur, halogenated and terpenes compounds. Specifically, aromatic compounds were the most abundant VOCs detected in the samples. Among them, xylenes were detected with the highest average concentration of 579 ± 484 µg m^{-3}, while 4-ethyltoluene was detected with the lowest average concentration of 23 ± 29 µg m^{-3}. All the VOCS showed a large concentration range and high standard deviation. Aliphatic compounds were the second abundant compounds and the highest concentration detected. However, with the reference to previous study of Rossi et al. (2018), the concentration range was typical of low calorific value LFG. In addition, the concentration of propylene (1743 ± 1202 µg m^{-3}) and n-butane (1673 ± 1136 µg m^{-3}) were the highest, followed by cyclohexane (677 ± 81 µg m^{-3}) and n-pentane (400 ± 281 µg m^{-3}). Concerning the other VOCs, the concentration of oxygenated compounds fluctuated from 154 ± 242 µg m^{-3} of acetone to 17 ± 23 µg m^{-3} of methyl-ter butyl ether, while the concentration of halogenated compounds fluctuated from 643 ± 500 µg m^{-3} of vinyl chloride to 25 ± 21 µg m^{-3} of trans-1,2-dichloroethylene. With reference to odor compounds, terpenes were detected with the highest concentration: α-pinene had the highest concentration of 3182 ± 4551 µg m^{-3} and was followed by limonene with 1217 ± 1704 µg m^{-3}. In spite, sulfur compounds had

lower concentration lavels than terpenes: the highest concentration was 138 isopropyl mercaptan 138 ± 79 μg m^{-3}. Finally, the concentration of H_2S resulted 3180 ± 1748 μg m^{-3}.

Equally, air samples collected from the biofilter surface were characterized. Among the 6 classes of VOCs identified in the raw LFG, 36 VOCs were detected at least once in the samples. Specifically, aliphatic and aromatic compounds were the prominent compounds. With reference to the former, concentration of propylene was the highest (55 ± 29 μg m^{-3}), while concentration of isooctane was the lowest (4 ± 2 μg m^{-3}). Concerning the latter, xylenes had the highest concentration level (15 ± 7 μg m^{-3}) and benzene had the lowest concentration level (4.3 ± 0.8 μg m^{-3}). On the other hand, the concentration of oxygenated compound fluctuated from 36 ± 57 μg m^{-3} of acetone to 2.7 ± 1.3 μg m^{-3} of methylethylketone, while the concentration of halogenated compounds fluctuated from 6.6 ± 4.2 μg m^{-3} of dichlorodifluoromethane to 2.6± 2 μg m^{-3} of chloromethane. With reference to sulfur and sulfide compounds, only dimethyl sulfide had a concentration level over its detection limit, while H_2S was never detected within the air samples. Finally, the concentration of terpenes oscillated from the highest value of 33 ± 53 μg m^{-3}, detected for limonene, to the minimum value of 2.9 ± 1.7 μg m^{-3} detected for α-pinene. The VOCs concentration in the air samples showed similar values of those indicated by Rossi et al. (2018) and the abatement efficiency of the active biofilter is comparable to those indicated for the passive biowindows.

3.2. Health Risk Assessment

Within these pollutants, considering their toxicological proprieties and their concentrations, cyclohexane, n-hexane, 2-methylpentane, 3-methylpentane, benzene, xylenes, toluene, dichlorodifluoromethane and vinyl chloride were selected to estimate the health risk. Among them, benzene was the only carcinogenic compound. In order to perform the health risk assessment, at first, for each compound and for both LFG management scenarios (*Reference scenario* and *Biofilter scenario)*, emission rates were evaluated. Then, by means of CALPUFF dispersion model, CA, the hourly concentration on annual base, were evaluated at each receptor. Based on properties of VOCs and on previous study (Liu et al., 2016), inhalation was the only exposure pathway assessed and the risk was evaluated considering *RfC* and IUR data reported for each compound on the Integrated Risk Information System database -IRIS- (US EPA, 2013) (Table 2).

Table 2. RfC and IUR values for non-carcinogenic and carcinogenic compounds (IRIS)

Parameter	***RfC (mg m^{-3})***	***IUR (mg m^{-3})$^{-1}$***
Ciclohexane	6.00E+00	-
n-hexane	7.00E-01	-
2-methylpentane**	1.84E+01	-
3-methylpentane**	1.84E+01	-
Xylenes	1.00E-01	-
Toluene	5.00E+00	-
Vinyl Chloride	1.00E-01	-
H_2S	2.00E-03	-
Benzene	3.00E-02	7.80E-06

**US EPA, 1999

Table 3 and Table 4 report the risk assessment results in terms of HI and R (non-carcinogenic and carcinogenic compounds respectively) for both LFG management Scenario. With reference to Table 3, HI resulted less than the acceptable value of 1 and the risk was negligible at each receptor. However, in the *Reference Scenario*, HI fluctuated from 1.00E-

02 to 3.84E-04; while in the *Biofilter Scenario*, HI fluctuated from 7.09E-04 to 2.72E-05 and was one order of magnitude less than in the *Reference Scenario*. In particular, the percentage change showed that HI is reduced by 93% on average in *Biofilter Scenario*. In both scenarios, in accordance to dispersion model results, receptor R5 that is located in an up-wind zone and it is the nearest receptor to the landfill site, showed the highest HI values.

With reference to Table 4, R resulted less than the acceptable value of 10^{-6} and the risk was negligible at each receptor. However, in the *Reference Scenario*, R fluctuated from 1.08E-11 to 1.19E-12; while in the *Biofilter Scenario*, R fluctuated from 3.02E-12 to 3.33E-13 and was one order of magnitude less than in the *Reference Scenario*. In particular, the percentage change showed that R is reduced by 17% on average in *Biofilter Scenario*. In accordance to what previously stated, receptor R4 and R5, showed the highest R values.

Table 3. HI – Reference and Biofilter Scenario (US EPA, 2009)

Receptor	***HI - Reference Scenario***	***HI - Biofilter Scenario***
R1	1.78E-03	1.25E-04
R2	2.43E-03	1.72E-04
R3	4.24E-03	3.01E-04
R4	6.33E-03	4.47E-04
R5	1.00E-02	7.09E-04
R6	1.64E-03	1.16E-04
R7	2.48E-03	1.75E-04
R8	1.43E-03	1.01E-04
R9	1.19E-03	8.45E-05
R10	7.04E-04	4.98E-05
R11	3.84E-04	2.72E-05

Table 4. R - Reference and Biofilter Scenario (US EPA, 2009)

Receptor	***R - Reference Scenario***	***R - Biofilter Scenario***
R1	8.48E-12	2.38E-12
R2	7.63E-12	2.38E-12
R3	1.18E-11	2.14E-12
R4	1.08E-11	3.31E-12
R5	2.04E-11	3.02E-12
R6	7.73E-12	5.74E-12
R7	8.02E-12	2.17E-12
R8	2.47E-12	6.94E-13
R9	2.87E-12	8.06E-13
R10	2.46E-12	6.92E-13
R11	1.19E-12	3.33E-13

Finally, because HI and R are proportional to EC that is a function of CA, we observed that the risk decreased when EC and CA decreased. In other words, the biofilter, reduce emissions of VOCs and consequently CA and EC decreased at each receptor. For this reason, the biofilter mitigate the risk from inhalation exposure to VOCs and is particularly suitable to treat toxic compounds such as aliphatic, some halogenated and some aromatics compounds as xylenes and toluene (Percentage change, 93%). Nonetheless, the risk from inhalation exposure to carcinogenic compounds, as benzene, is lower (Percentage change -17%).

3.3. Air quality assessment

Concerning odor characterization of raw biogas, Table 5 reported OAV values evaluated for each monitoring campaign. Ethylmercaptan, dimethyl sulfur, ethanol, limonene and H_2S were selected to evaluate OAV because of their nuisance effect and because of the OT values that were evaluated by dynamic olfactometry and that were reported in D.G.R., 2012. In particular, not all the odor compouds in Table 5 were always detected in the samples and in those cases, we replaced the missing values with the detection limit. During the three monitoring campaigns, the OAV fluctuated from 6632 UO m^{-3} to 2216 UO m^{-3}. H_2S resulted with the highest value of specific odor activity (SOAV) that was up to two orders of magnitude higher than the OAV of the other compounds. In general, H_2S alone could explain the pattern distribution of LFG (Kim et al., 2005), but we decided to consider all the compounds for completeness.

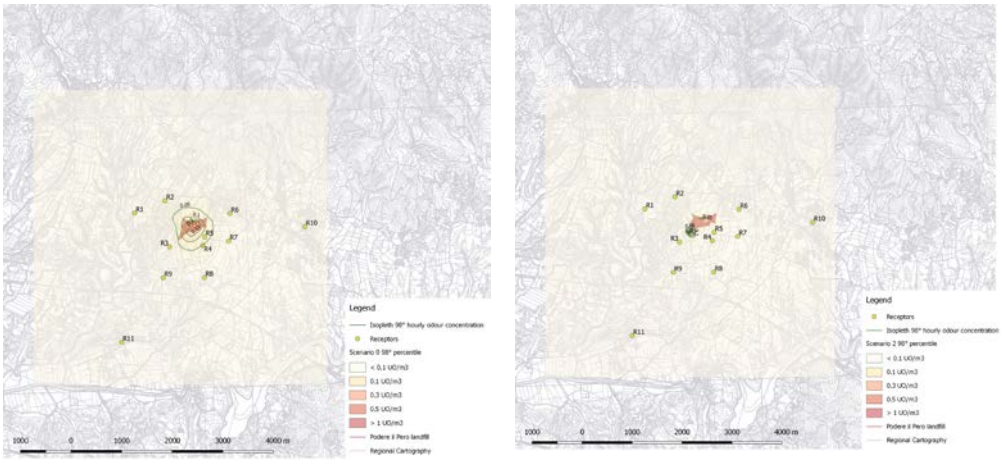
Table 5. Specific odor activity value and odor activity value of the gas mixture

Compound	***March 2017***	***August 2017***	***March 2018***	***Unit***
Ethylmercaptan	193	11	10	OU m^{-3}
Dimetyl sulfide	10	5	7	OU m^{-3}
etanolo	4	0	1	OU m^{-3}
Limonene	1	9	62	OU m^{-3}
H_2S	3773	2191	6553	OU m^{-3}
OAV	3981	2216	6632	OU m^{-3}

Concerning odor characterization of biofilter surface emissions, odor concentration of the samples were estimated by dynamic olfactometry. The results showed an average odor concentration of 118 ± 42 UO m^{-3}, 138 ± 97 UO m^{-3} and 238± 45 UO m^{-3} in the monitoring campaigns of March 2017, August 2017 and March 2018 respectively. The odor concentrations were always detected under 300 UO m^{-3} that is the limit value indicated in the Industrial Emissions Directive 2010/75/EU (EC, 2010) at the outlet of biofilter used in composting plants, for the treatment of exhausted air.

Then, the CALPUFF dispersion model was applied to assess the air quality in the surrounding of Podere il Pero. In particular, as input data in the *Reference Scenario* the SOER of LFG emissions from the landfill surface was evaluated as 4.44E-03 UO $m^{-2}s^{-1}$, while in the *Biofilter Scenario* LFG emissions from the landfill surface was evaluated as 1.24E-03 UO $m^{-2}s^{-1}$ and LFG emission from the biofilter surface was evaluated as 6.14E-02 UO $m^{-2}s^{-1}$. The reduction of SOER from the landfill surface in the *Biofilter Scenario* is due to the fact that diffusive emissions decreased from 2.67 Nl m^{-2} h^{-1} (evaluated before the installation of active biofilter) to 0.65 Nl m^{-2} h^{-1} (evaluated after the installation of active biofilter), because of the application of the biofilter to treat the fraction of LFG with low calorific value. However, the values of SOER are between 10^{-3} e 10^{-2} UO $m^{-2}s^{-1}$ that is in the range that quantified odor emission from post-closure landfill site (Lucernoni et al., 2017).

Fig. 1 shows the comparison of odor concentration maps in the Reference Scenario and in the Biofilter Scenario. The maps show the isopleths (0.05 UO m^{-3}) of the peak hourly odour concentration at 98° percentile for both scenarios. From the results, we observed that the odor nuisance is negligible at each receptor. In fact, the odor concentration is always below 1 UO m^{-3} that is the limit value over which the 50% of population perceived the odor nuisance. However, we noticed that in Biofilter Scenario the odor isopleths are contained in the boundary of the landfill.



a) b)

Fig. 1. Comparison of odor concentration maps in a) *Reference Scenario* and in b) *Biofilter Scenario*

6. Concluding remarks

The human health risk assessment and the air quality assessment were performed to evaluate whether an active methane oxidizing biofilter mitigate the risk from inhalation exposure to VOCs and odor compounds from a post-closure landfill site. For this reason, two LFG management scenarios were considered. One was the *Reference Scenario* and considered the LFG management strategy currently imposed by the regulation in which LFG is collected and burnt in a flare; the other was the *Biofilter Scenario* that considered the application of a methane oxidizing biofilter to treat the fraction of LFG with low calorific value.

The results of the assessment were then compared using the percentage change and showed that the biofilter mitigates the risk from inhalation exposure to VOCs on average by 93% and 17% for non-carcinogenic and carcinogenic compounds, respectively. Furthermore, also the odor impact is mitigated, and the odor concentrations levels resulted always under 1 UO m^{-3}.

However, this is a preliminary study and the work could be improved specifically in regard to the odor impact assessment and concerning the evaluation of the mitigation of odor emissions. In particular, the OAV of the air samples collected from the biofilter surface should be evaluated, because of the impossibility to assess the SOER relying only on direct odor measurements that were performed by dynamic olfactometry as also indicated in previous studies.

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RECYCLING OF TEXTILE FIBERS FOR THE PRODUCTION OF FIBRE-REINFORCED CEMENT*

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Abstract

This research analyzes the possible recovery of waste textile fibers as reinforcements for components made of cement. The study showed how the use of waste textile fibers for the reinforcement of components produced with cement paste represents an advantageous and feasible possibility for building applications. In detail, we used waste fibers produced during the finishing of fabrics, sampled at a textile company in Carpi. The fibers were characterized whit IR techniques, optical and electronic microscopic analysis, and subjected to pre-processing to increase their workability. With these fibers, joists were prepared in both cement paste and mortar. After maturation, the samples were characterized by bending test, optical microscopy analysis and withdrawal characterization. The results showed that the fibers used as reinforcement led to an increase in the mechanical properties of the samples with an increase in their percentage. In addition to the increase in bending load, a marked increase in toughness was observed, which is significantly higher in samples with fibers than in the reference white. The workability loss observed is relatively limited and in any case can be compensated with the addition of fluidizers. Ultimately, the possible use of waste textile fibers for the production of fiber-reinforced cement or mortar was demonstrated.

Keywords: recycling, textile fibers, cements, fiber-based

1. Introduction

Every year tons of waste produced by the fashion system are disposed of in landfills, although there are several studies that have highlighted the possibility of recycling and reuse, which would allow reducing the quantities of material disposed in the landfill. The ISPRA data (Special Waste Reports, 2017) identify that 37.4% of non-hazardous waste produced by

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the Italian manufacturing sector comes from the textile, clothing and industrial tanning sector. In fact, the economic model that has spread in recent decades is of the "linear" type, focusing on mass production and continuous growth in the market, without taking into account the quantities of waste produced.

Textile waste can be divided into two types: from clothing (clothes at the end of life) and from processed textile fibers (products from the textile industry). As for the waste from processed textile fibers, these are composed of fabrics, scrap pieces, waste yarn, waste fibers from processing, such as shearing, teaseling, finisching, and sampling. For the year 2015 the waste from textile industry in Italy is about 342 thousand tons (Special Waste Reports, 2017).

In our research we used fiber processing waste, in particular we used the waste produced by the finishing of fabrics. Recycled textile fibers, used for experimental research, are produced in the factory of the textile finishing company Stellatex (Carpi, Italy). In particular, raising and shearing machines present in the Stellatex factory are responsible for the production of waste fibers. The raising machine is used to form a fluff on the treated fabric, this treatment is done to increase heat insulation and to improve aesthetics. The shearing is used to cut the fluff from the fabric at a defined and adjustable height. During the shearing process suspensions of fibrous material in the air is generated. This fibrous material is aspirated with a special suction tube system, this conduit continues to the outside of the building where the suction pump and filtering air systems are located.

The recovered waste material is formed by microfibers of various types and sizes depending on the type of fabric being worked. A company like Stellatex produces 35 tons / year of this waste, depending on the quantity of fabrics processed during the year. It is estimated that in Italy the quantities produced by the entire finishing sector can be at least 5.000 tons / year.

The main purpose of this study is to analyze the possible recycling of waste microfibers produced in the finishing of fabrics in the production of fiber-reinforced cement components. In particular, the influence of microfibers on the mechanical properties, on the workability of the cement pastes produced and on the thermal properties of the manufactured articles were analyzed. The use of fibers for the production of cementitious matrix composites (fiber-reinforced cements, FRC) is consolidated over time (Aziz and Ansell, 2004; Shah and Rangan, 1971). The use of fibers improves the ductility of the cement conglomerate in the phase following the beginning of the cracking phenomenon, this take to a reduction of the brittle behavior of the cement matrix. The presence of fibers increases the toughness, prevents the propagation of the cracks, which are due to the onset of tensile stresses and at doses higher than 2% the fibers improve the bending load, tensile load, and shear strength (Andersons et all., 2006; Marchetti and Cutolo, 1991). Other strengths of fiber-reinforced cement mixtures are greater resistance to fatigue, greater impact resistance, greater resistance to thermal stress, and decrease of post-hardening linear shrinkage. This fiber behavior is linked to the "stitching" effect that the fibers develop in the cement matrix, increasing its resistance. The addition of fibers carry out to a reduction in the workability of the cement mix. The fibers normally used, are in steel, polypropylene, aramid, and glass, in recent years, research has been carried out on the use of natural fibers in particular hemp and cotton (Bledzki and Gassan, 1999; Sgriccia et al., 2008). The textile fibers have a structure similar to natural fibers, which suggested the possibility of using them for the production of FRC composites. With the use of textile fibers an improvement in the mechanical properties can be expected, in particular in the flexural modulus and in the breaking strength. However, given the structural difference between textile fibers and commercial fibers, we do not expect values similar to those of a FRC for structural use. Another interesting parameter is thermal conductivity, by inserting textile fibers that have low thermal conductivity in the cement, an overall reduction in conductivity of FRC is likely.

This work is divided in four main parts:

a) Sampling and characterization of recycled fibers, sampling was carried out by taking fiber fractions every week for a period of 6 months. This activity was necessary to obtain a representative sample of the microfibers produced in the Stellatex activity;

b) Preliminary treatment of the fibers;

c) Realization of the FRC samples using different percentages of fibers;

d) Physical-mechanical characterization of the samples produced and analysis of the data obtained.

2. Materials and methods

The fiber used is a mixture of microfibers obtained from the air purification plant of the Stellatex company. The material was characterized by IR analysis, and electron microscopy to obtain the fiber composition and their morphology. For IR analysis a FTIR Thermo-Nicolet Nexus has been used. In addition to these parameters, the fibers were analyzed to determine the water content and its water absorption. The importance of these parameters is due to the FRC sample preparation method. The preparation involves the dispersion of the powdered cement and of the fibers in water therefore, it is essential to know the behavior of the fibers in the presence of water. The absorption of water by the fibers would determine the variation of the water/cement ratio fundamental for the development of the final mechanical properties of the sample. The results obtained showed that the recycled fibers are dry, while immersed in water they absorb four times their weight. Using these data, research was carried out using both untreated and water-saturated fibers to verify the influence of the two conditions on the final properties of the samples. The saturated fibers are obtained by immersion in water at 25°C for 3 hours, filtered and left in the air at 25°C for 1 hour to remove the excess water.

In addition to the saturation treatment, part of the fibers was treated with NaOH in a 5% solution in water. This treatment was suggested by various studies, which show how the pretreatment of natural fibers with NaOH improves the adhesion properties between fiber and matrix and improve the mechanical properties of the fibers. In the treatment with NaOH the fibers are immersed in a 5% solution of NaOH for 30 minutes, then the fibers are washed in distilled water up to neutral pH. Finally, we proceed with drying the fibers in the oven at 80°C for 24 hours. The result of the treatment on the fibers is shown in the photo of Fig.1, where the increase in volume in the material after treatment is observed.

