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THEORY AND PRACTICE OF CIRCULAR ECONOMY

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direct services
Sofia
2019

This monograph is part of a three-year project (2016-2018) in Professional Trend 3.8, Economics, for a scientific research on "Innovative models for Circular Economy: Challenges and Possibilities for the Bulgarian Small and Medium-size Enterprises", as per Ordinance No.3 of the Ministry of Education of Bulgaria of 27/11/2015, approved with Report No.1 of 02/06/2016 by decision of the Competition Committee of the Scientific and Research Institute of Varna University of Economics.

ISBN 978-619-7171-76-1

CONTENT

INTRODUCTION

Since the onset of the industrial revolution development, the worldwide economic system has been characterized by a "linear model". With the linear model, the researchers highlight, in a simplified way, a model in which raw materials are extracted from the ground, transported to manufacturing, processed to make a commodity, and then stuck back into the ground as landfill ("*take-produce-dispose")*. This model is based upon the idea that consumption is the only contributor to human welfare and environmental deterioration is a direct consequence. It is evident that this idea *relies* solely on economic growth, without thinking of the repercussions for the future generations. If we exploit the natural resource to manufacture goods and at the end of their life cycle we dispose them into the environment, this is environmentally, economically and socially unsustainable. The natural resources necessary to make goods are not endless, neither is the capacity of the natural ecosystem to absorb or offset environmental deterioration. The "linear model" has been criticized over time for a number of different reasons. Perhaps, the first in the list of reasons is the rising of the price of natural resources due to their depletion (McKinsey, 2013). Another factor is attributable to the growing environmental and economic problems. A further reason reason concerns the ever growing economic and environmental problems related to the creating and management of landfills. Yet another reason is the increasing demand for energy.

In recent years, after different debates and study research, the concept of circular economy has taken hold, aiming at restructuring the *take-make-dispose* model emulating natural processes in which waste is not contemplated. To achieve this goal, circular economy proposes a set of measures in order to prevent waste propagation and facilitate recycling processes. The core idea of circular economy is to propose a regenerative model of manufacturing in which products and components are reused multiple times. It has become strategic to rethink and redesign the production model, designing commodities that can be reused after their end of life. With these products, the powering of the manufacturing systems can come from renewable sources. The latter is very important in order to become gradually less dependent on fossil fuels (without compromising prosperity). It is important to build up a different managerial culture, adopting new managerial tools and methods in order to identify problematic issues within the manufacturing process and propose solutions that can both minimize waste production and favour recycling systems.

Circular economy was formulated by the Ellen MacArthur Foundation as “an economy that is restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times, distinguishing between technical and biological cycles”. (MacArthur Foundation, 2015).[1] According to the European commission (2017), “circular economy covers the management and prevention of waste and the relative efficiency in resource use but also contributes to promoting the growth of a real well-being for individuals and resilience of the ecosystem”. The circular economy concept will replace the model of end-of-life of a product or process with a restoration system.[2] In this way, it has become possible to shift the focus to the use of renewable energies (with lower environmental impact in terms of CO_2 emissions production) trying to eliminate the use of toxic chemicals as well as waste through innovative design of materials, products and systems.

Circular economy can generate not only environmental benefits; it can *relieve* the pressure arising from the production system, thus generating economic benefit. It's interesting to try and measure this effect with concrete data. On a worldwide scale, the annual flow of resources from nature to the anthropic sphere is equal to 50-60 billion tonnes. One third of those is linked to the extraction of metals, rocks,

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[1] Ellen MacArthur Foundation (2015). Growth Within: a circular economy vision for a competitive Europe, available at: http: //www.ellenmacarthurfoundation.org/ publications/growth-within-a-circular-economy-vision-for-a-competitive-europe;

[2] European Commission, (2017) Report from the Commission to the European parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on the Implementation of the Circular Economy Action Plan, available at: http: //ec.europa.eu/environment/circular-economy/implementation_ report.pdf;

stones, sand and gravel; 45 billion tonnes of those are for the extraction of 14 billion tonnes of fossil fuels (which on their part produce 32 billion tonnes of CO_2); 80 billion tonnes of materials are eroded by agricultural practices; 27 billion tonnes of biomass; 4,000 cubic kilometres of water (Geological survey, 2014).[3] The World Bank has estimated to 1.3 billion tonnes the production of urban waste and the generation levels are expected to double by 2025.[4] This is an impressive mass, so far perceived as a problem. It is a challenge, though, to consider the waste as a possible future resource to re-enter the manufacturing system and not as waste to be landfilled. This is the basis of circular economy, even if its adoption requires important economic investments in innovation, research and development.