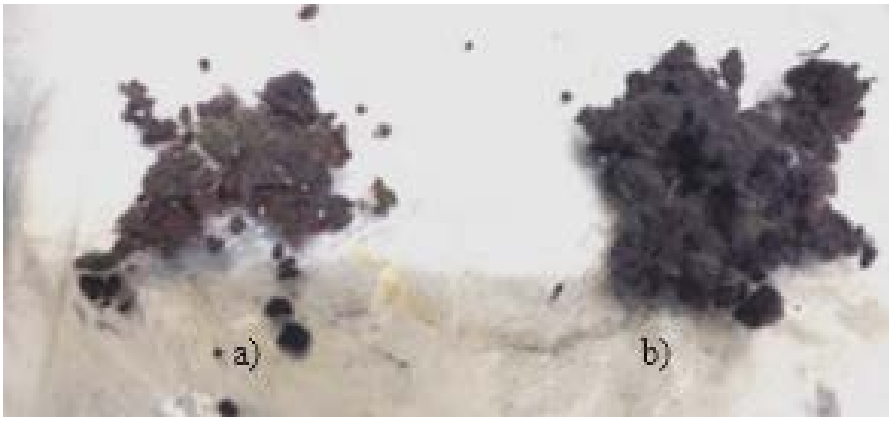

Fig. 1. Photograph of fibers a) untreated; b) treated with NaOH

For mechanical tests 5x3.5x30 cm joists were made by pouring in a wooden formwork, a Portland 42.5 R was used as cement. The joists were produced in cement paste using different percentages of fibers according to the compositions shown in table 1. The percentage of fibers is calculated as a percentage of the weight of the cement used and the fibers are considered dry. For each composition, five joists were made to obtain statistically comparable data. The samples produced were compared with reference beams produced with only cement and water with a 0.42 ratio. In the case of joists made with saturated fibers, the 0.42 water-cement ratio was obtained by decreasing the amount of water used. In practice it has been calculated the theoretical amount of water that the saturated fibers tend to yield to the mixture and subtracting it from the total of water used.

Table 1. Compositions of sample

Type of fibre	***% fibre***	***water-cement ratio***
Untreated	1; 2; 3; 4	0.42
Water-saturated	1; 2; 3; 4	0.42
NaOH treated	1; 2; 3; 4	0.42

As mentioned above, the joists are produced by casting in wooden formwork, at the end of each casting the formwork was vibrated to obtain maximum compaction; the joists are removed from the formwork after 72 hours. For a complete maturation and hardening of cement matrix, the joists ware placed in a climatic chamber at 23°C and 95% humidity until the 28th day after casting. After 28 day, the specimens were subjected a three-point bending test using the Instron 5567 testing machine using the UNI EN 12390-5 standard as a reference.

In addition to the mechanical properties, the linear shrinkage is measured to verify the effect of the fibers on this parameter, in fact one of the most delicate aspects of the cement mixtures is the hydraulic shrinkage, which leads to the formation of real cracks and fractures that already develop during laying and hardening of the material. The addition of fibers usually reduces this shrinkage, preserving the cement matrix from fractures.

To analyze the thermal conductivity of the FRC products, they were made of 30x30x3 cm concrete blocks. These blocks were made with casting in formwork using untreated fibers and cement, the water-cement ratio was 0.42 while the percentage of fibers used was 2%, 3%, and 4% percentage calculated relative to the weight of the cement. For the analysis of thermal conductivity, Netzsch HFM Lambda conductivity analysis system was used.

3. Results and discussion

The analyzes carried out on the recycled fibers used for the experimental part showed that these are composed of 60% pure cotton, 30% of cotton blend and 10% of synthetic material (Nylon, Viscose, Polyester). This result is obtained using IR analysis and electron microscopy, the IR spectrum of the fibers is shown in Fig. 2, while in Fig. 3 shows an image obtained by SEM. From the images, SEM emerges the impossibility to be able to measure the average length of the fibers given the strong intertwining of the threads, while the thickness can be evaluated on the order of 10 microns. As regards the measurement of linear shrinkage, the data obtained showed a reduction of up to 80% with the introduction of fibers (Table 2). In all cases, the shrinkage reduction is maximum when the fiber percentage exceeds 2%.

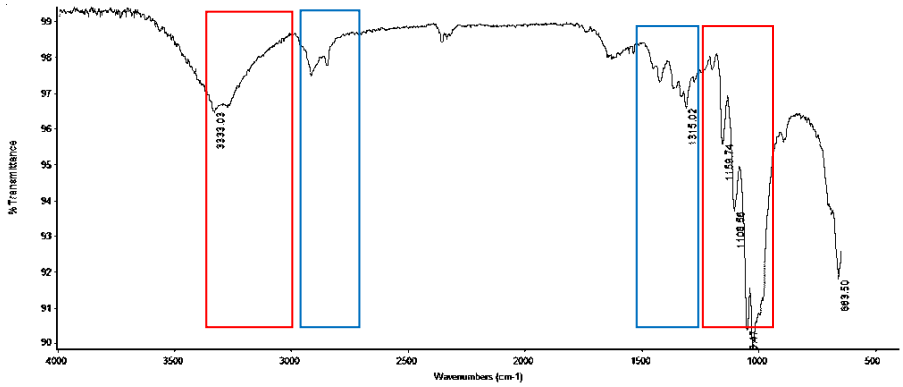

Fig. 2. Spectrum FT-IR of nontracted fiber. The red rectangles identify the peaks attributable to cotton, the blue rectangles identify peaks attributable to nylon and viscose fibers.

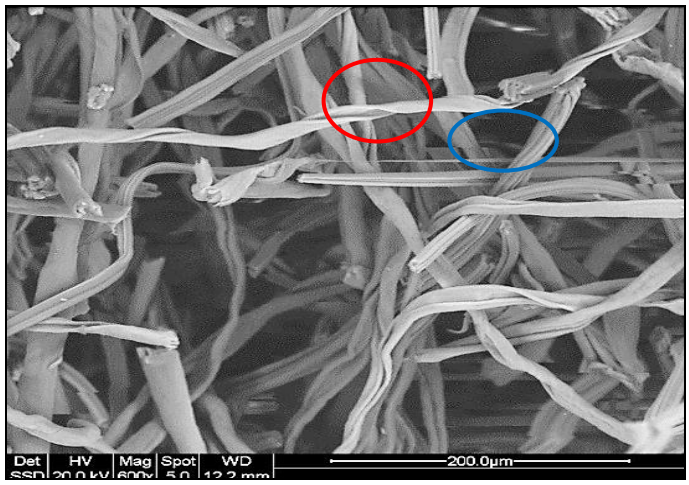

Fig. 3. Micrograph SEM of untreated fiber. The red circle indicates a cotton fiber; the blue circle indicates nylon and viscose fibers

The result obtained is in line with expectations given that the introduction of fibers has the consequence of reducing the linear shrinkage. The bending tests showed a significant increase in the value of the maximum bending load, as shown in the graph in Fig. 4, with values that quadruples with 4% of the fibers with respect to the reference sample data. The bending tests showed a significant increase of the maximum load value to bending as shown in the graph of Fig. 3 where it shows the average value of the maximum load measured. From the data in the graph, we can see how the samples produced with saturated fibers show an increase in the bending load up to 3% of added fibers, while the value of the load begins to decrease to 4% of added fibers. The data obtained, are probably related to the preparation of the sample because the amount of water used is reduced to compensate for the release of water from the saturated fibers. In practice, the samples have a real water-cement ratio of less than 0.42, which, as known, leads to an increase in the mechanical properties of cement products.

Table 2. Decreased percentage of linear shrinkage

% fiber	*Untreated, Δ%*	*Water-saturated, Δ%*	*NaOH treated, Δ%*
1	20	41	58
2	43	57	61
3	76	78	80
4	80	80	80

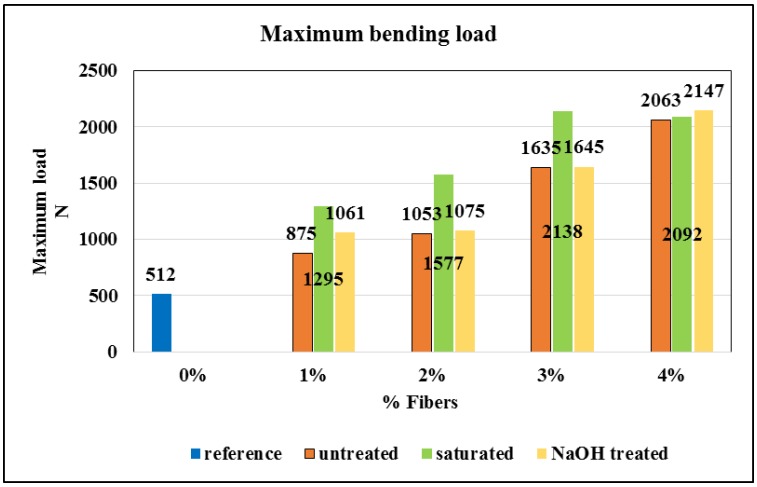

Fig. 4. Average value of the maximum bending load for FCR samples

With the saturated fibers was hypothesized that through the release of water would increase the amount of water in the water / cement / fiber mixture by returning the water to cement ratio of 0.42 reference value. In reality, from the data obtained it emerges that the release of water assumed by the fibers is not able to supply the quantity of water missing. Only with an addition of 4% fibers results come back in line with the other samples. The data obtained for the samples produced with untreated fibers and treated fibers with NaOH, have similar values, therefore the treatment with NaOH does not seem to improve the bending properties. It therefore appears that the fibers treated with NaOH do not determine better flexural properties in the FCRs than the use of untreated fibers. The specimen breaking sections were analyzed with Optika SZN 6 optical stereomicroscope to verify the dispersion of the fibers inside the cement matrix. The first information obtained is that the fibers inside the matrix have a high dispersion. Another information that emerged is the presence of accumulations of fibers that tend to increase with the increase in the percentage of fibers used (Fig. 5).

From the images of Fig. 6, we note how the action of the fibers appears after the cracking of the concrete, to the formation of the first cracks in the cement matrix the fibers are activated assuming a sewing effect of the openings creating a bridge (crack-bridging) between flaps of cracks. This involves a reduction in the width of the cracks and the fiber guarantees the concrete a residual resistance even in the post-cracked phase, this phenomenon is indicated as tensionsoftening. For the measurement of the thermal conductivity of the composites, as already mentioned, 30x30x3 cm concrete blocks were created, with 2% 3% and 4% fibers (Fig. 7). For each composition, three samples were made and four samples were taken on each sample.

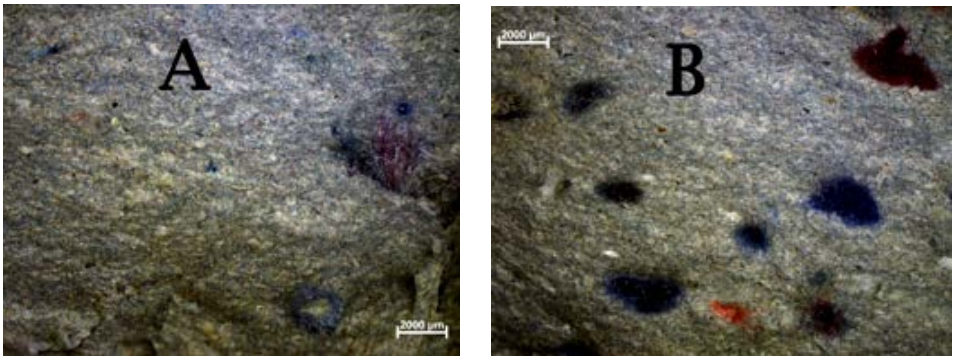

Fig. 5. Images of the rupture surface of samples with: A) 1% of untreated fibers, B) 4% nontreated fibers

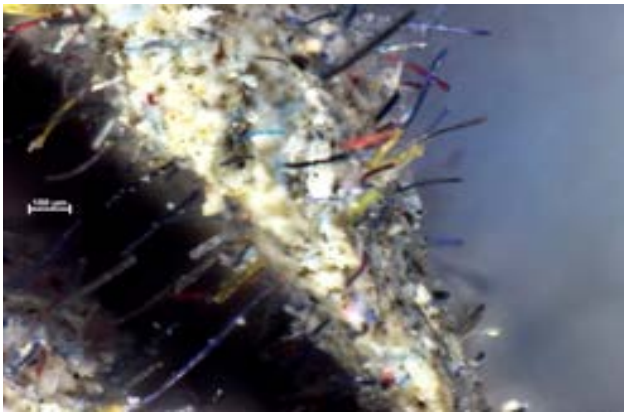

Fig. 6. Images of crack-bridging

Fig.7. Images of blocks of cement for analysis of thermal conductivity

Table 3 shows the averages of the thermal conductivity obtained. The results show the decrease in thermal conductivity with increasing percentage of fiber, with the value of Λ that was almost halved, it can therefore be inferred that the insulating power of the sheet is doubled.

Table 3. Thermal conductivity data

Fibers, %	***Thermal conductivity (W/(m·K)***
0	0.41
2	0.397
3	0.315
4	0.237

6. Conclusion

From the data obtained, the recycling of textile fibers in cement products can be an interesting option. Specifically, we can conclude with the following observations:

- The insertion of the recycled fibers inside the cement paste has led to a reduction in the hydraulic shrinkage, this figure improves with the increase in the percentage of inserted fibers.
- The results of flexural tests performed on the specimens show an increase in flexural strength, considering the different formulations, the best bending behavior was obtained using saturated fibers.
- Treatment of the fibers with NaOH does not increase the bending strength of the material, therefore the best solution is to introduce the fibers without any surface treatment or at most introduce them to the saturated state.
- The introduction of the fibers cannot exceed 4% by weight on the cement due to the loss of workability.
- As the percentage of fibers increases, the value of the thermal conductivity has almost halved and therefore the insulating power has doubled.

From the data observed, surely the introduction of recycled fibers is feasible to increase the insulating power of plaster and improve the shrinkage resistance of concrete floors. To continue the research activity, it will be interesting to study the use of superplasticizers in order to increase the dispersion of the fibers, improve the workability and increase the percentage of dispersed fibers.

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A NEW SUSTAINABLE PRODUCT IN THE GREEN BUILDING SECTOR: THE USE OF SICILIAN ORANGE PEEL WASTE AS HIGH PERFORMANCE INSULATION*

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Abstract

In the green building brands, the reuse of agro-food sector waste for the construction of building materials involves a new type of sustainable paradigm within that kind of company in order to provide several advantages in the production process and to create cooperation between companies of two completely different sectors, seeking efficient, premised upon a green-based way of thinking solutions to problems which include waste disposal and lack of resources. The objective of this paper is the use of orange peel waste (scrap derived from oranges) as insulation. It allows for an enormous costs reduction because the orange peels are waste for many companies that must usually pay to dispose of them. In this paper we will deal with the case of the Martelli company, located in Bronte (CT), operating in the field of green building. The Martelli company will collect these scraps, process them, and use the final product as an insulator. This study therefore proposes to use, as a secondary raw material, the orange peel waste which would otherwise be disposed of in landfills, thus reducing disposal costs.
In addition, this product allows access to a whole new market, where the territorial position is a point of strength to be exploited, while respecting the environment, obtaining insulated houses with green materials.

Keywords: building material, industrial symbiosis, insulated panels, landfills, orange peel,

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1. Introduction

Sustainable development is an important aspect of society which satisfies the present needs without compromising the ability of future generations to meet their own needs. It gives us an opportunity of thinking through and managing human impact on the world that can generate long lasting positive results for the greater benefit of human societies. International goals of sustainability have led to the development of the green building movement that has had unprecedented success. Sustainable development and green building are often used interchangeably. Although, they are related, they are not the same (Abdelfattah, 2018; Alyamia and Rezgui, 2012). The definition of "green building" is the activity of building in a way that protects the natural environment, for example by using green energy, materials that are completely natural and degradable and protecting occupant health and improving employee productivity (According to the Cambridge Dictionary). Green building is the practice of building up structures and making use of environmentally sustainable and resource efficient procedures all over the lifecycle of the buildings, from design to the construction phase (Kats, 2003; Kubba, 2010). In recent years more and more people have shown their interest in green building. The price of buildings turns out to be particularly competitive, especially in the area of prefabricated or modular buildings. Another benefits are linked to the environment and well-being "in general". Thanks to a greater energy sensitivity and general awareness of the advantages of energy-saving, the new biotechnologies for the realization of self-sufficient houses are increasingly being found in Italy (Wanga et al., 2005). Considerable advantages of these forms of construction have a great impact on human health and the environment.

Made with natural materials that are wisely combined with each other (wood and other components), the green building houses boast their perfect thermo-acoustic insulation, eliminating the formation of mould and humidity, with a minimum heat loss in winter and a maximum cooling in summer, thus achieving considerable energy savings by reducing the costs of heating in winter and air conditioning in summer. Europe's houses, offices and public buildings save up about 40% of all energy in circulation, more power than in either the industrial (32%) or transport sectors (28%). About half of a building's total energy is devoted to heating, ventilation and air-conditioning (HVAC). Some of many promising HVAC patent areas is air purification which incorporates technologies such as ultraviolet light and photo-reactive chemicals similar to those that occur in the Earth's atmosphere and passive solar and radiant heating, where warm, sunlit air is diverted to heat a building or, during the summer months, used to draw in colder air for ventilation. Energy-efficient heating can only keep a building warm if there is sufficient thermal insulation to keep the heat inside (Pargana et al., 2014). Many commonly used, high-efficiency insulators were developed several decades ago and have seen gradual improvements and refinements since then. These include insulating concrete forms (ICFs), the brainchild of German Canadian engineer Werner Gregori. ICFs use interlocking polystyrene concrete forms to create a seamless wall through which air cannot penetrate a very efficient and low-cost insulation but comes from oil transformation and therefore it isn't a good product for green buildings. Structural insulated panels (SIPs) are another frequently used insulation option, partly because they can be integrated into a number of materials, including particle and gypsum board, sheet metal, plastics and foams. They work by sandwiching insulation into interlocking sheets of building material to create uniform coverage (epo.org). A new type of insulator is Pastazzo, an innovative product, which comes from waste of agriculture sector (citrus peels) that has become a serious problem in past years, first of all due to expensive disposal costs. Pastazzo can be used for several applications, from agro-food to combustible sectors purposes, but the main theme of this paper is to analyze Pastazzo as an insulator and

enhance Pastazzo's properties, costs and benefits, as well as its applications in the market and an analysis between Pastazzo and other common insulator. This product is a perfect example of industrial symbiosis (IS). According to Chertow, the "industrial symbiosis" involves traditionally separate industries with an integrated approach aimed to promoting competitive advantages through the exchange of material, energy, water and / or products (Chertow, 2007). Among the key aspects that allow the realization of the industrial symbiosis are the collaboration between companies and the synergy opportunities available in a suitable geographical and economic environment (Zhu et al., 2014). The industrial symbiosis, in this perspective, plays a fundamental role because it could represent an opportunity for those companies that do not have the proper resources to adapt to the new environmental necessities that nowadays are increasingly urgent and at the same time offers a chance for companies to obtain several advantages and growth inside the market.

2. Material and methods

To achieve this, we propose a case study, with the company Prefabbricati Martelli located at Bronte, province of Catania. The case study concerns the use of the "orange peel waste", called also "pastazzo" - i.e. the by-product obtained from the transformation processes, consisting of pulp, seeds and peel - as an insulator, to isolate the inside of the house from the outside (Balu et al., 2012). Insulation is essential within a building to achieve maximum comfort throughout the year. In summer it keeps the environment cool and in winter it retains heat inside. The methodology is based on positioning insulated panels outside or inside, on the building's roof or on the walls, filling the spaces created with the "pastazzo".

Furthermore, the choice of an environmentally friendly material is a higher gear, both as regards the qualitative side and economically one, because the acquisition cost of this material is practically nil, and transportation costs are very low, thanks to the geographical position that allows find it almost at km 0. Moreover, in addition to be an effective and comfortable solution, it allows to obtain a considerable energy saving, thus avoiding the use of heaters in winter and conditioners in summer. It also represents an investment for the home because by improving the energy efficiency it will acquire value, deepening the qualities of the pastazzo. Initially the pastazzo was used as an animal food.

Today the pastazzo can have different uses thanks to its chemical-physical characteristics. It is formed of 60-65% of peel and essential oils and the remaining 30-35% of pulp and seeds (Table 1).

Nowadays we hear more and more talk about Circular Economy, which can have different definitions. It is an economic system designed to be able to regenerate on its own, thus also guaranteeing its sustainability. It enjoys a vast and growing market, worth 2.1 trillion euros for 19 million jobs.

The circular economy accompanies a product from the cradle to the grave, or better, from the cradle to the cradle. There is no waste, in fact we talk about Zero Waste. No product is dispersed in the environment but it is reused, thus causing no pollution. So, the circular economy is opposed to the linear economy that instead goes from the production of a product that remains only a waste. It is estimated that 40 tons of citrus peels are able to produce a quantity of electricity and heat equal to 23,976 kWh per day, satisfying the energy needs of as many as 333 houses. About 340 tons of pastazzo are produced in Sicily within one year. It is a quantity that allows the use of pastazzo in energy production and in agriculture as fertilizer. Moreover, besides producing clean energy, pastazzo helps to reduce the costs related to the disposal of the waste. In fact, 10 million euros would be needed to be disposed of each year. A very high figure that would fall to the producer.

Table 1. Chemical composition of the orange peel waste

	Orange peel waste		
	Fresh (pressed)	Ensiled	Dried
pH	3,6	3,1	n.i.
Dry substance	216-250	193	892-912
Organic substance	975	954	906-912
Protein	51-65	81	68-72
Fat	n.i.	n.i.	20-40
Sugars	n.i.	n.i.	573
Lignin	n.i.	n.i.	3-7
Calcium	7,3	n.i.	18-53
Phosphorus	1,7	n.i.	3-4
Magnesium	n.i.	n.i.	1-2
Potassium	n.i.	n.i.	7
sodium	n.i.	n.i.	0,3
d.s.: dry substance. n.i.= data not indicated			

The pastazzo can have various alternative uses, such as the use for:

- Human nutrition: it allows obtaining multiple products with high added value (such as bark, dietary fibre).
- Cosmetic and pharmaceutical industries: where flavonoids are the subject of numerous studies thanks to their biological activity (antioxidant, anti-aging, chemioprotective and anticarcinogenic).
- Soil improver: to increase the content of organic substance in the soil, thereby increasing its fertility.
- Compost production: the composting process allows to increase the degree of humidification and mineralization of the organic substance.
- Energy production: use as fuel or organic matrix for the extraction of bioethanol or biogas.

3. Experimental

The Prefabricati Martelli is a company specialized in the construction of wooden structures, civil and industrial roofs, accommodation and bathing facilities, recovery of building heritage, canopies, pergolas, gazebos, wooden turrets, bridges and walkways, railings and more. All structures are made of wood, a building material that has numerous advantages, such as ensuring a well-being of housing and high thermal, acoustic and seismic performances.

Thanks to the extensive experience accumulated in the construction sector in this material, the Prefabricati Martelli offers its customers technical and maintenance assistance, consultations and inspections for each type of structure, so as to have functional and long-lasting solutions. Starting in the 1950s, the Martelli family was involved in the marketing of coal and wood, moving on in the 1970s to the first concrete constructions and then in the 1980s the marketing of products for building and carpentry. In 2002, maintaining its traditional family business, the current Prefabricated Martelli Salvatore & C. was born, strong of the experience and love for wood handed down from father to son. The Prefabricati Martelli Salvatore and C. S.a.s. is a family-run company, located in Viale John Kennedy, lotto 125, 95034, Bronte, Catania, Italy. The company has been operating for years in Catania and the province and throughout the region, personally taking care of every stage of customer service: from design to commissioning on site.

The prefabricati Martelli pays special attention to the choice of sustainable materials and chooses its suppliers carefully. The main suppliers of Martelli's Company are:

- Naturalabau, wood fiber supply;
- Edilcanapa, a hemp supply that is used as an insulator;

- Rockwool, rock wool supply;
- Ediltech, a polystyrene supply used as an insulator;
- Technosugheri, supplier of roasted cork (called brown)
- Syfar, supplier of unroasted cork (also called blond)

The customers are mainly private, but in addition to the construction of private houses, Martelli has built a church and a gym, both located in Bronte, and mountain shelters. The Prefabricati Martelli has SOA certificate for the category OS32 that certifies to its quality in the execution of public works and Ministerial Authorization in accordance with decree 14/01/2008 (decree NTC 2008) for the processing of structural elements. It is also certified (UNI EN ISO 9001:2015) to ensure strict compliance with quality in the management of business processes and has (UNI EN ISO 14001:2015) to underline the concrete commitment to keep the environmental impacts of its activities under control and to systematically seek continuous, coherent, effective and above all sustainable improvement of its environmental performance (struttureinlegno Martelli).

The company is undoubtedly an excellent example of environmental sustainability, in a sector that could be among the most impactful for the environment.

4. Results and discussion

Prefabbricati Martelli, by virtue of their attitude towards the innovation in the building techniques and the use of modern and eco-friendly materials, is considered a leader in the green building sector. Situated in Bronte, Prefabbricati Martelli is specialised in designing and building wooden structures of a different kind: houses, bathhouses, mountain refuges etc. One of the most important parts of designing a building is the choice of an insulation material which is fundamental to protect the building from heat, humidity, cold and noise. The choice of the insulation is based mostly on the localization of the house, the temperatures of the building area, the moisture content, and it is fundamental for the successful outcome of the building. The most important features of thermal insulation materials are density, thermal conductivity, specific heat (Asdrubali et al., 2015); these features are regulated by international standards such as ISO 10456:2008, UNI EN ISO 6946:2008.

Prefabbricati Martelli has a lot of suppliers who provides them with different products of various characteristics and features. Two of the most used and common materials are wood wool and rock wool. The wood fiber panel l has a thermal resistance of R = 0.040-0.060 and a B2 fire resistance. The cost for the company is about €11.5 SQ M. Rock wool has a thermal resistance of R=0.037/0.040 and an A1 fire resistance. The cost for the company is about € 10-20 SQ M. Our proposal is the use of orange peel wastes, called pastazzo, as an insulation material; thanks to its mesoporous structure, pastazzo has a great potential to become an insulation material.

Desiccation of orange peels entails water evaporation, with a consequent increase of pastazzo's porosity; in addition to it, this process involves a decrease of the product's volume, that causes less transport cost. According to our work, pastazzo needs the fire and thermal resistance tests. We propose to use a combination of pastazzo blended with Portland concrete or a combination of pastazzo and wood fibre to increase and improve the insulation performances. Here it's possible to see a picture of pastazzo, with its visible moisture content. Based on our studies, there are 2 types of advantages of the use of pastazzo: economic and environmental ones. Regarding the economic ones, it is crucial to underline that pastazzo is a cost for the agricultural industry companies who have to pay for the disposal of orange peels. It costs them around €25-30 per tonne. Consequently, the raw material for the production of the panels would be gratuitous (excluding transport and stocking cost); as said before, the

desiccation phase is important because water evaporation and decrease of humidity allow a volume reduction.

Fig.1. Pastazzo

The comparison between the commonly used insulation materials and pastazzo's one shows that it is possible to make significant savings thanks to choosing pastazzo; the wood fiber's cost is €11,5 SQ M, the rock wool's cost is € 10-20 SQ M, whereas, according to o The processing costs are presented on the basis of our estimates: the desicattion cost is in a range of €25-30 per ton, there are only a few of desiccation facilities, so our suggestion for Prefabbricati Martelli is buying a desiccation and pressing facilities. This investment should have a cost around €40.000 - 50.000 but has the potential to be amortised with behalf of a third-party commission. In this way the panels production's cost would get halved.

As regards the transport cost, there is the advantage of the proximity to the citrus processing plants that decreases the cost, which is estimated to be around €500, with a quantity of 20-25 tons of pastazzo per route. According to our evaluations, the cost of pastazzo's panels would be €7-8 SQ M. Regarding the environmental advantages, it is important to highlight that pastazzo represents a huge and burdensome problem of the entire industry, a bulky and hard to dispose of waste, that is often the cause of environmental crimes. A lot of initiatives concerning the use of pastazzo have been born recently. Some of them are the use of pastazzo as a fertilizer, in the agronomic field or the compost production.

Unfortunately, they are not sufficient to dispose of all orange peels waste, which is around 700.000 tonnes in Italy per year, 340.000 of which is produced only in Sicily. The cost for pastazzo's disposal in Sicily is about €10.000.000.

5. Conclusions

Overall the findings and analysis presented in this paper may be valuable and useful in studying and analyzing the possibility of the use of orange peels waste as an insulation material. Our analysis showed that thanks to its chemical and physical properties, pastazzo might help in disposing of a relevant part of the citrus sector waste.

We hope and we will urge Prefabbricati Martelli to invest in the tests and experimentations of this new practicable product. This product showed that there are possibilities of making economic and environmental savings, and it will be a starting point for our project.

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TERRITORIAL AND AMBIENTAL RETRAINING OF PANTELLERIA'S ISLAND IN A CIRCULAR ECONOMY VIEW: IMPLEMENTATION OF RENEWABLE ENERGY SOURCES AS A LEVER OF ECONOMIC IMPROVEMENT*

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Abstract

Pantelleria's island represent a hidden treasure placed in the middle of Mediterranean Sea. The territorial and ambiental conditions of the island allow the efficient use of the renewable energy sources from every point of view. Resources as eolic and photovoltaic plant constitute a fundamental and efficient method of optimization and production of natural energy that will allow the island to be completely autonomous and more attractive from a touristic perspective. Pantelleria's inhabitants prove to be sensitive to the theme of waste; for this reason, the construction of waste treatment plants to recover energy would be efficient in a point of view of circular economy. The administration has already made some moves in order to make the mobility in the territory more sustainable through the introduction of incentive program for the use of electric means of transport as cars, motorcycles and bicycles. A collaboration has been started between the University of Catania and the local administration in order to implement a system of social and economic indicators to evaluate environmental performances and bring Pantelleria to a new level of efficiency.

Keywords: circular economy, environmental indicators, environmental performances, improvement, renewable energy, sustainable mobility means

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1. Introduction

In this paper we will explore and expose the different solution that can make possible the economic and territorial requalification of Pantelleria's island in an eco-friendly point of view. Already since 1995 links have been found between industries and environmental sustainability, the work in factories while ensuring development and progress has caused major problems such as acid rain, global warming, ozone depletion, deforestation and desertification (Shrivastava, 1995). Nowdays different solutions exist in terms of Circular Economy; this new line of thought differs from the classic ''liner economy'' thanks to the way in which products, services and production processes are designed to ensure a longer and more sustainable cycle and product life (Bonciu, 2014). Different solutions to be applied on the island can be taken into consideration ranging from renewable forms of obtaining energy such as wind or photovoltaic, to particular urban waste management systems such as composting, from the studies conducted by Dell'Abate et al. (2000). It is in fact possible to use the composting system especially in the agricultural field in order to guarantee sustainable management of soil but following carefully and monitoring the degradation processes of organic compounds.

The use of environmental indicators, intending "something that provides a clue to a matter of longer significance on makes perceptible a trend or phenomenon that is non immediately detectable" (Hammond et al., 1995), to interpret the result is fundamental for the project; the only difficulty in developing and interpreting agri-environmental indicators is that in these territories it is not possible to analyze the impact by focusing only on one aspect since each of them is caused by multiple factors that condition each other (Buchs, 2003). The choice of application methods will be carried out following the criteria indicated by Zijp et al. (2015). World government plans have been moving in this direction for several years, above all through R&D centers (Jacobsson and Bergek, 2004), there are also various investment methods for renewable energy (from anonymous, industry, large utility, home owner, municipality, energy, community) and all are characterized by a different level of specific incidence and a different risk rate (Mazzucato and Semieniuk, 2018). The objective of the paper is to find the most efficient and suitable instruments for the enhancement of the Pantelleria territory through the analysis of the advantages, disadvantages, impacts and economic returns.

2. Materials and methods

Tourism is the core business of many realities in Italy. However, it is not well exploited because of the lack of awareness of the real potential of the territory. For this reason, the tools that analyze the key point of a company, for the maximization of the opportunities that the market offers, are often underestimated. The following paragraph will show which tools and how they can give support to improve the opportunities of the third sector. A tool that can be useful to achieve this goal is the SWOT analysis. The SWOT analysis a fundamental tool to observe strength, weakness, opportunities and threats of a company or of a market sector.

First, we consider the strengths and weaknesses of recent tourism research. Then we point out opportunities for new research that could further advance our understanding of the dynamics of tourism and consider potential threats to continued advancement. Then we will consider the practical implications of the accumulated evidence (Jackson et al., 2003). SWOT analysis is one of the most appropriate tools for this aim because of its simplicity and practicality. As a framework, it has been widely adopted but, in general, its use has been accepted uncritically. It is time to exploit its value as a strategic management tool. If used simplistically, the SWOT framework is a basic tool which may lead to strategic errors. More

detailed analysis using complementary frameworks can overcome SWOT is inherent shortfalls (Table 1). SWOT should not be viewed as a static analytical tool with emphasis only on its output. It should be used as a dynamic part of the management and business development process (Pickton and Wright, 1998).

Table 1. SWOT Analysis

STRENGHT Autonomy European bonds National park Landscapes	**WEAKNESS** Geographic position Few transport Seasonal tourism Bathing platforms
OPPORTUNITIES Third sector growth Transport sector growth Sustainable use of energy from renewable resources	**THREATS** Devalorization of the heritage Brain drain Lack of information

As mentioned above, the criteria for identifying sustainability application methods are chosen based on the subdivision into five macro categories useful for identifying the characterizing aspects. They are: System Boundaries / Inventory (object, spatial focus, temporal focus, life cycle thinking), Impact Assessment / Theme Reaction (what is to be sustained, theme and indicator selection, spatial focus of impact, temporal focus), Aggregation / Interpretation (sustainability target, values/view on sustainability, view on integration of pillars, normalization), Method Design (context of the assessment, uncertainties), Organizational restrictions (formal requirements, Expertise requirements and availability, Software requirements and availability, Data requirements and availability). First of all, the main strength of Pantelleria Island is that it has a huge natural heritage,which includes a huge biodiversity; the island also its autonomous from different aspects such as the garbage collection system, also the possibility to create a local market based on traditional and characteristics products that allows a process of business development. A very big portion of Pantelleria Island is part of the "Parco Nazionale dell'Isola di Pantelleria" that every year receives European funds to improve the offer of services, and it's the main point of interest for the tourists. On the other hand, Pantelleria has some weaknesses such as the geographic location, because it's difficult to reach the island with a low budget; the steep coasts that make it difficult to reach the sea, for this reason the island needs an integrated platform system in a proactive way, in order to allow tourists that desire to enjoy the sea. Nowadays the Island has a greater number of opportunities than difficulties, which could stimulate an economic and social growing process.

One of the island's opportunity is the possibility of a great use of energy from renewable resources such as from photovoltaic system, from Eolic system or from hydroelectric system, which could represent a chance to reduce the costs of public administration, this is also an opportunity to create an eco-bike sharing system that could increase the influx of tourists. Another big opportunity of Pantelleria is the expansion of the third sector that now days is underestimated but is the most important because of the resource that the island has. It's important to must not forget any threats of the island in order to operate in an aware situation. It is clear that tourists have a distorted view of the island's attractions, probably due to a lack of information of the real potential of Pantelleria; another threat is represented by the fact new generations prefer to leave the island instead of evaluating it. That could slow down the growth process of the island.

3. Experimental

Pantelleria is an Italian municipality of 7759 inhabitants, in the province of Trapani, Sicily. The municipality covers the whole area of Pantelleria island which extends for more than 80 km² and It's located 110 km south-west of Sicily and 65 km north-east of Tunisia. The island's economy is based on specialized agriculture of vine production, very famous is the "Zibbibbo" and sweet wines as the "Moscato di Pantelleria" and the "Passito di Pantelleria"; these traditional products has been declared heritage of humanity in the 2014 by UNESCO. Another fine cultivation is the typical "Cappero di Pantelleria", which is an IGP (Indicazione Geografica Protetta). Fishing is rarely practiced but, on the other hand tourism activity is constantly growing, especially in summer. In fact, many famous people contribute to the economy of the island thanks to the typical "Dammusi". This island is characterized by different types of territorial configurations; in fact, at a distance of a few kilometers, it is possible to move from the sea to the mountains, from the hills to the flat territories, from enchanting beaches to overhanging on the sea.

For the Pantelleria's municipality is very important act in a sustainable way, in terms of the rational use of the energy, so for this reason one of the mechanisms used consist in the performance definitions relatively to the systems that consumes energy; this type of objective has been reached at European level with: EC Directive 91 (2002) related to the buildings energetic performances; EC Directive 32 (2005) in terms of eco-design; and the European regulation in terms of vehicles efficiency. For the development of alternative energetic are essential resources, reduction of energetic consumes through the waste disposal, efficiency growth, and the abolition of wrong means to optimize the relative cost/benefits ratio in alternative to fossil fuels.

The general approach of the Plan in the contest of local energy demand governance is based on the concept of the use of the best technologies and techniques available. The energetic efficiency sector is less developed than the alternative fuels research sector, this is due to objective difficulties; in many situations, the operations are characterized by a strong parcelling. The users are spread in the territory and for this reason it's characterized from relatively reduced efficiency potential. For example, from the PAES study prepared by the municipality of Pantelleria in 2011, the final consumption of the residential sector is divided into: refrigerator 14.6%, freezer 2.5%, washing machine 6.8%, dishwasher 3.1%, lighting 9.8%, electronic equipment 10%, electric water heater 34%, iron 3.9%, gas / electric cooker 1.7%, microwave 1.5%, electric stove 8.7%, air conditioner 1.9% and the remaining 1.6% for other miscellaneous applications

The consumption growth is due to the capillary diffusion of new devices such as, electronics devices and in the last few years also from air conditioning systems. However, that is also a consequence that comes from the demographic structure changes that led to an increase in household basics consumptions, such as illuminations, refrigeration and more devices.

4. Results and discussions

On the base of the studies done by the municipality, the island of Pantelleria is the perfect place to start a series of investment focused on the use of energy from renewable resources and the optimization of the current manage of waste. Most of the data used in this studies comes from the PAES drafted in 2011 by the Comune di Pantelleria, because represent a reliable sources of information related to the territory analysis.

4.1. Requalification of energetic consumes

On the island of Pantelleria there are high levels of consumption of electricity due to antiquated energy and domestic installations for this reason, the public administration had already advanced intervention programs in 2009 aimed at limiting such consumption. The town hall (with a size of 1833.8 m^2) is the second largest building with a consumption of 47.5 kWh /m^2 and it is interesting to note that the Rekhale elementary school shows levels of consumption equal to it but in correspondence with a considerably smaller area than the town hall (391.0 m^2) (Table 2).

Table 2. Energy consumption of public buildings, PAES 2011, Island of Pantelleria

Buildings	***Surface(m^2)***	***2009 consumption (kWh/m^2)***	***Consumption after interventions***	***Variation (%)***
City Hall	1,833.8	47.5	40.8	-14.1%
D'Ajelli Elementary	720.0	25.7	24.3	-5.3%
Rekhale Elementary	391.0	47.5	42.7	-10.1%
Tracino Nursery	446.3	7.6	7.6	/
Kamma Elementary	336.7	34.5	32.3	-6.4%
Alighiery Secondary	2.836.0	22.6	21.2	-6.3%
Salibi Elementary	307.9	15.5	15.5	/
Salibi Nursery	362.1	25.1	19.18	-24.5%

Referring to private dwellings the overall energy needs classified by year of construction of the buildings follows a decreasing trend and clearly shows the difference between those of old and new generation ranging from 280 MWh /a to 26 MWh /a (Table 3).

Table 3. Energy needs of buildings per year of construction, PAES 2011, Island of Pantelleria

Construction period	***Energy Requirements (MWh/a)***
Before 1919	280
From 1919 to 1945	331
From 1946 to 1961	252
From 1962 to 1971	129
From 1972 to 1981	115
From 1982 to 1991	40
From 1992 to 2001	26
From 2002 to 2009	76
From 2010 to 2020	77
TOTAL	**1325**

On the island there are different types of structures dedicated to the tourism sector: housing, at 2009 they were estimated at around 2141, up at 2344 at 2020; residence, it is estimated a number of 1745 in 2020; hotels, the current number is about 1800 beds, in the balance analysis, the consumption trend during the year shows a marked seasonality.

The production system of Pantelleria is composed of agricultural-type activities and an agro-industrial induced business mainly composed of small or medium-sized companies. The entrepreneurial structure of Pantelleria is characterized by a dimensional fragmentation

and a strong dispersion in the territory and the backbone of this sector is constituted by the small artisan company in the form of an individual company. Viticulture is the main agricultural activity. The total viticultural area of the island corresponds to about 500 ha and almost half of the farms are characterized by sizes ranging from 1 to 3 ha. Companies with sizes greater than 3 ha are around 8%. The grape harvest varies from the beginning of August and can even go until the end of September. The cultivation of the caper is also widespread, which is harvested by hand between May and August. Finally, another important crop of the island is the olive tree, which is harvested during the first weeks of November. To these crops must be added those of fruit trees.