This monograph aims at presenting some innovative solutions relating to circular economy through particular empirical research in the sectors of tourism, food industry and entrepreneurship in Bulgaria and some European countries[5].

The particular **scientific tasks** of the monograph focus on:

Presenting the circular economy concept;

- Analysis of the circular economy performance tools;
- Presenting the possible strategies for assessment of the effects of circular economy;
- A proposition of different approaches for studying circular economy – by country, region or sector.

The object of study of this monograph is the circular economy process, and the **subject** is the implementation of its innovative models.

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3 Geological survey (2014), Mineral Commodity Summary 2014, available at: https://minerals.usgs.gov/minerals/pubs/mcs/2014/mcs2014.pdf, ISBN 978–1–4113–3765–7;

4 World Bank (2012), Urban development series "WHAT a WASTE: a Global Review of Solid Waste Management" available from: http://siteresources.worldbank.org/INTURBANDEVELOPMENT/Resources/336387-1334852610766/What_a_Waste2012_Final.pdf.

5 The issue of circular economy can be surveyed within the different economic sectors. In this monograph, their range comes down to the above three sectors, with the separate empirical surveys revealing some of their regional, national and global peculiarities.

Chapter One follows the descriptive approach and traces different evolution moments significant for the development of circular economy. Chapter Two presents a comparative analysis of concepts close to the idea of circular economy. Chapter Three follows the deduction approach of the reasoning from the general (the nature of circular economy) to the particular (the tools which strategically enhance the environmental assessment of products and services and the efficient use of resources). In the following chapters (Four, Five, Six, Seven, Eight, Nine), the authors apply different empirical approaches – online questionnaires, in-depth interviews, statistical elaboration of data with specialized software, etc., in search of innovative solutions for assessment of circular economy in Bulgaria, Italy and some other European countries. In conclusion, the authors synthesize and generalize their findings.

The analysis is represented mainly from the position of the product and service user in strategically important sectors for circular economy – hospitality and wine, food and beverage production, energy production industries. In addition, the authors present the assumptions about circular economy of entrepreneurs in some European states, including Bulgaria.

The analysis in this monograph is of importance to analysts, managers, politicians, and the public, as Bulgaria has not yet fully transposed the European legislation relating to circular economy. The applied policies are at the level of initiatives and measures. The empirical research herewith reveals different points of view concerning circular economy, including: a) at the user level (applying the principles of circular economy via the effects of food films and coatings and the possibilities for eco-innovations in food industry); b) at the entrepreneurial level (applying the principles of circular economy by increasing informativeness about green entrepreneurship in some EC member-states; c) at the level of politicians and those responsible for making managerial decisions (applying the principles of circular economy through assessment of the carbon footprint and the life cycle in tourism, wine industry, syngas production, energy production from waste).

With the empirical research, the authors strive to prove that the implementation of innovative methods in the circular economy context *influences positively the competitiveness of the different sectors of the economy*. The analysis reveals that today more and more researchers show a keen interest in the new formats and approaches for studying circular economy.

For the needs of the monograph, different titles have been researched in the Bulgarian, Russian, English, Italian and Spanish languages. At the end of each chapter, a bibliography reference is given.

The results of the research are only preliminary and should not be taken as conclusive. The authors' research only shows one of the possible directions for the development and analysis of circular economy. In addition, it must be stated that there is no unified scientific approach for the type of studying of circular economy. In this respect, the research is a pilot in a new and undoubtedly useful trend which we hope shall enrich the knowledge of both specialist and entrepreneur.

The participation of the different authors of this monograph is given below:

Dr Teodoro Gallucci – Chapter 2, Chapter 3, Chapter 4.3 and 4.4., Chapter 5.3, 5.4, 5.5. and 5.6, Chapter 6.3 (co-participation of Associate Professor Vesselina Dimitrova, PhD), Chapter 8.1, 8.4, 8.5 (co-participation of Associate Professor Vesselina Dimitrova, PhD and Chief Assistant Dr. Petyo Boshnakov, 8.6 (co-participation of Associate Professor Vesselina Dimitrova, PhD);

Professor Giovanni Lagioia, DSc- Chapter 4.1, Chapter 5.1

Associate Professor Vesselina Dimitrova, PhD – Introduction, Chapter 1, Chapter 6.1 (50 % co-participation of Professor Stoyan Marinov, DSc), 6.2 and 6.3 (co-participation of Dr. Teodoro Gallucci); Chapter 8.3, Chapter 8.5 (co-participation of Dr. Teodoro Gallucci and Chief Assistant Dr. Petyo Boshnakov), 8.6 (co-participation of Dr. Teodoro Gallucci), Conclusion and general scientific information;