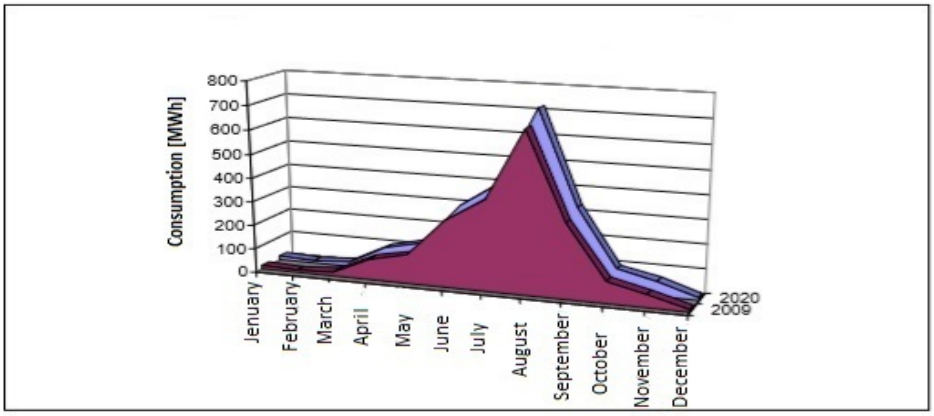

Fig.1. Electricity consumption of tourism sector, PAES 2011, Island of Pantelleria

Table 4. Energy consumption of the production sector, PAES 2011, Island of Pantelleria

SECTOR	***kWh***
AGRICULTURE	**591,294**
farms	298,332
irrigation	292,962
FOOD INDUSTRY	**209,579**
Agriculture associated	167,812
Meat, fish, milk and derivates	19,392
Agricultural products	22,375
WINE AND DRINKS	**375,525**
OTHER INDUSTRIES	**408,713**

From the data collected it can be seen how it could be convenient and efficient to promote the installation of sustainable energy production methods from the perspective of the circular economy. This can be implemented mainly by placing photovoltaic and wind systems on the territory, in fact the island is constantly exposed to sunlight over the course of the year and is also exposed to strong wind currents. As for the photovoltaic panels, these can be installed on the individual private houses, following specific incentive programs, or placed in a major system, in order to obtain levels that achieve the energy autonomy of the production companies, of the structures and public services; it is possible to satisfy the family's energy needs already with small 3 kW installations that prove to be able to produce between 3,300 kWh and 4,500 kWh per year in the case of simpler systems or, in the case of higher energy requirements, it is possible the installation of tracker systems (monoaxial or biaxial), a structure with a concrete base able to follow the movement of the sun, so as to

obtain 15-35% more energy than fixed structures (Fig. 1). In addition to environmental convenience it's also relevant an economic convenience, in fact it is estimated that the costs associated with photovoltaic systems can be recovered in about 7 years (Table 4). As regards the wind sector, just think that a 3 MW wind turbine is able, over the course of a year, to satisfy the needs of 3,500 people; the entire energy demand of the city of Pantelleria could therefore be satisfied with 2 or 3 turbines.

4.2. Composting

With regards to waste management, the inhabitants present in the Pantelleria area prove to be particularly sensitive to environmental issues, establishing themselves among the first places among Italian municipalities in terms of adherence to separate collection programs. Notwithstanding this, a landfill is not present on the island and for this reason the municipality is forced to transfer this waste by sea to the major island (Sicily) with associated costs connected to this process. Is therefore of fundamental importance the construction of a new generation landfill to which a composting system, an aerobic fermentation process that converts the organic material of urban or agricultural solid waste, into a hygienically safe material.

The initial concentration of carbon and nitrogen is fundamental for identifying the duration of the process that can vary from 2 weeks to 6 months. This process takes place thanks to fungi and bacteria and oxygen and therefore decompose the waste obtaining the formation of compost which is used as a fertilizer. It is a biological process, simple and natural and is characterized by low costs and is also free of toxic emanations.

5. Conclusions

It has been written how the island of Pantelleria intends to exploit the opportunities for an economic growth in an environmentally sustainable perspective, in particular in the tourism sector, in the energy sector and in waste management. The island has already begun a path of growth on the topics covered by the study.

Next years the municipality could start a sustainable mobility project with the installation of electric car charging stations and at the same time provide incentives to stimulate the purchase of electric cars. This could be a way to improve the image of the island in Italy and Europe, and possibly increase the flow of tourists and their satisfaction, crucial points for the economic growth of the island.

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REUSE OF OLD GRAIN WASTE TO CREATE ALTERNATIVE ENERGY SOURCES*

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Abstract

Wheat is a cereal of ancient culture, in the past it was called tritic. The Mediterranean represents the perfect area for the cultivation of ancient grains for its. Nowadays man has changed the characteristics of the ears of wheat compared to those of the past to increase the quantity of cereals and decrease the length of the stem that represented a gap for man. Since 1890 in Carlentini lives a reality called "Ancient Grains of Sicily": The next objective is to bring back to life the ancient grains of rustic starting from genomes of ancient grains with excellent feedback to taste and health. The company decided to bring back to life here the ancient grains, or long ears of wheat, up to 1.40 where the stem is higher than the quality of grain so that they are used both as hay for animals and to be transformed into biomass and through the use of a machine that activates the process of pyrolysis to produce biogas, bio methane, bio oil and coal. The aim of the paper is to demonstrate how this company can set in motion a process of self-sustainable circular economy within the entire production chain to reduce CO2 emissions with the aim of approaching 0 the costs of maintaining the chain.

Keywords: eco-sustainability, circular economy, no waste, old wheat, renewable energy

1. Introduction

Energy has been a much discussed subject in the current period, especially since the non-renewable energies that have polluted our planet for many years, causing irreparable damage, are running out are running out. Since 1970s, the perceived risk of remaining without fossil fuels has led to the development of new renewable energies which aim is to reduce fuel consumption in vehicles and achieve greater energy efficiency in buildings, businesses and homes (Chynoweth et al., 2001) These renewable energies will play an

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important role in the future of the planet, they are divided into several categories: solar energy, wind energy, biomass energy and geothermal energy. It is now more and more convenient to produce renewable energy for companies from an environmental point of view but it's becoming more important even on an economic point of view. Renewable energies have the aim of producing low-emission or zero-emission energy. Another important step is to ensure that all states comply with international agreements on compliance with environmental standards.

The issues of climate change are sensitizing the whole planet because everyone is experiencing global warming, the surface of the earth has a significantly higher temperature than decades ago, the production of renewable energy produces toxic substances such as CO_2 that seriously harms the entire living system (Panwar et al., 2011). There are three types of acceptance regarding renewable energy: socio-political acceptance, community acceptance, market acceptance (Wustenhagen et al., 2007).

A particular source of renewable energy is the one that is obtained from biomass that can be committed to meet a large energy demand, capable of generating enough electricity to an industrial plant, heating houses etc. You can get biomass or bioenergy through different technological solutions that can be separated into two basic categories, namely thermochemical processes and biochemical / biological processes. They are: Combustion, Fermentation, Anaerobic Digestion, Gasification and Pyrolysis and finally mechanical extraction processes. Biomass resources include wood and wood waste, agricultural crops and their by-products, solid waste, residues from agro-industrial and food products, aquatic plants such as algae. Biomass currently accounts for about 14% of the world's final energy consumption, 25% is used for industrial purposes, while the rest of 75% of consumption is used for heat production for households in developing countries (Parikka, 2004).

In this period, entrepreneurs have started to invest in the islands, especially in the renewable energy sector, in order to make them energy independent. This is possible because of the features of some islands that have a not too high number of inhabitants that allows each individual to take advantage of a part of the energy produced by the systems of biomass, wind, solar, etc.. These characteristics are found in the island of Pantelleria. It has a not very high number of inhabitants, climatic characteristics that are suitable for wind farms and an economy based on agriculture that can allow the production of energy (electricity or biomethane) from the biomass that accumulates during the season.

Another source of renewable energy adapted to the characteristics of the island is water energy, which can be used through the water purification system: water from the sea is taken to the highest points of the island and then distributed throughout the island. During this passage it is possible to insert turbines that can produce electricity. Finally, the last source of renewable energy is the sun through the photovoltaic panels. The objective is an accurate technical and financial analysis to re-evaluate the territory through the use of biomass for the self-support of the island.

2. Materials and methods

The ancient grains of Sicily are varieties that were used until 50 years ago. But the introduction of fertilizers to optimize the yield of the crop, the intensive cultivation and the standardization of the production process have caused that the main characteristic of the ancient grain, the long stem, disappeared to make room for a grain with a shorter stem but with more fruit, this phenomenon was speeded the human intervention selected the wheat by cutting the longer ears.

With the technological and industrial development the problem of industrial waste grows more and more, and the best solution is recycling (Topcu and Guncan, 1995). The ancient grains have nutritional substances no longer present in modern grains that make it

better both in an empirical and cultural sense, for this very reason many Sicilian and Italian entrepreneurs are investing more and more in relaunching ancient wheat because it is possible to lead companies to a circular economy where the agricultural waste or the stem are used to create biomass to be transformed into energy for sustaining the cultivation.

The importance of sustainability in the agricultural field with the use of ancient wheat has attracted many entrepreneurs and investors because it could lead companies to sustain costs closer to 0, so the aim is to have their own businesses that feed on themselves (Lomazzi, 1987). The ancient grains are more adaptable to environmental conditions and in the hilly areas they are easier to grow. Also in the past (but still today) the wheat stem is used to make hay and become animal feed therefore exclusively dedicated to animal husbandry, while now it is more important to use biomass to produce energy with current systems even if the dedicated biomass in animal husbandry has important beneficial properties (Cinquemani, 2017).

Biomass energy is, perhaps, one of the most controversial types of alternative energy currently used. The advantages of energy from biomass are different. First of all, biomass energy is a renewable resource. Secondly, it reduces the dependence on fossil fuels and is a carbon neutral resource: that is, it does not produce excess carbon dioxide during its transformation. Furthermore, organic waste in the form of leaves, grass and trees, but also animal carcasses and their excrement are available in abundance and can be used to produce energy (Caputo et al., 2005). This is a possible way of using waste because if it is not used to produce electricity, it increases the amount of waste in landfills. It therefore helps to reduce waste and waste management. Huge quantities of solid waste are created that can be classified as biodegradable, recyclable, but also dangerous toxic waste. Finally, biomass can be useful to create different products from different forms of organic material: it can be used for the production of methane gas, biodiesel and other biofuels or directly in the form of heat or electricity (Hoogwijk et al., 2003). In Sicily there are different varieties of ancient grain grown (Table 1).

Table 1. Different varieties of ancient grains in Sicily

Maiorcone	Robba Janca
Mantu di Maria	Romanor
Monococco	Russello
Palmentella	Scavuzza
Perciasacchi	Timilia o Tumminia o Triminia
Realforte	Tripolino Realforte
Regina	Urria
Biancolilla	Francesa
Biancuccia	Gigante
Bufale	Giustalisa
Casedda	Grano Monococco
Castiglione	Inglesa
Cuccitta	Maiorca(tenero)
Farro Lungo	Martinella

3. Outline of the work

F.lli Vescera s.r.l. is a baker company that produces bread, pasta, biscuits and all grain related products. It is a very important company in the primary sector in Sicily, one of the first to invest in ancient grains, in fact all its products are made with these particular species

of wheat and this leads to a slightly higher price level with higher qualities. It is also a vertically integrated company, as it is the one that produces the main input, wheat. The F.lli Vescera s.r.l was born in 1890 characterized by its bread made with a wood-fired oven located in Carlentini. Later the company replaced the wood oven with the electric one with the aim of concentrating on the quality of the grain and therefore the use of ancient wheat. The last challenge, in fact, by Francesco Vescera (owner) is to bring the ancient Sicilian grains back to life by collaborating both with the universities and with other research organizations.

Because of the work of the company in Sicily, the importance of ancient wheat used for bread making and varietal hand breads was reborn. Furthermore, since the damages caused by the abuse of the use of plastic, tanks and bad waste management have generally been discovered, they have led the company to deal with multi-disciplinary issues and around the year 2000 the company made a choice of follow a green economy production line. The word Green (biology, ecology) belongs to the environmental theme, while ancient grains belongs to the cultural theme, or to make products that are not replicable. At the beginning of the year the company received the award for "Best in Sicily" as the best bread in Sicily, in April it received the trend of pasta excellence in Bologna and finally won the title to the history for the recovery of ancient cereals and biodiversity. The company's method for reviving ancient grains consists in going to specific sites to do a bibliographic search that takes place above all in historical archives to document the species, then it continues with interviews in the field especially with the elderly and finally with tests of sow in the ground. The grains that are made in the Mediterranean with different climatic characteristics, give a variety of grains such as: Majorca, Il Russello, the black of the Madonie, the Tumminia, the Martinella, the black buffalo, the black Scorza and the bidet which are all produced by the company with relative products of every kind of grain. All these are produced by the company itself in Pantelleria, Mozia, Libertina, New Chain and the Madonnines and Ustica. Pantelleria has been chosen because this year the pet-climatic characteristics have been favorable so that the grain will enhance its quality. Various seedings have been made at different heights on the site of Pantelleria realizing that at each height the grain has different empirical and physiological qualities. In addition, the grain was sown in a natural way without additives and fertilizers of any kind for 100% organic. The production cycle is established based on the nutritional qualities of the grain; the first phase consists in hand-cleaning the grain or through an automatic cleaner, from this it passes to the milling and becomes flour or semolina according to whether it is soft wheat or durum wheat, based on the quality of the post-milling result the transformation processes begin to make flour or semolina into finished products, namely pizza, pasta, biscuits. Therefore the company F.lli Vescera s.r.l from the result of the milling addresses the intermediate product in various directions in such a way as to produce different finished products for different purposes that are more adequate and closer to the tastes and customer satisfaction.

The machinery used within the company are the electric ovens for cooking the dough, Two professional kneaders, 3 refrigerators, biscuit and pasta machines. The company uses the production waste for animal husbandry, this to activate a supply chain process that tends to reduce waste to 0. The packaging is made by hand using a special machine which will soon be replaced with an automatic machine. The packaging is made in traditional plastic. The main customers of the local company are "Decò" and "NaturaSì" managing the entire transport around the perimeter that delimits the Catania-Syracuse area and owning sales points in Villasmundo, Lentini and Augusta in via Umberto. While foreign customers are Japan, Russia and Spain, in the latter place in 2017 it represented Italy and Sicily at the Republic Day at the Italian Embassy in Madrid. Instead the main suppliers are the farmers who produce and supply the grain, the primary products are purchased by various companies, the choice of purchase is based very much on quality but also on economic convenience, the

company where F.lli Vescera s.r.l. is supplied is the unigroup, finally another supplier can be the fruit and vegetable market where it is possible to take fresh food at km 0.

The company has few competitors because the production of organic bread involves many controls making the production more inconvenient, so few invest in this sector, a danger may be some bakeries that are able to prepare organic bread, but the biggest competitors are large industries producing organic bread and other organic finished products. The company F.lli Vescera s.r.l works with Ecogroup which manages the various excellent certifications to obtain credibility and guarantee of biological quality of Vescera products. As for the type of energy used, the company does not yet have renewable energy sources but aims to use photovoltaic and biomass to cover the cost of electricity which is around 2000/3000 euros every two months. Today the company has an investment perspective that is divided into two lines: Agricola: Expansion of the company with an agri-food garden aimed at visitation by groups of people to learn about the various ancient grains and also other varieties of traditional Sicilian plants with various rooms inside that will be used for conventions and lessons for training professionals to train and inform people interested in learning skills in this field. Following the variables that follow one another, F.lli Vescera s.r.l. will adapt and be proactive in its territory.

4. Biomass energy production

It is possible to obtain biomass or bioenergy through different technological solutions that can be separated into two basic categories, namely thermochemical processes and biochemical / biological processes.

The thermochemical processes, are the following:

- **Combustion**, used to convert biomass energy into heat, mechanical power or electricity, with this process the conversion efficiencies up to 40%.
- **Gasification**, this process convert the biomass into a combustible gas mixture of carbon monoxide, hydrogen and methane that can be burnt to produce heat and steam, or used in gas turbines cycles to obtain electricity. Conversion efficiencies up to 50%
- **Pirolysis,** which is the conversion of biomass into a solid fraction, a liquid fraction and a gaseous fraction by heating the biomass in absence of air.

As for as biochemical processes are concerned, the main conversion options are the following:

- **Fermentation**, that is used to produce ethanol from biomass containing sugar. Usually sugar is extracted through a crushing process; then it is mixed with water and yeast, and kept warm in a fermentator. The yeast breaks down the sugar, converting it to methanol. A distillation process removes the water and produces concentrated ethanol which is drawn off and condensed into a liquid form.

- **Anaerobic digestion**, that is the conversion of biomass into biogas, mainly composed of methane and carbon dioxide, by means of bacterial action in the absence of oxygen. This is a commercially proven technology widely used for treating high moisture content biomass such as MSW.

- Another technology is represented by **mechanical extraction processes**, able to produce energy informs of bio-diesel.

The type and quantity of biomass resource, energy carriers and the end-use applications, environmental standards and economic conditions are all factors that influence the choice of appropriate conversion process (Caputo et al., 2005).

In recent years in Sicily several technological revolutions have taken place in the sector starting also from new technological systems for agriculture that allow a greater selection of the same grain so as to optimize the collection of the stem to be used as biomass

with the anaerobic digester or with the method of fermentation. On Pantelleria the innovations necessary to make itself sustainable have not yet been reached, but with the right investors it is an achievable goal. Pantelleria is an island in the Sicilian channel that is about 110 km from the Sicilian coast. It is of volcanic origin and has a population of residents of only 7,800 inhabitants in winter while in summer we reach almost 20,000. Pantelleria is an island characterized by a dry climate and strong winds coming from the north and south-east, moreover the territory is very left to itself, finally a solar exposure 2,500 hours. The island being small and having few inhabitants needs little energy in fact an accurate analysis has defined that the total energy requirement of the island is of 87.830 MWh per year that is satisfied by some fossil energy sources transported by sea. To make the island self sustainable it would be enough to use all the renewable energy sources that the island has available:

- **water**: for the production of water energy
- only for the production of **thermal-electric** energy through the use of photovoltaics
- **intervention**: to build electricity through the construction of a wind power plant that will allow replacing the power plant consisting of 1. A wind power plant with 5 2 MW turbines totaling 10 MW 2. A lower storage tank of 225 thousand m3 . A tank at 690 m of an altitude of 500 thousand m3 4. A hydroelectric power plant of 10 MW 5. The cost of the power plant was 54 Million Euro financed partly by the Spanish government. The environmental benefits consist of lower emissions equal to: 18,700 t of CO2 100 t of SOX and 400 NO.
- **biomass**: if Pantelleria farmers decide to invest in biomass they would get energy from the waste of living material that up until now they have called waste, but tomorrow it will be possible to transform these types of waste into usable energy for various purposes (Parisi et al., 2015). One of the island's advantages is the possibility of offering an island with beautiful views, but in terms of tourist attraction compared to the other islands and far behind, 95% of the island is part of the national park, so the municipality has a power limited decision-making due to the bureaucratic slowdown of the two institutions, but the island has several natural spas, the lake of Venus immersed in the unspoiled nature of the island, the arch of the elephant, then the city of Pantelleria that offers the greatest services of the island, certainly the economic capital of the island there are bars, pizzerias, fish restaurants and hotels and the port of Pantelleria. Some areas of the island are difficult to reach for this reason the trips are sometimes not facilitated, Pantelleria also offers a lounge bar-restaurant that hosts customers even above the roof to let tourists enjoy the spectacle of the sunset over the sea on the island of Pantelleria with an excellent aperitif next door. At Pantelleria there is the airport that facilitates the accessibility of other national cities such as Milan, Catania, Palermo, Naples and other destinations.

For the transport sector, 46,560 MWh of energy is consumed, especially in the form of petrol and diesel. Inside the island is composed of: 5,200 cars, 1,100 motorcycles, 1,150 trucks). Considering an average efficiency of vehicles with an internal combustion engine of 30%, the mechanical energy requirement is approximately 15,000 MWh which could be supplied by electricity produced with wind turbines for a power of about 5.6 MW. The use of electric transport systems, brings advantages in terms of less pollution and energy independence, makes the set of accumulators of vehicles connected to the network form a distributed and shared storage system, for balancing the electricity grid and for satisfy demand in times of low production. For the smaller islands quickly reach food and economic energy sovereignty. Given the current production costs, the use of renewable sources is already competitive, bringing benefits from an environmental and economic point of view. (Parisi et al., 2015).

6. Concluding remark

This study has explained and demonstrated how through the waste of the wheat it is possible to produce biomass, used as fuel to create energy. This energy can be used to meet the energy needs of the field itself, reducing costs to 0.

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COMMUNICATION AS A PREVENTION TOOL: A KEY LEVER FOR GENERAL ACCEPTANCE OF THE ROLE OF INCINERATION (WASTE-TO-ENERGY) AND TRANSFORMATION PLANTS TOWARDS CIRCULAR ECONOMY*

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Abstract

These days, the public debate within European institutions and public opinion is characterized by different opinions about the willingness of EU citizens to accept an increased number of incineration and transformation plants. In Sicily (a Southern Italian region), like in many other areas, even if the general public shows a lack of comprehension of the phenomenon, at the same time we can see an increase in the awareness about the consequences of inaction and immobility. The solution is communication strategy in which the main stakeholders of the industry will share the advancements in knowledge on this subject to the public in a way that is easy to understand and metabolize. By working closely with the company "Ge.S.P.I. S.r.l. - Management of port and environmental services", located in Augusta, Italy, we have collected the data and concepts of one of the most advanced plants in Italy, in order to study how to democratize them to the wider population.