Professor Stoyan Marinov, DSc – Chapter 6.1 (50% co-participation of Associate Professor Vesselina Dimitrova, PhD)

Associate Professor Vera Amicarelli, PhD – Chapter 4.2, Chapter 5.2

Associate Professor Bistra Vassileva, PhD – Chapter 9 (50% co-participation of Assistant Professor Plamena Palamarova)

Associate Professor Sabka Pashova, PhD – Chapter 7.1, 7.2, 7.3 (50% co-participation of Yordan Ivanov, PhD)

Chief Assistant Petyo Boshnakov, PhD- Chapter 8.2, 8.5 (co-participation of Associate Professor Vesselina Dimitrova, PhD and Dr. Teodoro Gallucci)

Assistant Professor Plamena Palamarova – Chapter 9 (50% co-participation of Associate Professor Bistra Vassileva, PhD)

Yordan Ivanov, PhD – Chapter 7.3 (50% co-participation of Associate Professor Sabka Pashova, PhD)

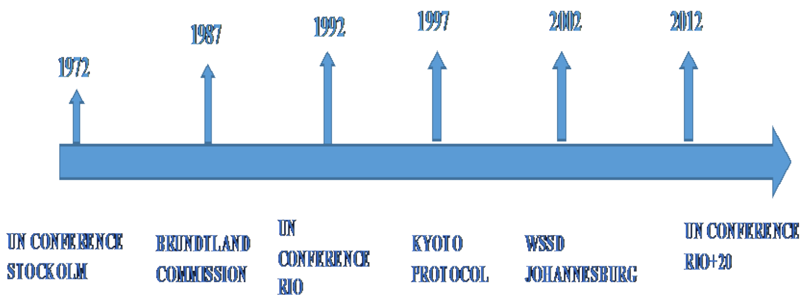
FIRST CHAPTER
THE ROADMAP TO CIRCULAR ECONOMY

1. First steps to the circular economy concept

Before arriving at the point of expressing the CE concept, different levels of knowledge related to sustainable development or industrial ecology, have been formulated. The process of argumentation of different methodological approaches in order to include ecological considerations in the economic theories has been difficult and very problematic mainly due to the necessity to deconstruct the basic economic system. At the beginning, the idea of studying the interrelation between economy and environment, and the impact of the development of cost effective industrial activities on the environment was not considered very important for improving economic effectiveness, and only with time and experience, the environmental and natural resource management have become more important.

In this paragraph are highlighted the pillars which lead to formulating the "sustainability" concepts. Circular economy arises from these preconditions and it is useful to study the obstacles faced, for elaboration. Figure 1.1 outlines the main steps (debated at conferences) which have led to the circular economy concept.

Figure 1.1:
Main steps to circular economy concept



Source: personal elaboration of the author

The 70s of the 20c. saw the focusing in a global aspect on topics relating to the interdependence between economy and environment. In that period, different researchers and managers issued several reports in which they outlined the importance of extending the basic economic model towards new parameters, such as the "human capital" and the "natural capital". A preliminary concern started spreading about the environmental problems of business activities. It was clear that production activities were totally locked into a system characterized by huge raw material and energy consumption (Cooper, 2005). The only purpose of businesses was to meet the objective of growing capital without thinking about the consequences for the next generations. Several debates brought light on how a development model based on fostering consumptions rather that minimising negative externalities will be unsustainable. In consequence, the objective of capital growth must take care of the environmental externalities, as well. In this way, the re-modulation of the economic system required the restructuration of the current managerial mentality (Cox et al, 2013).

In the mid-70s, a non-profit and non-governmental association of scientists, economists and civil rights activists, called the Club of Rome, commissioned to the MIT (Massachusetts Institute of Technology) a study report for highlighting the limits of our planet. The report was issued in 1971 with the name *Report on the Limits of Development* also known as the *Meadows Report*. The report study showed for the first time that the current economic model would lead to a collapse of industrial production jointly with an ecological crisis within the next hundred years if there were no change in the economic model. The report was published at the time of the severe oil crisis of the 1970s and the occurrence of some environmental catastrophes. The report, translated into thirty languages, became a true global bestseller, with nine millions of copies sold (Meadows et al, 1972). The didactic form of the report contributed to its circulation: although it is a mathematical model, there is not a single equation in the book, but only easy-to-read graphs.

Environmental issues were again discussed at the United Nation (UN) conference held in Stockholm on June 16, 1972, where the leaders of the 110 delegations approved the *Stockholm Declaration on the Human Environment*.

This conference outlined some guidelines in order to pursue freedom equality and the right to live in adequate conditions. On that occasion, the axiom was established that natural resource safeguard must play a key role in the legislative and economic processes of the Countries (Declaration of the United Nations Conference on the Human Environment, 1972).

Another stage of this trend relating to the interconnection between environment and economics is attributable to the Brundtland report *Our Common Future*, issued in 1987. The report analyses the main causes for the general economic crisis which occurred in that year, in order to propose concrete actions. The report emphasizes that the world is facing a "global challenge" to which it has to answer by assuming a new "sustainable" development model. It also coined the term *sustainable development* which means "development that is able to satisfy the needs of the present generation, without compromising the possibility that future generations can satisfy their own". Sustainable development can be considered a process of change so that resource exploitation, investment management, technological development and institutional change must be consistent with future needs as well as with current ones. It is very interesting to read those parts of the report which show how sustainability becomes a strategy in every economy: “This Commission believes that people can build a future that is more prosperous, more just, and more secure. Our report, Our Common Future, is not a prediction of ever increasing environmental decay, poverty, and hardship in an ever more polluted world among ever decreasing resources. We see instead the possibility for a new era of economic growth, one that must be based on policies that sustain and expand the environmental resource base. And we believe such growth to be absolutely essential to relieve the great poverty that is deepening in much of the developing world.” (Brundtland report, 1987)

On the one hand, "sustainable development” implies meeting the fundamental needs of everyone and extending to everyone the opportunity to pursue their aspirations for a better life, and on the other, the proposal places optimistic confidence in technology which will lead to a new era of "economic growth". The concept of sustainable development involves limits, but not absolute ones, due to the current state of technology and to the ability of the biosphere to absorb pollution from human activities. Technology must, however, be managed and improved in order to open a new era of economic growth. Another aspect that emerges from the report is the social one: "Meeting the essential needs demands not only a new era of economic growth for nations where the majority of the inhabitants are poor but also the guarantee that such poor have their own just part of the resources needed to support such growth. Such equity should be supported by both political systems that ensure effective participation of citizens in decision-making and greater democracy in international choices."

In 1989, the concept of sustainability was also proposed for tourism. The world Tourism Organization defined it as: "Sustainable development of tourism meets the needs of tourists and current host areas and at the same time protects and improves the opportunities for the future". Sustainable tourism should involve several principles for resource management so that economic and social needs are met for preserving cultural integrity, biodiversity and supporting the improvement of the quality of life.

In 1992, the United Nations Conference on Environment and Development (UNSD, 1992) was held, also known as the Earth Summit in Rio de Janeiro. 178 Heads of State, delegates and representatives of the United Nations and international organizations gathered to discuss how to solve the issue of the disparity between environmental protection and economic development. The output was a Declaration which stated 27 principles to be followed by the future sustainable development strategy. These include:

• the principle that every generation has a duty to preserve nature for future generations;

• the precautionary principle;

• the principle which differentiates the responsibilities of the industrialized and developing countries;

• the *polluter pays* principle.

The conference established Agenda 21 as well, with the aim to show the programmatic objectives for the 21st century. Agenda 21 was subdivided into 40 chapters and 4 sections, in order to distinguish the sectoral policies with which to achieve "Sustainable Development". Agenda 21 addresses specific issues (forests, soils, oceans, climate, atmosphere, energy, deserts, mountain areas), general ones (demography, poverty, hunger, water resources, consumption patterns, urbanization) and intersectoral ones (financial resources, cooperation, technology transfer, awareness-raising and environmental education, information and training). The important aspect of Agenda 21 is twofold: the global scale of action, where the political decision-maker tries to solve the "big" problems and a local scale where the administration works with the citizen for proposing measures in order to solve environmental issues (UNSD, 1992). The Rio Summit also produced other important documents, such as the revision of the Global Forests Convention. The Convention widely encouraged G7 countries to adopt measures for a better management of forest and biodiversity.