Keywords: democratization, NIMBY effect, social acceptance, transformation plants, waste management

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1. Introduction

Nowadays, the gap between Northern and Southern Europe in the field of waste management is becoming increasingly clear. Northern Europe (in particular countries such as Sweden, Austria, Denmark and Germany) is more sensitive to this issue, as demonstrated by the presence of numerous waste-to-energy plants in these entirely green countries. It is important to underline the difference between incineration and waste-to-energy plant: the former are plants that just burn waste, while the latter burn waste to produce energy. Even if the zero impact does not exist, these plants do not substantially pollute, as evidenced by studies by CNR and Ispra, but have the problem of waste, especially ashes and fumes. Such plants must comply with precise and restrictive regulations concerning the maximum limits of emissions of fumes and substances such as CO_2, SO_2 and NO_x. In this regard, in 2000 the Waste incineration Directive 2000/76/EC came into force in Europe, the objective of which is to reduce emissions and consequently the resulting risks to human health. In Italy, 30 million tons of waste are produced every year, of which about 1/6 tons are disposed of each year by plants operating in our territory, about forty or so, 63% of which are located in the northern regions. Despite this, our country was warned in 2004 and 2007 for the lack of proper implementation of the legislation. Important attention in favor of this technology is given by the European Waste Framework Directive 2008/98/EC, which defines an order of priority in waste management, considering the recovery of energy through incinerators a more technologically sustainable solution than landfilling. For this reason, modern waste to energy plants have 4 levels of filtration for flue gases and very advanced ash treatment and recycling systems.

Waste-to-energy plants can have a significant cost advantage over power options, as the waste-to-energy operator can get revenues for receiving waste as an alternative to the cost of disposing waste in a landfill (Giunta et al., 2017). Also, for these reasons, the recent epidemiological analyses carried out around modern plants have not shown an increase in diseases. In Northern Europe, waste-to-energy plants are located in urban areas. In Vienna, for example, "waste" is disposed of in a waste-to-energy plant in order to supply thermal energy to the nearby hospital. They are therefore seen not as waste in itself but as "fuel" to produce energy, new materials or slags that are N times more inert and less voluminous than a landfill or a different disposal technique. In Italy, and particularly in Sicily, public opinion is not yet sensitive to the use of waste-to-energy plants, because of the fear of emissions released and because of the NIMBY effect (not in my back yard), i.e. the protest by members of a local community against works of public interest on its territory but that would not oppose its construction in another place (Hsu, 2006). Such opposition may be motivated by fear of negative effects on the environment, risks to the health or safety of the inhabitants or a reduction in the status of the territory.

Since the NIMBY syndrome gained prominence, it has been characterized negatively based on two assumptions: (1) NIMBY facilities are essential to solve pressing social problems; and (2) selfish local parochialism generates conflict and prevents realization of that important social benefit. The aim of the paper is to use environmental communication tools, so that Italian citizens and stakeholders can be encouraged to understand the role of waste-to-energy plants, in order to ensure proper waste management and energy recovery within our land.

2. Materials and methods

In this paper we analyze how an environmental communication strategy might play a role to raise the awareness level of the public opinion. While it is very easy to analyze for the

expert in the field, all the sustainability indicators such as CO_2 emissions, shown in eco-balance sheets and sustainability reports (Adelle and Pallemaerts, 2009) or the Italian law DPR 254/2003, are something far from the common public debate, or the knowledge bubble of the non-experts. While a modern plant does more good than harm, the public opinion tends to take a strong position against this type of facility in southern European countries, Italy included (Mazzanti and Montini, 2013). While decision makers, scientific committees, professionals and insiders are well informed, the information isn't quite as widespread and simplified as per reaching the common citizen. The preference is on waste-to-energy incinerators rather than landfills with limits such as the burden of potential energy derived from them and because it is increasingly difficult to find a site where they can be placed (De Carli, 2017). In Italy 25% of waste ends up in landfills (EUlimit: 10% by 2035). Air pollution is one cause for concern: people misbelief that waste recovery releases dioxins into the air as a result of the combustion. In fact, dioxin are contained inside many materials, and the incineration process is calibrated to avoid the emissions in the air, resulting in a service to the population that eliminates the risk dioxin risk instead of provoking it. For instance, a clarifying comparison is: in Naples, the enthusiasm of the barrels and rockets produces on the New Year's Eve as much dioxin as 120 incinerators in full operation emit in one year. With regards to the landfill sites and air pollution, one must take into account the possibility of an accident. The fire that developed in the Ipb waste deposit of Quarto Oggiaro (Milan), where 16,000 tons of plastic and other residues had been stacked, may have produced as much dust as all Italian incinerators could emit in 2,700 years of uninterrupted operation. In a circular economy, waste that can be recycled is injected back into the economy as secondary raw material but they still account for a small proportion in EU. Many ways in which an incineration plant plays key social functions (Abbasi and Kamalan, 2017):

• Healthcare and pharmaceutical waste: huge risk of contamination, injury and spread of diseases or viruses. A plant like our case study assures the proper management of this threat.

• Petrochemical: needs characterization including quantity, type, and composition. Especially for industrialized areas: to have a plant in that specific region means to reduce costs for the management of hazardous materials coming from the manufacturing and industrial processes carried out in the area.

• Waste from vessel traffic: especially in Sicilian coasts. Boats used for illegal immigration may bring health risks with themselves, since those trips do not respect any authorized medical procedure and unfortunately have ill people on them that need to be cured as soon as possible. But also, illegal fishing which needs to be destroyed before it gets to people's tables for hygiene issues, or illegal drugs or substances trafficking by sea.

• Quality control: major agri-food producers destroy production batches if they find inconsistencies that could lead to health risks or commercial threats, and they hire the incineration plants to do the job.

• Miscellaneous and possible of the everyday life of citizens: proper management of home medications, batteries, carcasses of pets, masonry waste and so on: everything is taken care of by incineration plants and would otherwise end up in landfills or even illegally polluting nature.

Analyzing this chain, citizens are only aware of the middle step, that sees them as protagonists, and almost have no clue of what happens after the disposal of waste, especially those they do not produce directly (Fig. 1). This leaves space for fog and uncertainty that may lead to misinformation and incorrect formation of personal opinions on waste management.

3. Experimental

The case study of this paper is based on one of the most avant-garde plants in Italy and in Europe, and the owner company, one that has seen itself renovate many times in its history,

always focusing on innovation of processes, commercial practices and positive social outcome: "Ge.S.P.I. S.r.l.", located in Augusta, Sicily. One of the main innovations in their production cycle is a special incineration grid which is used to achieve dry extraction. It is the second company in Europe (after a Swiss one) to adopt this solution. The core business of "Ge.S.P.I. S.r.l." is to incinerate special waste via combustion to produce energy and minimize slags. The plant uses trash as a fuel for generating power. This fuel heats water into steam that drives a turbine to create electricity.

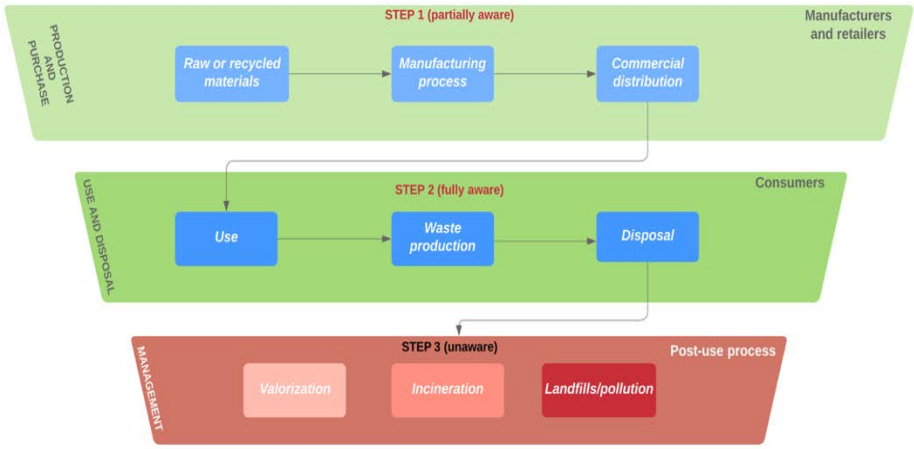

Fig. 1. Consumer awareness of make-use-dispose from goods to waste to process

The process can reduce a community's landfill volume by up to 90 percent and prevent one ton of carbon dioxide being released for every ton of waste burned (www.deltawayenergy.com). The result of the process is the production of energy, as well as the creation of ash; this ash is then treated in order to separate dangerous heavy metals from the ash through the technique of eddy currents. Metals and purified ash are then put on the market (Matarazzo et al., 2018). "Ge.S.P.I. S.r.l." has various certifications such as ISO 9001 that concerns the quality aspect of the product certified by "Rina Services" (www.rina.org) and ISO 14001 that regards the environment and the protection of it certified by "Certiquality" (www.certiquality.it). "Ge.S.P.I. S.r.l." intends to implement "Norma 231/2001" in the coming months. The company's plant offers the disposal of 45,000 t/a of special waste and the annual production of 11,166 MWh of energy, which saves 2088 TEP of primary energy, avoids 5,929 tons of CO2 and meets the annual energy needs of as many as 4,500 families. Plants such as Copenhagen and Vienna have higher capacities in relation to the size of their systems. The Copenhagen plant has two grate boilers, each with a capacity of 35 tons/h and a nominal thermal load of 112 MWh, as well as two wet flue gas purification lines. This guarantees a significant energy recovery, with an overall efficiency of 107%. (www.mater.polimi.it) In addition, it provides electricity to 65 thousand homes and hot water to 150 thousand. The Spittelau incinerator (Austria) currently has a capacity of 250,000 t/a, produces 40,000 MWh of electricity and 470,000 MWh of energy for district heating. This quantity is sufficient to provide heat for one year to more than 60,000 families in Vienna and produces air conditioning in summer.

A particular feature of the Sicilian plant is the adoption of a system for the dry extraction of slag which, in addition to reducing 50% of its volume, optimizes the oxidation process and allows a further 70% reduction in water consumption. This innovative technology

is in line with European objectives and ensures a concentration of dust significantly lower than the limits of the law. In order to study how "Ge.S.P.I. S.r.l." is positioned in its reference market, it is useful to look at its SWOT analysis (Table 1).

Table 1. The firm's SWOT analysis

STRENGHTS - Reliability - Technicians / managers - Innovative technologies - Production of energy - Different kinds of waste	**OPPORTUNITIES** - Extension of the plant - Proximity to the harbor and to other plants - Implementation of industrial symbiosis
WEAKNESSES - Proximity to the social contest - Limited spaces - Distance from important urban centers	**THREATS** - Lack of appropriate infrastructures - Regulatory progress and fragility of the legal system - Society disinformation and disturbing behaviors

Ge.S.P.I.'s claim: "We give more energy to your waste". The term"waste" is still present as a bridge from the current idea that the public opinion has, towards an updated and informed one.

4. Results and discussions

Table 2 shows the categorization of the communication elements that Ge.S.P.I. S.r.l. could implement in its integrated environmental communication strategy.

COST: on a scale from one ($) to three ($$$) indicates the impact of the relevant cost item

BENEFIT: on a scale from one (○) to three (○) indicates the potential effect of the action

Table 2. Communication elements we suggest the company to implement

Category	*Content*	*Form/Channel*	*Topic*	*Target*	*Goal*	*Cost*	*Benefit*
Direct communication	Sustainability report	Paper document, online content	CO_2 emissions, material recovering, social functions	Decision makers, stakeholders (plus banks and insurances)	Inform, convince, negotiate	**$**	○○○
	Brochure, pamphlets, leaflets	Paper	Touchpoints with real-life occasions of the consumers	Consumers	Reassure, change public perception	**$**	○○
Guerrilla marketing	QR Codes	Link to online interactive pages	Quizzes, games, short films	Consumers	Reassure, change public perception	**$**	○

	Artistic installations such as fake waste, miniature plants, huge billboards, chimneys	Artistic installations, art performances, shocking social experiments	Pollution, social functions of the plants, what would happen without them	Consumers, earned media	Shock, show, convince, fix a memory, sparkle awareness	**$$$**	○○○
Social media marketing	Free infoproducts	Posts, newsletters, website, online news	Simplified info for the non-expert	Consumers, families	Reassure, change public perception	**$**	○○
	Influencer marketing	Sponsored posts, celebrities, video-content	Light-hearted information in an entertaining form	Consumers	Inspire, convey positive emulation factors	**$$$**	○○
Activities and events	Workshops and guided visits	Innovative teaching techniques	State of the art	Students	Educate with first-hand experiences	**$**	○
	Hackatons	Event, competition	Technological challenges	Young professionals	Encourage, align with new technologies	**$$**	○○
	Startup Weekends	Event, competition	Business challenges	Entrepreneurs	Inspire, sparkle innovation	**$$**	○○

One notable example of a new concept that evolves the meaning of a plant facility to an actual enrichment to the urban ecosystem is a plant in Denmark, in Copenhagen city center. It not only deals with waste but is also recognized as a meeting place and tourist attraction, accepted by the population and a source of income for both public and private, thanks to the presence, on the roof of the plant, of a 600 m ski slope, a climbing wall and a picnic area, all accessible with a daily pass of 10 euros. (www.ilfattoquotidiano.it). Also the waste-to-energy plant in Vienna, located in the city center is among the top 10 best destinations for tourists. Destroyed by a fire in 1987, it was transformed into a colorful structure, full of windows separated by trees and a golden dome that is impressive on the city. It is important to note that such systems can therefore assume a prominent role in the city not only for their technical capabilities and their fundamental importance from the economic and environmental point of view, but also offering themselves as architectural and tourist attractions, thus becoming part of the daily life of entire populations who accept, respect and admire them. The stakeholders of Ge.S.P.I. are clients (who pay them to process their industrial/hazardous waste: hospitals and clinics, pharmaceuticals, agri-food producers, security forces and vessel traffic) and banks, insurance companies, investors and legislators.

Corporate social responsibility (CSR) is the integration of ethical concerns within the strategic business vision. Social Accountability International (SAI) has issued the SA 8000 standard to ensure that companies' working conditions respect social responsibility, a fair supply of resources and an independent process of control for the protection of workers. Ge.S.P.I. is compliant with it, so it is concerned not only with the protection of the external environment, but also with the protection of the personnel. Given the above-mentioned facts and assumptions, the premises of "Introduction" and "Materials and methods", and the repeatedly confirmed attitude of the company of our case study, our proposal for Ge.S.P.I. is to continue what they started with their claim, following Table 2.

5. Conclusions

Let's explore the possibility where not only one company follows this plan, but the majority of the stakeholders of the Italian ecosystem do their part or join the leader (like our case study could be). It will drive a process with much force and efficacy, recreating something similar of what's already happening in Northern-European countries since decades.

Italy would become an example of virtuosity in the circular economy that would lead South-Europe towards the efficiency of the other European, and consequently of the continent all towards a new level of sustainability never seen before and never so necessary.

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DISPOSAL OF WASTE BIOMASS TO POWER A RESIDENTIAL BUILDING SYSTEM THROUGH A CIRCUIT BASED ON RENEWABLE SOURCES IN EVALUATING NZEBs

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Abstract

Significant progress has been made in waste and biomass sector, especially in its energy exploitation. This review focuses on the pivotal role of waste biomass in creating residential buildings, including a smart system, which provides a union between who treats organic wastes and who transforms them into energy, contributing to improve a sustainable ecosystem as an efficient resource in order to contain energy consumption. According to European Directive 2009/28/EC, this essay highlights the way to create a self-sufficient residential building, powered with both a photovoltaic system and a biomass power plant. The synergy between the systems is guaranteed by the partnership of two Sicilian firms: F.E.R S.r.l., which operates in designing and incentivising Renewable Energy Sources, particularly in the photovoltaic solar power sector, and EcoHouse Immobiliare, which realizes sustainable residential buildings. Both of them are able to assure a low cost waste disposal and a cost amortization too. This project develops a way to generate energy with solar power and biomass resources, contributing to provide a sustainable development via the construction of Nearly Zero Energy Buildings. By the way, the present research shows how biomass energy in the construction of residential buildings has several economic and environmental advantages, such as reducing greenhouse gas emissions and minimizing the dependence on non-renewable energy resources. Moreover, due this analysis it is possible to underline the reduction of disposal costs and the fulfilment of the connected environmental benefits and decrease in costs.

Keywords: MMC (modern methods of construction), NZEBs (Nearly Zero Energy Buildings), RES (Renewable Energy Sources), solar panel efficiency, waste biomass

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1. Introduction

Since the early 1970's, the impact of environmental conditions linked with global warming have made necessary the super imposition and transposition of a bio climatic energy model to find solutions and technologies that can define an adaptive functioning of buildings development, including systems consisting of energy recovery from waste (biomass energy) and photovoltaic/thermal collectors. A commonly known interest in the global energy discussion scene is the rush of defining a new energy model with innovative energy-environmental standards, capable of creating a framework for the definition of near-zero energy buildings (NZEB) (D'Olimpio, 2017). Therefore, the main purpose is to construct buildings capable of adapting to climate and environmental changes determined by the seasonal cycles to reduce the energy demand of housing the consequential carbon emitted during the occupation of a building (Monahan and Powell, 2011).

The technical constructive scheme, from a practical point of view, highlights the execution of a renewed arrangement that requires innovations: to pursue such innovations, is it necessary to have *demand pull* and *research push* type incentives. Targets of investments in energy saving have been introduced on a national level by eight European countries, including Italy. The incentives support energy efficiency investments in residential buildings such as grants, target loans and tax relief (Annunziata et al., 2013).

More precisely, this kind of incentives have the goal of suggesting the implementation of innovative materials, new products and a smart process of structure development. Moreover, another goal of these incentives is to push for the publication of scientific research results on this matter. In this sense, the administrative procedures and codes provided by the directive 2009/28/EC-EX ART13- has set out a framework of ambitious authorization certification and licensing procedures to the process of transformation biomass into new energy. Moreover, "Member States shall recommend to all actors, in particular local and regional administrative bodies to ensure equipment and systems are installed for the use of electricity, heating and cooling from renewable energy sources and for district heating and cooling when planning, designing, building and renovating industrial or residential areas. Member States shall, in particular, encourage local and regional administrative bodies to include heating and cooling from renewable energy sources in the planning of city infrastructure, where appropriate". In point 6 of the above-mentioned article, "Member States shall promote conversion technologies that achieve a conversion efficiency of at least 85 % for residential and commercial applications and at least 70 % for industrial applications" (EC Directive, 2009). The ways to support the energy efficiency have to develop assets of technologies related to renewable resources, which have the aim to highlight the achievable synergies between the percentages indicated in the European Directive and the energy efficiency technologies in the building sector. Furthermore, the share of renewable energy in the energy consumption of NZEBs have to be calculated in the output of the energy performance calculations (Beerepoot, 2006). For this reason, the future research at national level should be able to adopt energy efficiency measures in order to integrate renewable sources and energy efficiency targets via the quantifiable targets for adopting renewable energy sources in NZEBs. The materials specified and the construction of technologies used greatly influence the overall embodied energy and carbon emissions during the construction phase. Another area of concern is the embodied energy associated with waste (Presson and Münster, 2016). This review which contributes to the increasing number of scientific research on the design and implementation of smart residence energy management system and on environmental models to realize it, shows a practical approach that is structured as follows: Section 2 "material and methods" summarizes regulatory and policy instruments adopted as tools to implement energy efficiency in residential buildings; Section 3 "Case study" describes the operative methodology if two local firms (F.E.R Srl and

Ecohouse immobiliare) and their activities in evaluating environmental solutions for architecture; Section 4 "Results and discussions" highlights the business plans of the two companies, in order to show the decisive integration of energy efficiency and clean energy technologies between the two aforementioned companies, understanding how to reduce the energy consumption and how to increase the adoption of renewable sources; Section 5 "Conclusions" defines the ultimate benefit that this research is hypothesizing; Section 6 "References" lists author bibliographies.

2. Materials and methods

Bio-energy and energy efficiency of residential buildings can strongly influence the entire energy use in the building sector (Hamdy et al., 2013). By the year 2020, a 20% reduction of the greenhouse gases emissions and a 20% of primary energy savings are expected to be achieved via the optimization of energy performance in buildings, following the climate and energy perspectives stated by the EU. Furthermore, the Institute of Sustainable Energy Policies (ISEP) predicted that by the year 2050, only 33% of non-renewable energy will be available for power generation. Therefore, the remaining 67% has to be replaced by renewable energy resources. The thermoelectric generator (TEG) that this research proposes proves to be a potential boon for small scale power production (Ismail and Ahmed, 2008) using direct conversion of its syngas into electrical power.