The Convention named Kyoto Protocol took place in 1994, and by 1995 governments had begun negotiations on the creation of a protocol. The text of the Kyoto Protocol was adopted unanimously in 1997 and it came into force on 16 February 2005 after being ratified by the Russian Federation. The Protocol identifies the six greenhouse gases responsible for climate change whose release into the atmosphere must be reduced. In order to do so, the measure identifies a target of reducing emissions of such gases by at least 15% as compared to 1990 levels, with a period of performance 2008 to 2012 (Kyoto protocol 1997). In 1997, five years after the Earth Summit, the United Nations convened a special assembly, United Nation General Assembly Special Session (UNGASS), which verified the status quo of Agenda 21. During the summit, obstacles and difficulties in achieving the approved criteria were discussed. UNGASS has the merit of identifying a number of priority objectives within the broad project designated by Agenda 21, stressing the importance of respecting the commitments made. (Baker, 2014)

The new century opened with a declaration of international solidarity, the Millennium Development Goals (UN, 2000), joined by all

191 UN member states. All participants agreed to propose a multilateral commitment on eradicating extreme poverty, reach universal primary education, promote gender equality and women's autonomy, and reduce child mortality; improve maternal health, combating HIV/AIDS, malaria and other diseases; ensure environmental sustainability, developing a world development partnership. Although the objectives do not cover all aspects of sustainable development, it is important to consider it as the greatest shared ethical expression ever achieved.

Another important conference that deserves to be cited is the World Summit on Sustainable Development (WSSD) held in Johannesburg in 2002, or ten years after the Rio Conference(Report of the World Summit on Sustainable Development, 2002). This summit is considered the turning point for sustainable development.

Despite scepticism, more than 190 nations, local authorities, scientific institutions, non-governmental organizations, trade unions and businesses took part. The conference, as a result produced three documents: a) the Johannesburg Declaration, which is the main achievement; b) Agenda 21 Implementation Plan and c) a list of specific initiatives to be pursued. Over the years, the so-called "implementation plan", albeit complex and particularly articulated, became the most important policy and action tool for many of the countries and organizations involved in the sustainable development process. The plan outlines the importance of two principles expressed in the Rio Declaration: the *precautionary principle* and the *principle of equality*. The document orients and extends its actions to different areas: promotion of human rights, fight against poverty, health protection, supply and maintenance of drinking water, protection and maintenance of biodiversity, etc. Another new feature of the summit was to place greater emphasis on the creation of partnerships than on the definition of new governmental agreements. These partnerships are seen as the main tool for the implementation of the Sustainable Development Goals [6] on the basis of which the Eight Goals of the Millennium are construed (The Millennium Development Goals) in the 2030 Agenda of the UN, namely: eradication of poverty; achievement of universal primary education; gender equality and empowerment of women; reducing child mortality; improvement of maternal health; combating HIV/AIDS and other diseases; ensuring environmental sustainability; development of global partnership. The 2030 Agenda defines mechanisms for development and reviewing of sustainable development indicators at the national, regional and local levels. In this connection, the indicators to ensure environmental sustainability are of exceptional usefulness, all true because the levels of carbon dioxide emissions have increased by 50% during 2015, as compared to 1990. (UN, 2015)

In the interim of negotiating a new agenda and sustainable development goals, it has been established that the world requires a change, both in the current model of economic development and in consumer behavior. One of the most pronounced concepts for a change in this direction relates to the *green growth* concept. Green Growth allows for the integration of quantitative and qualitative indicators for measuring growth in the conditions of encouraging sustainable and social development, education and environmentally healthy and friendly behavior. (MLTM, 2012) Based on the Rio Declaration of 1992, in 2009, ministers from 34 countries signed the *Green Growth Declaration*, which states their commitment to: "enhance the efforts to formulate new strategies in response to the crisis, recognizing that "green" and "growth" can go hand in hand" (OECD, 2011). The strategies for green growth must therefore be flexible enough to adopt new technologies and seize

[6] There are 17 sustainable development gals (SDG) in all: SDG 1: No poverty; SDG2: Zero hunger; SDG3: Good health and well-being; SDG4: Quality education; SDG 5: Gender equality; SDG6: Clean water and sanitation, SDG7: Affordable and clean energy; SDG8: Decent work and economic growth; SDG9: Industry, innovation and infrastructure; SDG10: Reduced inequalitites; SDG11: Sustainable cities and communities; SDG12: Responsible consumption and production, SDG13: Climate action; SDG14: Life below water; SDG15: Life on land; SDG16: Peace, justice and strong institutions; SDG17: Partnerships for the goals.

new opportunities. Efficient resource management is one of the essential objectives of economic policy, jointly with tax and regulatory measures.

Green growth has not been conceived as a replacement for sustainable development, but as a subset of it. The green growth relies on the important role played by technological innovation, being able to decouple growth from dependence on natural capital, the only driver towards a green economy. In the book "*Towards Green Growth*" (OECD, 2011) which is the reference book of green growth study, it is reported that "green growth tools and indicators can help expand economic growth and job creation through sustainable use of natural resources, efficiencies in the use of energy, and valuation of ecosystem services. Ministers noted that innovation, supported by a strong intellectual property rights system, is a key to countries' abilities to achieve economic growth, create green jobs, and protect the environment." Two broad sets of policies are essential elements in any green growth strategy. The first set consists of broad framework policies that mutually reinforce economic growth and the conservation of natural capital (such as fiscal and regulatory settings or tax and competition policies). Innovation policies should be added to this set as well. The second set includes policies providing incentives to use natural resources efficiently and making pollution more expensive. These policies include a mix of price-based instruments, for instance environmentally related taxes.

Green growth will bring new ideas, new entrepreneurs and new business models, thus contributing to the creation of new markets and, ultimately, the creation of new jobs and industrial processing. Business leaders and entrepreneurs are exploring the opportunities of green business, sometimes based on system thinking and radical innovations, with the aim to capture and create value from new business models (OECD, 2012). The concept of green growth has the potential to address economic and environmental challenges and to open new paths to growth through the following channels:

- Productivity: incentives for more efficient use of resources and natural goods that will lead to improved productivity by reducing the consumption of materials and energy and making the resources available to the highest value in use;

- Innovation: opportunities for innovation, encouraged by appropriate policies to enable new ways of addressing environmental problems;
- New markets: creating new markets by stimulating demands for technologies, green goods and services, including for the creation of new job opportunities;
- Trust: to increase investor confidence through greater predictability regarding the way in which governments are held accountable to the key environmental issues and stability of the decisions made;
- Stability: more balanced macroeconomic conditions, which reduce the volatility of price resources, eliminate the negative impact on growth resulting from bottlenecks in the availability of resources; imbalances in natural systems that increase the risk of potentially irreversible loss of biodiversity due to, for example, climatic change.

Last but not least within the evolution of the ideas for sustainable development is the 21 Session of COP (COP21) on the United Nations Framework Convention on Climate Change (UNFCCC**)**. It is not a conference in the current sense of the term (with individual rapporteurs, academic values, etc.), but a sort of negotiating and updating information and positions, sometimes ending in agreements and legal texts. The Climate Convention held in Rio de Janeiro in 1992 launched a nearly annual COP, of which COP Paris (FR) is the 21st. During the COP-Paris, an agreement with a very ambitious goal was signed. The agreement envisages keeping the world's global temperature rise below 2° C, ideally pursuing the goal of +1.5 C. According to the agreement the countries have to cut emissions between 40 and 70% by 2050, so as to achieve the target of 1.5° C less, the cut should be more substantial, between 70 and 95% by 2050. Promoters of this goal were the representatives of the small islands and other countries more exposed to the climate change impacts. The agreement recognizes the importance of investing more in adaptation resilience, but also in this case it does not enter into the specifics of concrete actions. Another aspect is that developed countries have to allocate funds in order to achieve the target goals. With regard to transparency and review mechanisms, the agreement establishes a flexible framework with which each country has to regularly submit an inventory of emissions produced and absorbed, updating on the progress made in achieving the intended objectives and information on technological know-how and capacity-building support. A mechanism is then set up for review by the COP in order to record the progress made every 5 years.

According to the COP 21, "Developed countries must provide financial resources to assist developing countries. The financial support, equal to 100 billion annually from 2020, represents only a starting point and additional funds must be allocated to the extent that will be decided in 2025". However, there are no details when and how they will be provided.

The most delicate issue was climate compensation for loss and damage suffered by countries vulnerable to climate change triggered by advanced economies and established in the previous COP-Warsaw. COP-Paris states that loss and damage "does not entail or provide any basis for any liability or compensation." Furthermore, fossil fuels may well continue to be extracted for many years. The Paris agreement does not set any deadline for the exploitation of coal, gas and oil. The only goal is to reach the peak of emissions as soon as possible in order to reach "a balance between emissions of anthropogenic sources [...] and the absorption of greenhouse gas tanks in the second half of this century.″ The principle of climatic neutrality, not the zero emissions or decarbonisation, is a phenomenon that industry fears (Report COP Paris, 2016)

2. Achievements of the European Union on the Road to Circular Economy

Sustainable development is the main goal of the EU, listed in Article 3 of the Treaty on European Union (the Maastricht Treaty of 1992). In 1993, the Maastricht Treaty confirmed the adoption of the *precautionary principle*, which sustains within the Union a balanced model of economic development activities which are mindful of the environment. In May 1994, in the town of Aalborg-Denmark was held the first European Conference on Sustainable Cities. On that occasion, local European authorities pledged to implement Agenda 21 at the local level, including the development of long-term plans for sustainable development and the launch of an awareness campaign. At the conference, the Charter of European Cities & Towns towards Sustainability (Charter of European Cities & Towns Towards Sustainability, 1994) was signed.