The photovoltaic/thermal solar collector sector is one of the fastest growing industries worldwide[8] and in other to maintain this growth rate need for new developments with respect to material use and consumption, devise design, reliability and production technologies as well as new concepts to increase the entire efficiency arises[7]. The photovoltaic system offered by F.E.R. S.r.l. is a General-Contractor with proper track records which can provide a performance bond to financers. A sample of 12 residential buildings is depicted in figure 1 (*F.E.R. S.r.l.'s sample of a PV system composed 12 residential buildings*), in which the photovoltaic system can be noticed, which is located on the residence's parking space, used as a canopy.

The present research is based on qualitative-longitudinal analysis of the synergy of F.E.R. S.r.l. and EcoHouse Immobiliare case study obtained by primary data collection methods based on data set implementation and secondary data information, such as research projects, non-written documents acquired from conferences and meeting and written documents obtained from reports and correspondences. In result of this, the object of this research is the hypothesis of the existence of a system composed of one TEG and a photovoltaic system for residential buildings, i.e. NZEBs.

With notable reference from the American Environmental Protection Agency (EPA), the issues raised by the Intergovernmental Panel on Climate Change (IPCC) prove, with quite enough certainty, the scientific evidence of Climate Change (Edenhofer and Seyboth, 2011). The search for solutions in this merit can be especially seen in the current debate on the sustainability of cities. In this regard, modern methods of construction (MMC), e.g. EcoHouse's modern houses based on wood, promote the idea of constructing environmentally and energetically efficient buildings. Moreover, the European Directive on Energy Performance of Buildings clearly states that all new buildings should be "nearly net zero energy buildings" (NZEBs) after 2020 (Lu et al., 2015) NZEBs are an effective solution to mitigating CO2 emissions and reducing the energy usage in the building sector, which is currently about 40% of worldwide energy (ASHRAE, 2011).

This empirical study on the implementation of a system of photovoltaic panels and a TEG in NZEBs is strongly connected with the concept of Circular Economy, for three main reasons (Iakovou et al., 2010):

1. Both EcoHouse Immobiliare and F.E.R. S.r.l. are significant entities in the management of eco-efficiency in the building sector, it is in fact notable that they are certified entities;
2. These two companies collaborate with each other with a flexible and eco-friendly vision, created by collaborative assets;
3. Both companies use the newest available technologies in their plants in achieving a cooperation strategy based on a vision that is projected to the future compatibility with Circular Economy technologies, i.e. considering the long-term benefits.

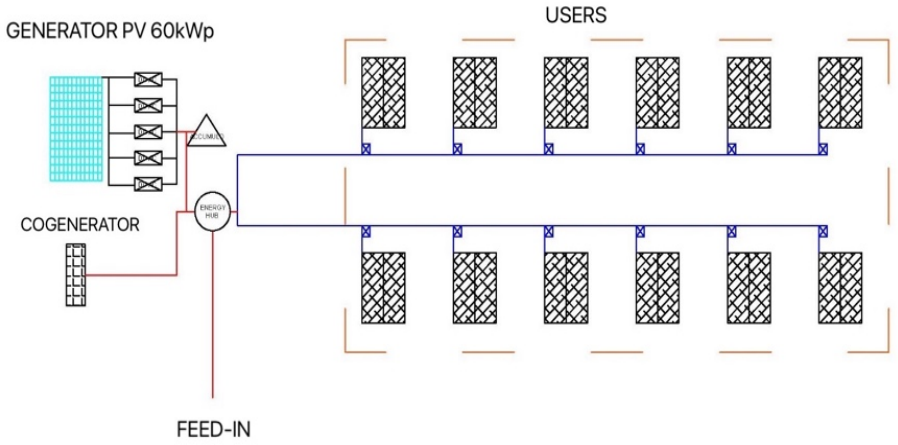

Fig. 1. F.E.R. S.r.l.'s sample of a PV system composed 12 residential buildings

3. Experimetal

3.1 Case Study: F.E.R. S.r.l.

This firm has been chosen because it allows us to express clearly our idea regarding green economy and renewable energies. Our aim is to power an entire residence building without the common uses of fossil fuels reaching the NZEBs. In particular, our firm is F.E.R. S.r.l. that is located in Catania, C.so Sicilia, 24, 95131, Italy. F.E.R. S.r.l. comes from the synergy of managers, engineers and designers and fans of the world of renewable energy, which after years of experience at the best companies, it dedicated to activities aimed at energy saving and energy production renewable, and that thanks to its know-how and experience, design, develop and implement photovoltaic and energy saving solutions. Moreover, consists of a highly qualified and experienced in different situations working in the field of photovoltaics that from 2007 to date have contributed to many photovoltaic and feasibility studies. It is able to offer advices and assistance to the design and construction. One of the purposes of the technical assistance is to provide the resources necessary for the development of new skills and competencies that designers and contractors will apply to future projects. Assistance may include education and training on new technologies and tools analysis. Partnering with designers and contractors can, depending on the needs of each case, extend up to turnkey management of design and construction of the plant photovoltaics.

The F.E.R. aims to show the development of photovoltaic systems in Sicily by using specially built structures in industrial or agricultural areas, targeting services. The company has conducted a study involving experts of different disciplines involved in design,

implementation and operation of photovoltaic and proceeded to do a check on field identifying the first potentially interesting sites.

The project involves the construction of photovoltaic systems located in Sicily where the level of solar radiation reaches peaks unreachable in the Italian territory. Consider also that the creation of ad hoc structures produces also a great advantage to be able to set the unit in an optimal manner in leadership term maximizing so electricity production expected from the system. For construction of the plants the company intends to use a General-Contractor with proper track records can provide a performance bond to the financers. The components used are of leading international brands known worldwide. The company organization chart is made up of a Chief Administrative Officer, a Manager Commercial, a technical manager who coordinates the staff-technical engineers (www.fotovoltaicoenergiarinnovabile.it). The company's organizational chart is depicted in figure 2 (*F.E.R. S.r.l.'s organizational chart*). The F.E.R. S.r.l.'s certifications in green economy sector are: KHC ESCo UNI CEI 11352:2014 N.104/17, SMC ISO 9001:2015

Fig. 2: F.E.R. S.r.l.'s organizational chart

3.2 Case Study: EcoHouse Immobiliare

EcoHouse is a real estate company which works in the green building sector. This choice depends on two reasons: the decline of the traditional real estate market and the big incentives from the State. EcoHouse is based in Adrano (CT) and was founded by a group of professionals that, although they came from the traditional construction sector, create a new Eco-friendly brand that links environmental needs with those of an economic nature. The main material that they use in their structures is glulam, a particular type of wood that is characterised by a high earthquake resistance and reduces the own flaws of massive wood through a pressure-making process. The plants that EcoHouse uses in their works are: solar panel and photovoltaic plant. EcoHouse decides to sell with a lower price than the prices adopted In the sector where they operate in order to filming the customers. An important characteristic of this type of construction is represented by the time. In fact, to build an EcoHouse dwelling, 120-150 days are required, while building a traditional dwelling needs 240-270 days.

4. Results and discussion

The PV plant (Azimut 45°, tilt 5°), placed in Catania, works within 60.00 power Kwp at an annual capacity of 1405 Kwh/Kwp for a capacity of 28.8 Kwh.

The business plan, evaluated for private customers, provides two variables (consumptions and costs):

1. The annual consumption, depicted in building consumption information, which shows a purchase energy cost which is expressed in ratio €/Kwh for 0,25 € at the counter power consumption of 3.0 KW. The estimate of the variance of consumption in the years is expressed by a percentage of 10. The increase of the purchase cost of energy is expressed by a percentage of 5.

The self-consumption is expressed by a percentage of 39, so the total consumption cost, expressed in Kwh, equals to 64800. In particular, in figure 3 (*Cash flow and break-even analysis of residential buildings*), in the time period between the year zero and twenty, the totals of cash flows (393.751 €), break-even (393.751 €) and total revenue (515.851 €) are displayed.

2. The PV's plant estimated total costs (including VAT) are equal to 122.100,00 €. This value, is structured as follows:

- plant cost PV (excluding VAT): 96.000 €
- plant cost PV/Kpw (excluding VAT): 15.000 €
- storage system cost: 15.000 €

In addition, is necessary to consider ordinary and extraordinary costs which respectively amount to 1.800 € per year. Moreover, there are insurance costs that amount to 60,00 € per year.

Year	Producibility	Cash Flows	Break-Even	Tax deduction	Subsidy Exchange	Surplus Net Metering	Outlay on Self-Consumption	Maintenance and Insurance Costs	Overall Revenue
0	0 kWh	- 122,100 €	- 122,100 €	- €	- €	- €	- €	- €	- €
1	84281 kWh	- 107,311 €	- 107,311 €	- €	7,140 €	1,260 €	8,309 €	- 1,920 €	14,789 €
2	84197 kWh	- 90,771 €	- 90,771 €	- €	9,208 €	526 €	8,725 €	- 1,920 €	16,539 €
3	84112 kWh	- 72,337 €	- 72,337 €	- €	11,194 €	- €	9,161 €	- 1,920 €	18,435 €
4	84028 kWh	- 51,848 €	- 51,848 €	- €	12,789 €	- €	9,619 €	- 1,920 €	20,489 €
5	83944 kWh	- 30,584 €	- 30,584 €	- €	13,085 €	- €	10,100 €	- 1,920 €	21,265 €
6	83860 kWh	- 8,632 €	- 8,632 €	- €	13,267 €	- €	10,605 €	- 1,920 €	21,952 €
7	83776 kWh	14,041 €	14,041 €	- €	13,458 €	- €	11,135 €	- 1,920 €	22,673 €
8	83693 kWh	37,472 €	37,472 €	- €	13,659 €	- €	11,692 €	- 1,920 €	23,431 €
9	83609 kWh	61,699 €	61,699 €	- €	13,871 €	- €	12,277 €	- 1,920 €	24,227 €
10	83525 kWh	86,763 €	86,763 €	- €	14,093 €	- €	12,890 €	- 1,920 €	25,063 €
11	83442 kWh	112,704 €	112,704 €	- €	14,327 €	- €	13,535 €	- 1,920 €	25,941 €
12	83358 kWh	139,568 €	139,568 €	- €	14,572 €	- €	14,212 €	- 1,920 €	26,864 €
13	83275 kWh	167,400 €	167,400 €	- €	14,830 €	- €	14,922 €	- 1,920 €	27,832 €
14	83192 kWh	196,250 €	196,250 €	- €	15,101 €	- €	15,668 €	- 1,920 €	28,850 €
15	83109 kWh	226,167 €	226,167 €	- €	15,386 €	- €	16,452 €	- 1,920 €	29,918 €
16	83026 kWh	257,207 €	257,207 €	- €	15,685 €	- €	17,274 €	- 1,920 €	31,040 €
17	82942 kWh	289,425 €	289,425 €	- €	16,000 €	- €	18,138 €	- 1,920 €	32,218 €
18	82860 kWh	322,879 €	322,879 €	- €	16,330 €	- €	19,045 €	- 1,920 €	33,455 €
19	82777 kWh	357,633 €	357,633 €	- €	16,676 €	- €	19,997 €	- 1,920 €	34,754 €
20	82694 kWh	393,751 €	393,751 €	- €	17,041 €	- €	20,997 €	- 1,920 €	36,118 €
Total	1669701 kWh	393,751 €	393,751 €	- €	277,710 €	1,786 €	274,754 €	- 38,400 €	515,851 €

Fig. 3: Cash flow and break-even analysis of residential buildings

The functioning of the TEG, which can be considered as the second part of the proposed system, is illustrated in figure 4 (*functional scheme of the TEG system*). The TEG could be located in a far off location, considering the possible confusion deriving from the accumulation of biomass. This model represents a microgenerator which operates as a machine to produce thermoelectrical and electrical energy, using a process of molecular dissociation of organic materials (biomass), obtained at high temperatures: pyrogasification.

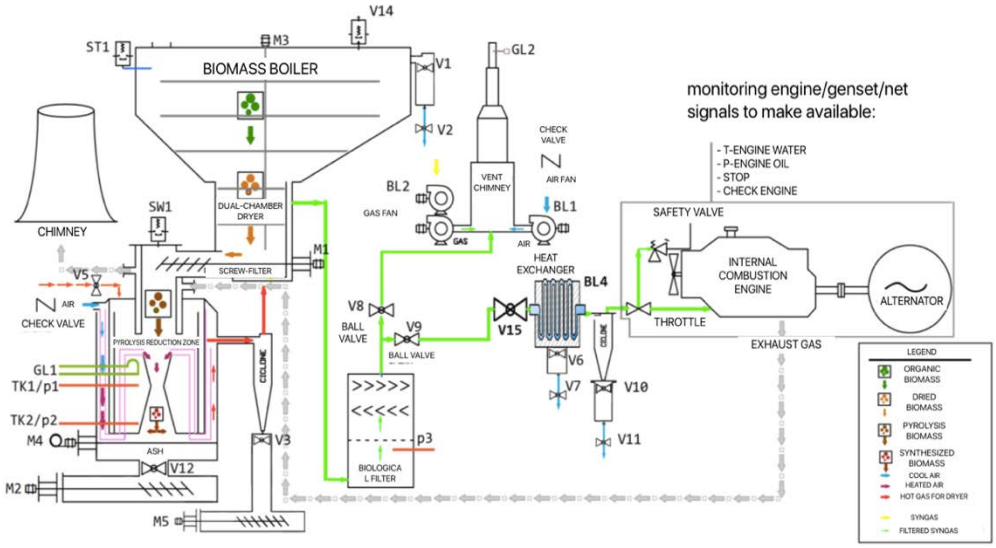

Fig. 4: Functional scheme of the TEG system

5. Conclusions

The present research was made possible thanks to the partnership of FER Srl and Ecohouse immobiliare through the support of the department of Economics and business of Catania (Italy). The system presented here provides an innovative way to generate renewable energy thanks to NZEBs.

Renewable energy sources play a pivotal role in The current global strategies to reduce stress in local ecosystem within the context of circular economy.

In particular, tris case study, through a business plan, highlights The capacity to generate energy with solar power and biomass resources, contributing to provide a sustainable development via The construction of NZEB. Biomass-to-energy plants offer both generation of clean electric power and environmentally safe waste management and disposal.

Analysing the possible advantages (ad shown before) is possible to reduce greenhouse gas emissions and minimizing The dependence on non-renewable energy resources.

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ENVIRONMENTAL PERFORMANCE INDICATORS REGARDING THE WATER SYSTEM IN A LEADER SICILIAN STEEL INDUSTRY

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Abstract

Recently, water scarcity and water quality have become two important issues for worldwide appeal and, for this reason, implementing a sustainable water management system is fundamental, considering that the steel industry represents a quarter of the global economy.
The outcome of this research is to create a digital control chart using environmental performance indicators (EPIs) that contributes to achieve both an environmental report and an eco-balance sheet in order to implement water saving measures and to enhance the management of the industry water system.
The firm which is the subject of this study is Acciaierie di Sicilia S.p.A., a leader steel industry located in Catania (Sicily) that believes in sustainability and proves it by implementing some voluntary certifications such as: ISO 14001 and Susteel concerning the environment and its protection.

Keywords: environmental performance indicators, reducing costs, steel industry, water system, water pollution.

1. Introduction

Since the industrial revolution, the pollution deriving from human activity has grown up exponentially and, recently, it has assumed significant importance, attracting, the attention of governments, companies and the population of consumers. A 2009 time magazine cover story, for instance, illustrates that consumers are increasingly willing to change their shopping behavior for environmental reasons (Stengel, 2009).

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Since the 1980s and 90s, in particular, there has been an increasing consumer focus on problematic social and ethical issues; concern regarding environmental degradation, pollution, waste, poverty, depletion of natural resources, human rights, distribution, justice and inter and intra-generational equity have increased in prominence. For this reason, today, a key element of competitive differentiation concerns the ability of the company to cope with the environmental problems generated during the production process, being more sustainable and using all the "environmental accounting tools".

These are divided into ecological balance sheet and environmental performance indicators. The first ones are information tools through which it is possible to analyze the environmental impact generated by the output of a production cycle. They are consequently divided into eco – balance, environmental balance sheet and environmental report. The second ones enrich the information activity through the data interpretation and transformation according to the regulation ISO 14031: 2013 which defines the EPI's such as that qualitative and quantitative values which allow to evaluate the efficacy and efficiency in the use of environmental resource from a firm or a sector (Clasadonte et al., 2005).

There are different types of EPI's and between them it is necessary to highlight:

- *Eco - financial indicators* which measure if a firm is sustainable or not, calculating the ecologic efficiency indicators which considers the output produced and the environmental impact.
- *Management indicators* which measure the firm's ability to reach environmental goals, the conformity to the environmental law and the reactivity to new acts.
- *Environmental impact indicators* are the category that wrongly encloses all the EPI's. It values the impact in monetary and physical terms.
- *Process indicators* are aggregated quantitative measures used to understand which is the production phase that mostly impacts. They are also a start point to make decisions and for this reason they are a sort of database.

Particularly, the focus of this research is on the process indicators because of their real contribution to make a firm more efficient and sustainable. But what does it mean more sustainable? According to the definition provided by the United Nations Commission for Sustainable Development, a development is "sustainable" if it is able to "meet the needs of the present generations without compromising the ability of future generations to meet their own needs" (UNWCED, 1987). Thus, sustainability represents fundamentally a "global" and "spatial" concept (Contrafatto and Burns, 2013) that refers to the "properties of a physical system in some physical space" and its capacity to sustain. The concept of sustainability embraces notions of eco-efficiency in the use of resources; and eco-socio justice in their distribution both intra-generational and inter-generational.

Besides, it is clear that communicating effectively with stakeholders on progress towards economic prosperity, environmental quality and social justice is a distinctive feature of corporate responsibility in the 21st century. In this sense, one of most important environmental accounting tool is the Environmental Profit and Loss Account (EP&LA) that is an instrument to report the environmental and economic performance of a company in combination, relying on emerging methodologies to calculate the economic impact of the company's operation on the environment. It is based on the idea of complementing "traditional" profit and loss account by creating a new document, which stands alongside the legal one, and introduces into its figurative revenues and costs related to different environmental impacts (Arena et al., 2015). In order to operationalize this methodology, two choices are crucial: the definition of the boundaries of the analysis and the methods used for the evaluation of the environmental impact (Bebbington et al., 2007). Concerning the evaluation methods, it combines three different approaches: the cost of preventing the environmental impact, the cost of repairing the environmental damage and the value lost by the community due to the environmental damage (Huizing and Dekker, 1992). Besides, it is

possible to extend the boundaries of the analysis to the entire supply chain, focusing on four dimensions of environmental impact: emissions, water and land use, and waste. In this case, some of the most evaluation methods are the "Social Cost of Carbon" (SCC) for air emissions; the "indifferent use value" for water; the loss of biodiversity for land.

The EP&LA, structured as described above, provides a synthetic view of economic and environmental performance, translating into monetary terms the environmental results, and is also used to support decision-making processes for the management. The aim of this research is to create a digital control system using environmental performance indicators (EPIs) that contributes to achieving both an environmental report and an eco-balance sheet in order to implement water saving measures and to enhance the management of the industry water system. This concept should be considered in a bigger context, the environmental report, where are considered also the air, soil and waste variables. Although the focus, at the moment, is only on the water resource, considering the problem about the exploitation and deterioration of this resource, which a growth about 55% is estimated, due to the incessant request made by the firm, which wants back in circulation the hot water originated by production cycle and this causes the ice-melting and the raising of sea level.

2. Materials and methods

As mentioned before, a company that uses environmental accounting tools and in particular environmental performance indicators (EPIs), it is able of monitoring and analyzing what is happening during the production cycle, in order to be always ready and conscious of what they are producing and, mostly, of how much their production chain may impact the environment. Integration of key sustainability indicators is quite essential for decision-making (Singh et al., 2006), often, they simplify the problem (Atkinson et al., 1997): for example, steel industry is one of the most impacting, not only because of the main raw material that is implemented. As a matter of fact, in these recent years, in order to become a responsible corporate citizen, the industry has responded to these challenges through adoption of pillars of sustainability (Singh et al., 2006), but there is more to considerate.

In terms of water wastes, in 2008, average freshwater consumption for per ton steel was 7 e 8.3 m3/t in most big steel enterprises of China, whereas the number was merely 3 e 4.2 m^3/t in developed countries (Jin, 2009). Since then, this problem has been faced so many times, and a lot of possible solutions have been given, such as the application of water pinch technology in network optimization (Gao et al., 2011). Throughout this paper, a new sustainable method will be analyzed, in order to reduce both water waste and water pollution and production costs, all this thanks to a more careful review of the Control Chart. Some indicators have been developed specifically for steel industry (Singh et al., 2006), indeed, each indicator's analytical soundness, measurability, cost effectiveness and time series completeness, it determines its usefulness for evaluations (Maclaren, 1996). Nevertheless, any indicator, taken alone, it is not helpful for the company, but they must be all considered into a framework, that will give to those who will look at it, a better chance to understand the situation and the best way to react.

3. Case Study: Acciaierie di Sicilia S.p.A.

Acciaierie di Sicilia S.p.A is a leader Sicilian steel industry located in the industrial area of Catania. It participates in a holding: *Alfa Acciai S.p.A* which is located in Bergamo, in the north of Italy. In particular, the holding's policy is focused on respecting both the environment and the quality of materials used and produced: such as the sustainable steel B450S which is their flagship product because of its being anti-seismic and eco – friendly.

For this reason, the outputs are both nationally traded and exported in Greece, Spain and northern Africa because of the favorable position of the steel industry in the Mediterranean Sea.

Indeed, company's customers are firms that works in civil constructions sector and for its green approach to the process, there are also companies interested in the process waste that buy for use it as aggregating asphalt and substrate road. Starting from their production process, it is understood that the company is dedicated to the circular economy, indeed, it works using the secondary method less impacting than the primary one. This second typology uses scraps as inputs and electricity as energy, they are both supplied by third which provide also to the furniture of methane, ferroalloys, cast iron and process gases.

The production cycle is divided into three parts corresponding to the units present in the plant: first of all, there is the scrap processing area where a collection of scraps is carried out according to adequacy criterion through a metal separator mill.
The second unit is the steelworks one, it melts the selected scraps through the electric arc furnace, subsequently they become molten steel which thanks to the steel bar it turns into square billets of 130 millimeters on the side or 6-12 meters long. Then, there is the department of rolling mill that uses as input the excess billets produced in the steelwork unit; they are heated through the methane furnace, then pass to the train pulpit to be reduced in section and finally steel beams are created, then they are cut and packaged in different lengths which varies from 6 to 15 meters. This typology has also the opportunity to be packaged as a coil about 1450 kilos.

The Sicilian firm believes in sustainability and demonstrates it through the implementation of an integrated management system according to ISO 9001:2015 for quality, ISO 14001:2015 for environment and ISO 45001:2018 for safety. In addition, company disposes about an Integrated Environmental Authorization related to energy activities, production and processing of metals, this mandatory regulation (Legislative Decree 152/2006) provides for the use of BAT, *Best Available Techniques*, widely owned by the company to improve efficiency levels of plants and reduce pollution. Moreover, firm is certified ISO 14021: 2016 concerning the content of recycled material and ISO 14025: 2006 with regard to the environmental product declaration and its impacts. Finally, company has the Susteel which is a voluntary certification of the sector and the ICQM ECO which measures environmental performance of the product.

Acciaierie di Sicilia until now, in the industrial symbiosis view related to water - safety, it has implemented purifier, iron – removing and water – waste treatment plant. Concerning the air variable, it has installed scrubber systems and gas cleaning to monitor and reduce fine dust and CO_2, then it has also injection system of carbon active which allows to control emissions and, in particular, mercury's ones. Additionally, the steelwork has the continuous monitoring of emissions to avoid environmental accidents and the dioxin sampler that has the same scope. Lastly, the firm wants to implement in the recent future carbon footprint, the water footprint and also the environmental performance indicators.

4. Results and discussion

Environmental performance indicators have been implemented in three variables with a higher risk of impact: air, water and wastes, though this paper focus only on the water system. The quantified indicators analyze four of six water resources present in the plant. This research keeps out two water resources because they are water in entry known as lake and *shaft*, consequently, they are exogenous to the production cycle and charged naturally about some constituent physical and chemical.

Instead, about the others four water resources, they have been divided according to the origin of the water such as: *first industrial drain* for water which origins in steelwork and

rolling mill units, *second industrial drain* when water sources from waste – treatment, *rainwater* that includes rain water and also water that is collected from steelwork and rolling mill units and *civil plumbing* for water which derives from offices and industrial services. In particular, values monitored are provided by the Environmental Integrated Authorization and they are more than twenty, between them five are particularly sensitive for this sector and they are iron, lead, copper, sulphate and zinc. Sometimes, they can be cause of anomalous values, the firm defines in this way those values which overtake an internal limit established at 80% of law limit. For example, if in law rules, iron cannot pass 2 mg\l, in firm's guidelines this limit can overtake 1.6 mg/L, and if a value is 1.8 mg/L for the law is not considered a risk but for the firm is something about work.

To make easier the identification of anomalous values and in emergency for law, it has been created a control chart on Microsoft Excel where all parameters has been inserted together with the methodology of data collection, the date of collection and the limits of the firm and naturally of the law. This control chart includes all six water resources, water in entrance too, with the aim to make an evaluation about the company's performance and the impact that its production cycle has in entrance water.

To establish environmental performance, trends inspected report to a period of five years included (2013 – 2018). In those years, there are not in absolute values in emergency, sometimes anomalous values are present especially in summer, due to, as it was observed before, iron in this season tends to increase its value, a growth that is reflected also after the production cycle and all this creates an anomalous value. According to industrial secret, it is not possible to report punctual values, but considering one of multiple graphics realized to investigate environmental performance indicators through the EPI's. In the graphic above (Fig. 1) there are reported the EPI's trend for iron, considering in x – axis the period analyzed and in y-axis the values analyzed.

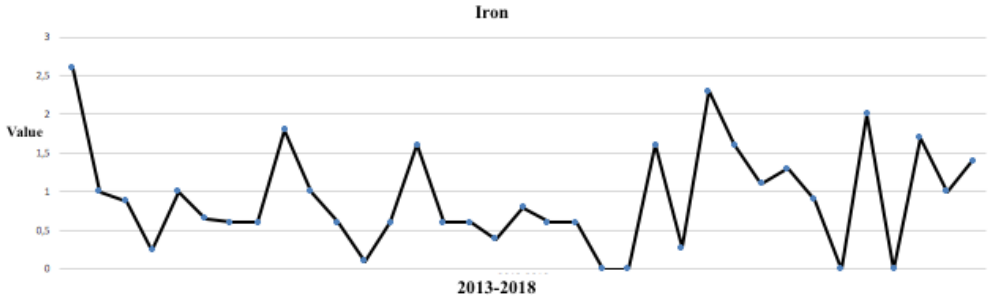

Fig. 1. "Iron in first industrial drain"

The advantages deriving from the use of EPI's and a control chart have a double nature: environmental and economics. On one hand, from an environmental point of view, through this continuous monitoring it is easier to understand if there are gaps between company's environmental policy and operating planes arranged to realize it. In this way, environmental accidents are warded off and consequently also ethical, legal and economics problem. On the other hand, from an economical point of view, monitoring the performance makes the production cycle more efficient than before, because it highlights the energetic inefficiency, input wastefulness and creation of non – output that are waste. To resolve this, it is possible to intervene through the implementation of BAT directly on that phase of the process allowing to save energy, trade of inputs and waste disposal, even if Acciaierie di Sicilia S.p.A sells its waste – process. Lastly, it involves a cost reduction and a lightening of

balance sheet item, particularly considering that this analysis is made to realize a complete eco-balance sheet concerning also the air, soil and waste variables.

5. Conclusions

In conclusion, environmental performance indicators allow steel industry but in general companies to monitor their processes and make them more efficient because the environmental accounting tools and the EPI's highlight where the problem is and consequently in what phase it is suggested to intervene.

These tools permit to avoid waste and in water context they allow the preservation of first quality water, considering that nowadays it is a routine issue for global governments.
The use of the best available techniques promoted by European Union allow the water conservation through methods of filtering, purification and reuse.

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ECONOMIC AND ENVIRONMENTAL ASSESSMENTS OF COSMETIC PACKAGING. CASE STUDY OF AN INNOVATIVE STARTUP*

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Abstract

In recent years, the Italian cosmetic industry has been experiencing a period of constant growth, with huge international exports that represents a serious threat to the environmental sustainability of our country and beyond. The materials used for industrial packaging are often produced with virgin raw materials that often cannot be recycled. The analysis carried out in the sector has made it possible to understand that a conversion to green-oriented logistics, would reduce the negative impact and achieve cost savings. In fact, these days, the use of bioplastic for packaging is an ideal substitute in a sector where 'throwaway' is the only distribution practice used. To this end, an innovative startup that is experimenting with a green-oriented logistics system has been analyzed.

Keywords: bicycles, cosmetic industry, environmental awareness, fossil plastic, green-oriented logistic, recycle, unsorted waste

1. Introduction

Since 1960, the production of plastic has raised more than 20 times on a global scale and it has skyrocketed, achieving a shocking amount of 322 million tons in 2015 (European Commission, 2018a, b). Indeed, since 1980, the plastic industry has had a growth rate of 3.4% (Kuruppalil, 2011). Furthermore, Europe generates over 25.8 million tons of plastic waste every year and less than 30% of this waste is recycled (European Commission, 2018b).

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Unfortunately, recycling of plastics has really low levels, especially if compared with other materials as, glass or paper. These are just some of the many terrifying numbers that show how critical the effects of plastic pollution are. The most affected areas are the marine ecosystems.

Every year, globally, more than 13 million tons of plastic are poured into the oceans (European Commission, 2018b). As these data show, plastics is the mostly used material, especially for packaging. The reason for this can be found in some attractive properties of plastic such as heat seal ability, transparency, softness (Cinelli et al., 2019). The source of most of the plastics commonly used is petroleum and, consequently, they are non-biodegradable plastics, or they take more than 10 years to degrade. A great solution for this problem is the so called "green plastic". The adjective "green" is used to refer to some specific properties of plastics such as source renewability, biodegradability and environment compatibility (Kuruppalil, 2011). This type of plastic is also called "bioplastics", in which the greek prefix "bio" means "human life" (Johansson et al., 2012). As a consequence, the term "bioplastics" is referred to both biodegradable material and materials from renewable resources (Johansson et al., 2012). Bioplastics have positive effects on the environment, the society and the economy (European Bioplastics, 2016). Indeed, they have multiple advantages such as reduction of CO_2 emissions, depletion of the number of toxic run-offs, decrease of carbon footprint (Reddy et al., 2013). Furthermore, bioplastics have incredibly important properties, both physical (density, water content, degradation time) and mechanical such as tensile properties (Van de Velde and Kiekens, 2002).

The plastic pollution's impact is increasing especially in the cosmetic market, that is growing at a yearly rate of 6.4% and is expected to reach 675$ billion in 2020 (Cinelli et al., 2019). Considering the growing importance of the cosmetic market, it is focusing on spreading messages on the usage of "sustainable" packaging for their products (Cinelli et al., 2019). "Sustainability", as defined by the European Commission (2018b), "is not only a legal obligation, it is an opportunity for all parts of Europe and underpins most EU priorities". Indeed, sustainable products have the crucial advantage of fulfilling the present generations' needs without compromising the future generations' ones. To conclude, it can be said that bioplastics are fundamental to fix this critical existing problem and they are the result of a common effort of all the people in our society. The aims of this paper are to make the reader more aware of the use of plastic. It is important to know what are the effects of continuing to maintain negligent behavior, even in small actions or choices, such as the choice to purchase a product that can be recycled plastic, easily recyclable or even better reusable; reducing the use of disposable plastic. In particular, in the case study that we are going to analyze, the goal of the company that operates in the field of cosemetics and detergents, is to be able to raise awareness and to let more potential customers adopt a sustainable and alternative system to the waste of disposable consumption.

2. Materials and methods

Bioplastic is a type of plastic that can be biodegradable or bio-based or possess both features. A bioplastic can be defined as "bio-based" when it is biodegradable and consists wholly or in part of annually renewable plant raw materials. A bioplastic can be biodegradable, even if it is derived from fossil oil. From a practical point of view, biopolymers offer two main advantages when compared with synthetic plastics (Table 1):

- biodegradability/compostability,
- eco-friendly,
- availability from renewable resources.

Table 1. Advantages and disadvantages of plastics and bioplastics

	Petrochemical	***Partly Bio-Based***	***Bio-Based***
Non-biodegradable	PE, PP, PET, PVC, PS	Bio-PET, PTT	Bio-PE
Biodegradable	PBAT, PBS(A), PCL	Starch blands	PLA,PHA, Cellophane

Currently the only European standard that specifies what is meant by "biodegradable plastic material" is En 13432 of 2002, dedicated to compostable packaging, adopted in Italy as UNI EN 13432: 2002 and determines the compostability criteria of a certain bioplastic in an industrial composting plant: high temperatures (55-60 °C), at a given humidity level, in the presence of oxygen: conditions more suitable for biodegradation than the natural conditions of biodegradation in the soil, in a marine environment or in fresh water.

The bioplastics currently on the market are mainly composed of corn flour or starch, wheat or other cereals. Moreover, we can have nanocellulosic materials, which they are based on renewable matrices and fillers for applications in packaging markets thanks to the great variety of polymers that can be extracted and or synthesized from bio-based sources the most widely used biopolymer in packaging is the polylactides (PLAs). Chemical industry has been investing in the bioeconomy and the production of bioplastics in recent years. Advanced biorefineries use chemistry to convert renewable resources into sustainable chemicals, materials and fuels.

Circular economy package represents an opportunity for bioplastics, they contribute positively to our economy, our society and our environment. They represent an innovative sector that is growing between 20% and 100% per year. Bioplastics sector depends on a long-term policy framework which supports the use, re-use and recycling of these materials (Table 2). According to International Union of Pure and Applied Chemistry (IUPAC), a bio-based polymer or bioplastics is derived from biomass or produced from biomass derivatives (Maheshwari et al., 2013). The most used polymers are High density poly(ethylene) (HDPE); poly(propylene) (PP), non-transparent packages; and poly(ethylene terephthalate) (PET), transparent packages. This rigid packaging fraction is generally recovered from waste and separated from other plastics. In several countries, the fractions consisting of HDPE and PP, and PET, are obtained. The packages are then transformed into scraps, washed, and then used to produce recycled products.

Table 2. Bio-plastics vs. oil based plastics

Property	***Bio-plastic***	***Oil based***
Renewable	Yes	Partially No
Break down in the environment	Biodegradable and/or compostable	Some degradable by polymer oxidation
GHG emissions	Usually low	Relatively high
Fossil fuel usage	Usually low	Relatively high

Nowadays there is high and increasing demand for packaging made from bioplastics. Biodegradable and bio-based polymer matrices will be an added value versus the petrochemical-based polymers that are not bio-recyclable. "The impact of cosmetic products on the environment, in particular on the marine one, is one of the most recently recognized and most worrying forms of pollution. Even at very low concentrations, the ingredients of cosmetics show very strong biological effects on aquatic life, largely unknown part" in Italy, compared to over 130 million packs of 250 mL shampoos consumed in 2009, 4,557 tons of waste were produced.

It is estimated that only in Europe, 5,100 tons of cosmetics are thrown into the sea every day. Faced with such an important datum, it is certainly useful to stop and reflect on the practices that lead to such a deleterious impact and on what can be done to stem it.

The harmful environmental impact of a cosmetic can take place in different phases:

• process of production of the ingredients: an ingredient deriving from the extraction of oil will pollute much more than a vegetable ingredient produced, for example, by an organic farm;

• production process of the finished product: in the same way, a chemical ingredient will involve the disposal of a certain amount of non-biodegradable waste, which in most cases will be thrown into the sea;

• packaging: a cosmetic product whose packaging, after the product has run out, cannot be reused

• transport: a cosmetic product in Italy will have involved an expenditure of energy and fuel, and therefore a production of polluting material, less than a cosmetic coming from from the United States or foreign countries in general;

• daily use and elimination of residues: throw the foam of a shampoo containing petroleum substances into the drains (or throw a certain amount of expired cream into the garbage) and therefore not biodegradable, it represents a greater pollution than the same amount of shampoo produced with vegetable ingredients.

The global cosmetics market, already $460 billion in 2014, is still growing, and is expected to reach $675 billion in 2020, thus showing a 6.4% growth rate per year. There is an evident, strong trend towards the use of sustainably produced raw materials in the cosmetics field, mainly as active ingredients in formulations. Sustainably produced raw materials are being introduced into the cosmetics field not only as ingredients for cosmetics, but also as components of the packaging materials. Indeed, cosmetics marketing stresses that the use of green, possibly compostable or biodegradable packaging is an added value to the cosmetics product, since it witnesses customers' and producers' environmental attitude and care.

3. Experimental

The company studied is a new startup, born from the commitment and dedication of his founders, it's located in Holland, but they work also in Bologna. In order to proceed with the analysis of the discussed sector, a collaboration was carried out with this start-up which will be analyzed. Perpetual Product is an innovative start-up with a strong green soul that wants to make a difference in the logistic of cosmetics sector through a restructuring of the old process. The startup wants to promote the use of biodegradable bioplastics, in fact, they take care of offering alternative containers to those supplied by the producers that can contain perishable products such as cosmetics. The objective of Perpetual Product is to put customers in front of a choice, offering not only recyclable packaging but also an alternative way of the distribution of products using green or zero-impact vehicles, such as electric bicycles or electric cars to cover greater distances. The service offered consists of a circular relationship with the customer, who will purchase the products of his interest on the perpetual products website, the operators will deliver to their homes through the use of green electric footprint vehicles; once the product is finished, the customer can reorder the product by delivering the old packaging to the operator upon delivery of the new one. Perpetual products will take care of disposing of the packaging in the most suitable way.

Perpetual product with a view to continuous improvement, is looking and working for voluntary certifications, ISO 14001 (2015) would be a great way to grow and enter the market as a pioneer company in a new way to market goods with low unit value and more. In this initial phase, Perpetual product's team is trying to test the methods designed and establish relationships with providers and customers. The chosen suppliers are producers operating with

attention to materials and production methods, many of them are certified for organic production and, on the other side, reference customers are more sensitive to the footprint they leave on the environment.

4. Results and discussion

The case study has been developed in order to understand how the use of recyclable and reusable materials can lead to a reduction of management costs and a lower environmental impact. For this, the company analyzed by us intends to modify the internal management process by relying on more efficient logistics, since it allows us to use green vehicles in order to obtain a saving of internal costs, as well as a reduction in CO_2. The objective of the company is to create a business, starting from the fast delivery systems that in the field of food and beverage have spread widely in recent years, the company wants to enter the market through the delivery of body care products for which this delivery method has not yet been applied. One of the goals set is to create this zero-impact business, so it can help alleviate the scourge of single-use packaging pollution, and thus pursuing social and environmental protection objectives. A virtuous bond is created between producer and consumer, in which Perpetual Products acts as an intermediary. It is possible to resume the main objectives of the company:

- Green vehicles
- Volunteer certification
- Supply-chain optimization
- Biodegradable packaging

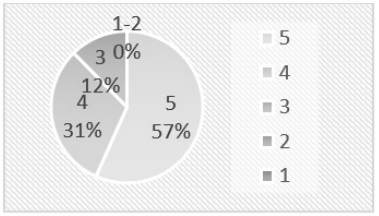
In terms of strategic objectives, a series of investments in marketing will be implemented in order to make the company better known and also investments within the company itself, in order to acquire in the future new vehicles with zero impact such as electric bikes and other two-wheeled vehicles more innovative. The distribution of products ordered by electric or emission-free vehicles allows a reduction in delivery times as well as a lower impact on the environment.

The objective of the company is the reusing local product in order to avoid further waste. With the delivery of high-quality products and the collect of empty packagings, the company pursues a better strategy. In the future, the company will intend to obtain certifications, in particular, the ISO 14001 (2015) regarding the environment in order to reach an added value and to become more attractive towards competitors.

Also, the company performs an important intermediary function as it arises between manufacturer and end customers by acting as a go-between in the supply chain. Moreover, among the strategic objectives posed by the start-up, there is greater attention to customer relations. In fact, customers who request delivery of the various products are loyal and, even if they pay an additional price, are aware of the impact of the activity almost zero carried out by the company. This allows making the consumers more satisfied producing only what they require.

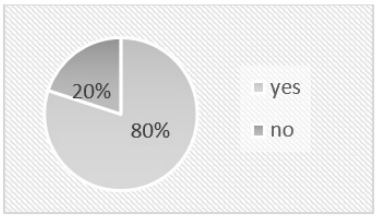
In the initial phase of idea development and testing, the start-up collaborators proceeded to administer questionnaires to a sample of subjects of various ages (Fig. 1). Through the questionnaire it was possible to highlight the position taken by these subjects with respect to the pollution issue, and more specifically, that deriving from the use of non-biodegradable plastic. The start-up will be able to keep pace with innovation and the need to combat environmental pollution through the use of biodegradable plastic. This in order to make consumers aware of the need to protect the environment and to prevent the plastic already in use from ending up in the landfill. Being still a start-up in a phase of increase it is not possible to explain the various results in economic terms and of environmental impact in the long term but in future, this will be made available.

a). Sensitivity of the subjects subjected to the questionnaire, through the use of a scale of values from 1 to 5, in which 1 indicates not interested and 5 very interested.