In 1996, the second European Conference on Sustainable Cities was held in Lisbon. If the first conference in Aalborg aimed at implementing Local Agenda 21, the next phase focused on the implementation of the principles signed in Aalborg, the exchange of ideas and experiences of local best practices reinforcing the idea to collaborate with other European communities on joint projects. In this way, the policy makers contributed to sustainable development, as well.

The next European Conference on Sustainable Cities was held in Seville in January 1999. The conference is the result of initiated earlier meetings for exchange of experience and good practices in different regions: for the Baltic countries (Turku, 1998); for the countries in Central and Eastern Europe (Sofia, 1998), for the countries in Central and Western Europe (the Hague, 1999).

After the conference in Hanover in 2000, the politicians addressed Agenda 21 directly towards the European Parliament, the national governments, the European Union regions and its financial institutions.

Ten years after the first conference in Aalborg, there again in June 2004, a new conference was held which reviewed the goals of sustainable development of the European Union, mindful of the inclusion of new member-states. The focus is on environmental and natural resource management, the planning of proper urbanization of cities and regions, increasing transport mobility, guidelines for health care and administration of law.

In March 2007 in Seville, a discussion was held on the manner of carrying out of monitoring of sustainable development in the European

Union, the methods of cooperation and communication with the different representatives on the subject matter.

The new century opens with the so-called "Lisbon Process" (Lisbon strategy 2000-2010) whose aim was to create in Europe "the most competitive knowledge-based economy in the world", based on operational reform strategy. A peculiar feature was to remove obstacles to competitiveness such as gender inequality, delays in the development of the tertiary sector, regional imbalances in terms of unemployment, and lack of professional qualification. Actions were also identified to revive the knowledge economy and economic reforms called for:

• Innovation and Entrepreneurship;
• Reform of welfare and social inclusion;
• Human capital and job retraining;
• Equal opportunities for women's work;
• Liberalization of labour and product markets;
• Sustainable development.

The final report provided analytical background documentation in the field of employment and social policies for the national governments within the European Union. The environmental theme, completely absent in the Lisbon Council, was re-discussed at the Göteborg Council (2001). Within the Göteborg Council, an additional Paragraph 14 was adopted: *Sustainable Development Strategies,* which complemented environmentally the remaining European parameters – in an economic and social aspect (Steurer and Berger, 2010). With the adopted amendments in Göteborg, the Lisbon Conference was complete and in it six priority areas of intervention are identified with objectives and instruments of action:

• limiting climate change by widening the use of clean energy, pushing other countries to meet Kyoto commitments and intervening to lower emissions by 1% per annum by 2020;

• addressing public health threats, ensuring higher quality of food, addressing infectious diseases, in particular antibiotic resistance phenomena, and limiting the adverse effects of chemicals;

managing natural resources more responsibly, decoupling resource consumption and waste generation from economic growth, halting the loss of biodiversity and combating over-exploitation of fish resources;

• improving the transport system and the management of transport use, bringing the road transport percentage to no higher than the 1998 figures;

• combating poverty and social exclusion, intervening to reduce the number of poor people, increasing employment to reach a 70% rate in 2010, fighting gender disparity and halving by 2010 the number of young people who do not continue their studies;

• tackling the socio-economic implications associated with population aging through changes in pension systems, health care and increasing the employment rate for people between the ages of 55 and 64 up to 50% in 2010.

In 2001, complementing the Lisbon Strategy, the European Sustainable Development Strategy (EU SDS) was created. The objective of EU SDS was to create a strategy for pursuing environmental, economic and social development policies. The purpose of the strategy was to influence the behaviour of society through the action of public opinion and politics. In 2006, during the Presidency of Austria, the European Sustainable Development Strategy (EU SDS) was reviewed in greater detail. The focus is the result of the adopted by Eurostat in 2005 policy for regular monitoring of the strategy. This new report described how Europe would want to face the challenge of sustainable development more effectively. The overall objective is to achieve continuous improvement of the quality of life of citizens through sustainable communities that efficiently manage and use resources, exploit the potential of ecological and social innovation of the economy and ensure prosperity. In order to make the strategy more effective, it added as an integral part, the progressive monitoring of indicators towards sustainable development (Eurostat, 2015).