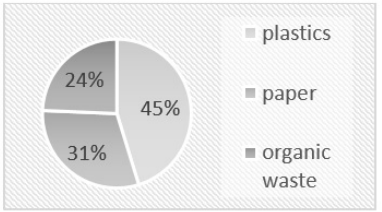
The data obtained from the questionnaires allowed us to observe how more than half of the sample has a very high sensitivity to the topic in question. While only a small percentage showed a neutral interest. Moreover, no person has expressed a value from 1 to 2.

b). Percentage of subjects interested about use of biodegradable or recycled products.



This survey gave us results in line with the analysis carried out in previous graph, demonstrating that the subjects not only know or sensitive to the topic, but are also willing to change their habits in order to impact less.

c). Percentage of materials presents in domestic waste.



From this survey, it was possible to highlight that not only plastici s present in waste but also other impacting materials, such as paper and organic waste; however, it is clear that the largest slice is represented by the plastic.

Fig. 1. Results of questionnaires on the position taken by subjects with respect to the pollution issue, deriving from the use of non-biodegradable plastic

5. Conclusions

This case study shows how important it is to pay attention to the factors influencing climate change and pollution of our planet such as emissions into the atmosphere and the use of environmentally friendly and environmentally friendly materials recyclable products and services. This increased sensitivity to environmental issues has been felt by entrepreneurs from the national territory who, thanks to their business activity, focus on process innovations that allow cost savings and environmental impacts.

In fact, the start-up has implemented and in the future will tend to implement sustainable investments, in particular regarding the means of electric transport to the aim to zero the emissions of CO_2. These are used in the performance of its business for home delivery to customers who require the various products. The objective of the company will be to make itself known more and more in order to raise consumer awareness on these issues, in particular also for the less impact that the use of bioplastics results.

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SIMULTANEOUS DETERMINATION OF CHLORINATED ORGANIC POLLUTANTS IN ENVIRONMENTAL MATRICES*

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Abstract

Epidemiological studies have shown that the exposure to Persistent Organic Pollutants (POPs), such as polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDDs/Fs), polybrominated diphenylethers (PBDEs) and polychlorinated biphenyls (PCBs), is associated with negative interferences on the endocrine system. The determination of these pollutants in the environment, is of great importance for ecotoxicological point of view. The accurate analytical determination is however a challenge, both for the low concentrations found in the environment (at the trace levels), and the complexity of real matrices. Furthermore, the need for use of sophisticated and costly analytical instrumentation represents a further element of complexity. In this paper, a method for simultaneous determination of PCDDs/Fs, PCBs and PBDEs in environmental matrices with a single extractions is shown. The use of Accelerated Solvent Extraction (ASE) gave excellent results compared to other traditional extraction techniques. Gas chromatography coupled to triple quadrupole tandem mass spectrometry was used as detection technique. The developed methodology was then applied to the analysis of marine sediments taken from a contaminated marine coastal area. The analysis of the distribution of the PCDDs/Fs and PCBs congeners in the analyzed samples (Fingerprint), has proved an effective tool for the identifying the sources of contamination of these pollutants.

Keywords: accelerated solvent extraction, chlorinated organic pollutants, GC-MS tandem

1. Introduction

The presence of toxic substances in the ecosystem has always been a problem of great importance both from an ecological and a social point of view. Some of these compounds are

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very dangerous because they are highly persistent and bioaccumulables. Polychlorinated dibenzo-dioxins (PCDDs), Polychlorinated dibenzo-furans (PCDFs), Polychlorobiphenyls (PCBs) are today some of the main categories of contaminants also known as "Priority Organic Pollutants (POPs)", regulated by the Stockholm Convention of Persistent Organic Pollutants (Stockholm Convention, 2001). To these are added "emerging" contaminants such as Polybrominated diphenyl ethers (PBDEs), Pharmaceuticals and Personal Care Products (PPCPs). The problem of the analytical determination of these compounds is linked to the very low concentration in real matrices (ppb or ppt levels). Given the complexity of environmental matrices, the analytical determination requires a complex sample preparation and the use of highly sensitive and selective instrumentation. A review of the main analytical methods for these organic contaminants has been effected by Reiner (2010). Among the official methods used at international level, the US-Governmental Environmental Protection Agency (US-EPA) has proposed a series of methods for the determination of these compounds in various matrices, using the gas chromatography (GC) coupled with high resolution mass spectrometry (GC-HRMS) (US EPA, 1994, 2007, 2008). This technique is considered the reference technique for the analysis of dioxins and chlorinated compounds because is highly sensitive; however the US-EPA methods is time consuming and not suitable for extensive environmental surveys and the analysis of a large number of samples. Moreover, the presence of interfering compounds in real matrices (e.g., humic acids and fats) may affect the detection of analytes; therefore, to remove these interferences the official methods require one or more clean-up steps.

The aim of the present work has been the optimization of an innovative method for the simultaneous determination of three classes of chlorinated compounds in complex environmental matrices based on selective extraction by Accelerated Solvent Extraction (ASE) in order to reduce both the analysis time and the use of toxic organic solvents. The development of the analytical method concerned the determination of the most important environmental congeners of the various contaminants. For dioxins and furans, the congeners examined have been those most toxic and structurally similar to 2,3,7,8-TCDD. For PCBs, the 12 "dioxin-like" congeners and the 6 PCB markers were considered; the sum of these congeners represents 50% of the total PCBs contamination in the environment (APAT, 2006). In addition, PCB 128 has been determined which, although it is not a "dioxin-like" congener, is in any case required by the current regulations on environmental monitoring. For PBDEs, the congeners 28,47,99,100,153,154 have been determined. Gas chromatography coupled with triple quadrupole tandem mass spectrometry was used as a detection technique. This technique proved to be more effective than high-resolution GC-MS especially for screening a large number of samples (García-Bermejo et al., 2015; L'Homme et al., 2015). Quality parameters of the method (e.g. extraction recoveries, linearity, limits of quantitation) were also determined. The method developed was then applied to the determination of contamination levels in matrices of environmental interest, such as marine sediments.

2. Materials and methods

2.1. Reagents and standards

All solvents used were HPLC grade purity for trace analysis. N-hexane, dichloromethane, nonane, sodium sulfate, sulfuric acid and silica gel were purchased from Sigma-Aldrich (Steinheim, Germany). Ultra-pure water was from a Milli-Q purification system (Millipore Corp., Bedford, MA).

A set of five calibration standard solutions (CS1-CS5) of the 17 toxic chloro-substituted PCDDs/Fs containing the corresponding ^{13}C-labeled compounds in nonane (EPA-

1613 CVS), were obtained from Wellington Laboratories Inc. (Guelpth, ON, Canada). These standards have been used to obtain the calibration curves and analytical quantification. A mix of ^{13}C-labeled PCDDs/Fs was spiked to samples prior to extraction, in order to recoveries calculation. Calibration standards for PCBs were purchased from O2si (Charleston, SC USA). Labeled 2.2',4.4',5-penta BDE (BDE-99) was purchased by LabService Analytica (Bologna, Italy).

2.2. Sediment samples

Superficial marine sediments (0-15 cm) to be analyzed were taken in the First Inlet of the Mar Piccolo basin in Taranto (Ionian Sea, Southern Italy); this coastal marine area is subject to high anthropic impact. Taranto, in fact, is a highly industrialized town for the presence of a large steel and iron factory and an oil refinery of ENI. The samples were taken using a Van Veen grab. Immediately after collection, the samples were frozen, then lyophilized and homogenized.

2.3. ASE extraction

The Accelerated Solvent Extraction (ASE) for examined compounds was carried out in 66 mL steel cells using a Dionex extractor model ASE 3000 (Bjoërklund et al., 2002; Dionex, 2000); 5 g of lyophilized sample were mixed with 15 g of anhydrous sodium sulfate, 15 g of copper powder, to eliminate the sulfur, 5 g of silica gel and 10 g of silica acidified with H_2SO_4 (Si/H_2SO_4, 60/40). To the sample mixed with diatomaceous earth, it has been added the mixture of standards for the recoveries calculation. The extraction was then carried out with n-hexane at a pressure of 1500 psi with a cycle lasting 11 min. Four consecutive extraction cycles were carried out to obtain satisfactory extraction yields. The final extract (about 250 mL of hexane) was evaporated under nitrogen flow up to a volume of 0.5 mL by using a Turbovap evaporation system (TurboVap® II, Caliper). 10 µL were taken from the extract for PBDEs analysis. The remaining part was added with 10 µL of clean up standard solution and subjected to purification by column chromatography for PCDDs/Fs and PCBs determination.

2.4. Extract purification

The purification of the hexane extract for PCCDs/Fs separation from the PCBs was carried out with the automatic chromatography system Power Prep Fluid Management System (LabService, Bologna, Italy). The system uses the Solid Phase Extraction (SPE) and consists of teflon columns containing multilayer silica and alumina. The multi-layer silica column (ABN = acid-base-neutral) eliminates interfering compounds and fats; in particular, the acid phase eliminates basic interferents and initiates the hydrolysis of fats, while the basic phase eliminates the interfering acids and continues the hydrolysis of fats (saponification). The neutral phase carrying out an action of dimensional exclusion on molecules with a higher molecular weight such as lipids. The alumina column, operating by polarity restrains PCDDs/Fs and PCBs which are then eluted with different solvents: dichloromethane (DCM) at 8% hexane for PCBs elution and a 1:1 n-hexane / DCM mixture for PCDDs/Fs. At the end of the purification process two different extracts were obtained: 150 mL of a 8% DCM / hexane, and 90 mL of 1: 1 DCM/hexane. These two solutions were evaporated under nitrogen flow. Subsequently, the two residues containing separately the PCBs and PCDDs/Fs was dissolved in 500 µL of nonane and analyzed by GC-MS.

2.5. GC–MS analysis

GC-MS analyses were performed with a gas-chromatograph (Agilent Technologies 7890B GC System) coupled to a triple quadrupole tandem mass spectrometer (QqQ) (Agilent Technologies 7000C GC/MS Triple Quad). The gas chromatograph was equipped with an auto-sampler (Multi Purpose Sampler MPS - Gerstel) with 10 µL microsyringe. The split/splitless injector, used in the splitless mode, was kept at 270°C; the temperature of transfer-line was 325°C. The electron impact ionization source (70 eV) was maintained at 330°C, while the quadrupolar mass analyzers were at temperature of 150°C. The chromatographic separation was carried out using a DB-5MS Ultra capillary column inert (length 60 m; diameter: 0.25 mm) (J&W Scientific). Ultra-pure helium (99.99999 %) was used as a carrier gas at a constant flow of 1 mL/min. One microliter of sample was injected in the splitless mode at 270°C.

Table 1 show the conditions of the gas chromatographic separation used respectively for the analysis of PCBs, PCDDs/Fs and PBDEs. The quantification of congeners was performed using the isotopic dilution technique (US EPA, 1994). The GC-MS chromatograms were acquired in MRM (Multiple Reaction Monitoring) mode, monitoring two specific transitions for each precursor ion. For each target, two MRM transitions were used, one for quantitation and one for qualification. The two transitions used two different and specific precursor ions and two distinct product ions. Quantitation was performed with the quantitative transition only, while the qualitative transition was used to verify the ion ratio between the two transitions. This approach minimized the risk of interferences or of the wrong peaks. Data analysis was performed with Agilent Mass Hunter Quantitative Analysis Software.

Table 1. Gas chromatographic conditions used for the analysis of various compounds

T initial, °C	***Ramp,*** °C/min	***T final,*** °C	***Hold,*** min
PCDDs/Fs			
130			2
130	10	220	16
220	5	235	7
235	5	350	
PCBs			
80			1
80	25	185	1
185	5	210	10
210	5	280	1
280	30	310	5
PBDEs			
60			2
60	60	220	0.5
220	25	300	13

3. Results and discussion

The ASE extraction technique, as already seen, uses high temperature solvents and high pressures: this allows the solvent to remain liquid even at temperatures above the boiling point, accelerating the extraction process (Antunes et al., 2008). In the optimization

of the method, an important factor was the choice of the extraction solvent: its polarity must be similar to that of the compounds to be extracted and its boiling point must be not too high to allow a rapid concentration of the extract after the ASE phase. Compared to the longer Soxhlet extraction indicated by the EPA 1613 B method, the ASE has several advantages such as the lower solvent consumption and the shorter time spent. This allows to obtain higher extraction yields even by performing more extraction cycles for the same sample. In order to further simplify the method, a single solvent (n-hexane) was used, able to simultaneously extract the three classes of tested compounds. The combination of the ASE extraction with a "clean-up" stage directly in the cell was a further innovation to eliminate, already in the extraction phase, the polar interferences present in complex matrices. This was done by adding neutral and acidic silica gel to the sample to be extracted. The presence of anhydrous sodium sulfate in the cell also ensures the elimination of water.

The use of copper powder has proved effective for the removal of sulfur extracted from marine sediment samples. In order to test the reliability of analytical method, parameters such as extraction recovery, linearity, repeatability, and limits of quantification (LODs) were evaluated. The use of labeled compounds added to the sample before extraction made it possible to calculate the recoveries of the extraction and of the entire methodology for the various compounds. As an example, Table 2 shows the average values of the recoveries and the relative standard deviations calculated for the various labeled dioxins and furans congeners examined. The recoveries fall within the acceptable ranges defined by the EPA 1613 B method confirming the accuracy of the entire analytical process: extraction, purification and analysis.

Table 2. Recoveries (%) for different dioxins and furans congeners

Compounds	***Recovery (mean** ± s.d.)*	***EPA Method 1613 B***
2,3,7,8-TCDD	71 ± 5	24-169
2,3,7,8-TCDF	70 ± 6	25-164
1,2,3,7,8-PCDD	73 ± 6	24-185
1,2,3,7,8-PCDF	74 ± 6	21-178
2,3,4,7,8-PCDF	75 ± 6	25-181
1,2,3,4,7,8-HxCDD	68 ± 8	26-152
1,2,3,4,7,8-HxCDF	69 ± 8	26-123
1,2,3,6,7,8-HxCDD	65 ± 10	29-147
1,2,3,6,7,8-HxCDF	66 ± 9	32-141
1,2,3,7,8,9-HxCDD	64 ± 10	28-130
2,3,4,6,7,8-HxCDF	71 ± 7	28-136
1,2,3,4,6,7,8-HpCDD	58 ± 16	28-143
1,2,3,4,6,7,8-HpCDF	52 ± 17	23-140
1,2,3,4,7,8,9-HpCDF	48 ± 11	23-138
OCDD	37 ± 15	17-157

The linearity was determined by analyzing standard solutions (in triplicate) at five concentrations ranging from 0.05 and 200 ng/mL. The linearity was found satisfactory, with correlation coefficients $R^2 > 0.9990$; for calibration lines, the intercepts were not significantly different from zero, at a 95% confidence level. The repeatability, expressed as the relative standard deviation (RSD) of the spiked sample concentrations, was significantly better, with

values of 20% or less. The limits of quantification (LOQs) were calculated for the various congeners by linear regression analysis, slope of the calibration lines and intercept standard deviation (MacDougall and Crummett, 1980).

For dioxins and furans, LOQs ranged from 19.7 pg/mL (for 2.3.7.8-TCDF) to 170.8 pg/mL (for 1,2,3,4,7,8-HxCDD); for PCBs LOQs ranged from 0.05 ng/mL (for PCB 77) to 0.67 ng/mL (for PCB 169), while for PBDEs from 0.28 ng/mL (for BDE 99) to 1.25 ng/mL (for BDE 154). These values were suitable to determine concentration levels normally found in sediments sampled in a contaminated marine coastal area.

The method has been successfully applied to the determination of the three classes of chlorinated compounds in contaminated sediments taken from the coastal marine area of Taranto. Fig. 1 and Fig. 2 show the concentration levels determined in two of the most contaminated sediments analyzed. The analysis of the distribution of the various congeners (Fingerprints) can give useful indications on the origin of the contamination, even if in relation to different degree of volatilization, dispersion and degradation of the compounds, the profiles can undergo a modification over time, which tends to mask the nature of the source of the original contamination. Some Authors have highlighted two characteristic profiles for PCDDs/Fs in environmental matrices; the first dominated by the OCDD congener, due to the presence of combustion processes as polluting sources, the second characterized by OCDF, a characteristic congener deriving from polyvinyl chloride (PVC) and / or metal processing contamination (Bellucci et al., 2000; US EPA, 2006). In the present work, the profile of PCDDs/Fs congeners in the samples analyzed is dominated by the abundance of OCDD congener, so it is possible to state that important sources of contamination in the examined area are above all industrial combustion processes.

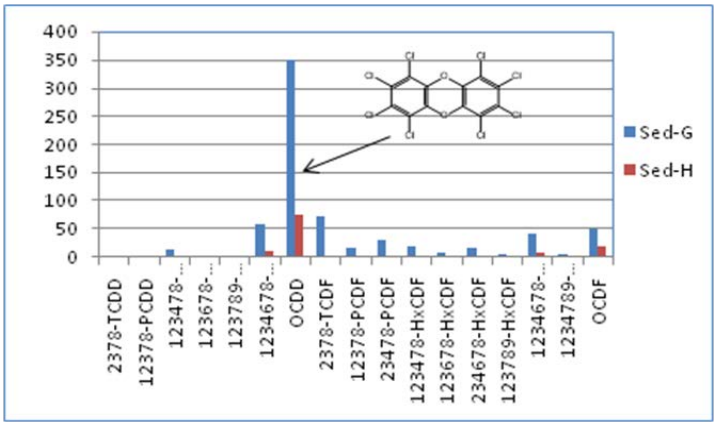
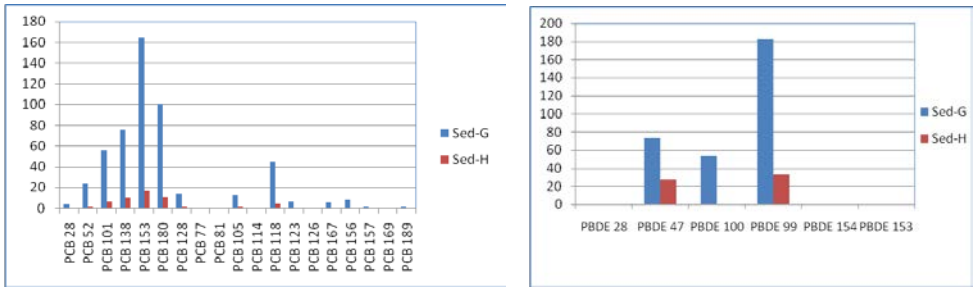


Fig. 1. Distribution of PCDDs/Fs in two contaminated sediments (named G and H)

As for PCBs, the dominant congeners in the sediments examined are the six PCB markers. The profile of the PCB markers is dominated by the penta-, esa- and hepta-chlorinated congeners and, in particular, by the PCB138, PCB153, PCB101 and PCB180 (Fig. 2 A), in agreement with the literature data (ARPAV, 2014). The abundance of these congeners derives from both from their high concentrations in the original Aroclor mixtures, the main sources of environmental contamination, and from a poor biodegradability related to chemical structure (ISS, 2002).



a) b)

Fig. 2. Distribution of PCBs (a) and PBDEs (b) in two contaminated sediments analyzed

For PBDEs the highest levels are found in the samples where the highest PCB values were also found. The most significant congeners determined were the BDE 47, 99 and 100 (Fig. 2 B). With regard to regulatory aspects, the first restrictions regarding PBDEs have been adopted at European level with the Directive 2003/11/EC (EC Directive 11, 2003) which amended Council Directive 76/769 / EEC by adding to the list of dangerous substances the Penta-BDE and the Octa-BDE. In Italy these European directives have been implemented with the Legislative Decree 25 July 2006 n. 151 (Legislative Decree, 2005), aimed at reducing the use of hazardous substances in electrical and electronic equipment.

5. Conclusions

The applicability of ASE extraction coupled with GC-MS triple quadrupole for the simultaneous determination of three classes of chlorinated compounds (PCDDs/Fs, PCBs and PBDEs) in real matrices (e.g sediments) was demonstrated. Satisfactory validation parameters, including recoveries, linearity, LOQs, were obtained, demonstrating the feasibility of the method.

The analysis of the distribution of PCDDs/Fs and PCBs congeners in the sediments analyzed provided useful indications on the contamination sources. With regard to PCDDs and PCDFs profiles, for example, the predominance of octa-chlorinated dioxin (OCDD) indicates the combustion processes of the industrial area as the most probable sources of contamination.

Regarding the profiles of PCBs congeners (dioxin-like and markers), the predominant congeners (PCB118 and PCB153) seem to indicate (despite the inevitable "weathering" processes) that the commercial Aroclor 1260 blend, used in the past in electrical transformers, is the most probable source of contamination. Therefore, the developed methodology is expected to provide a new tool (easier and faster) for the simultaneous monitoring of toxic chlorinated compounds in environmental matrices.

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