Up until 2008, 25 EU member-states had ratified the Lisbon conference, and 14 of those has already revised it. Since 2010, the monitoring of sustainable development indicators has been carried out in conjunction with monitoring of the implementation of Europe 2020

Strategy for smart, sustainable and inclusive dgrowth. (Eurostat, 2016) The latest publicized results for 2017 from Eurostat monitoring report on the implementation of EU SDS, respectively the Sustainable Development Goals for Europe, outlined 100 indicators for monitoring: six for each of fifteen of the goals and five for each of goals 14 and 17. Of all indicators, 14 are multifunctional and can be applied to more than one goal. The level of implementation of each goal in the short run is given in Table 1.1.

Table1.1.

Level of Implementation of the Sustainable Development Goals in EU for 2017

Level of Implementation	Sustainable Development Goals
Progress	SDG 3 Good health and well-being SDG 7 Affordable and clean energy SDG 11 Sustainable cities and communities SDG 12 Responsible consumption and production SDG 15 Life on land
Medium achievement	SDG 1 No poverty SDG 2 Zero hunger SDG 4 Quality education SDG 5 Gender equality SDG 8 Decent work and economic growth SDG 9 Industry, innovation and infrastructure SDG 10 Reduced inequalities SDG 17 Partnerships for the goals
Lack of progress	SDG 6 Clean water and sanitation SDG 13 Climate action SDG 14 Life below water SDG 16 Peace, justice and strong institutions

Source: Eurostat (2017) Sustainable development in the European Union: Overview of Progress Towards SDGs in the EU Context, European Commission, pp. 1-22.

The results from Table 1.1 show that the European Union has mainly short-term progress in sustainable development. The lack of progress in the outlined goals comes from the lack of data on the basis of which assessment can be made. This fact confirms that sustainable development in the EU concepts are strategies in constant progress, getting perfected through new concepts and indicators. For instance, the European Commission Work programme for 2017 underscores the significance of circular economy principles, whose implementation shall bring about the achievement of *green growth* in the EU.[7]

With the implementation of Europe 2020 strategy 2020 Europe 2020 Strategy for smart, sustainable and inclusive growth of 2010, the European Commission transferred to sustainable development whose main drive is innovation, not only technological innovation but one for more efficient resource management. The states are offered the opportunity to meet the challenges posed by sustainable development recognizing the role of eco-innovations and the significance of the investments in that sector. (Scarpellini et al., 2017) An eco-innovation is any innovation which enhances the achievement of the desired sustainable development through two conditions: a) alleviating the industrial production impact on the environment, and: b) increasing resilience to the pressures on the environment by creating more efficient and socially responsible policies for using natural resources. (OECD 2012) Eco-innovations are business orientated as they are in their own right a strife for creating new opportunities, growth and reversing negative image. We are faced with a double challenge: on the one hand – to improve products with high environmental indices throughout their life cycle, and on the other – increase the demand for products with lower environmental impact. In order to promote for the market new environmentally friendly technologies, the European union has activated a number of instruments, including green procurement, eco-labelling, audits of environmentally friendly technologies, financial initiatives,

[7] EC (2016) Communication from the Commission to the European Parliament, the Council, The European Economic Social Council and the Committee of the regions: Next steps for a sustainable European future- European action for sustainability, COM (2016) 739 final: 22.11.2016, pp. 2-18

voluntary implementation of environmental considerations and industrial standards. The EU has also taken specific financial measures for shouldering together the risks when investing in eco-innovations. Rules were made for getting state aid for environment protection, which guarantee a more efficient support for innovative technology. For almost three years now, the European Commission has been analyzing the trend in eco-innovations via a special Eco-innovation Observatory. It elaborates on the eco-innovation definition, expanding it thus: Eco-innovation is the introduction of any new or significantly improved product (good or service), process, organizational change or marketing solution that reduces the use of natural resources (including materials, energy, water and land) and decreases the release of harmful substances across the whole life-cycle." (Eco-innovation Observatory, 2011)

As cited above, the debate on the importance of the environmental externalities within the economic mainstream has led to the definition of sustainable development. Sustainable development can be considered an economic principle based on environmentally friendly industrial and productive development.

Over the last decade, the sustainable development issue has become more concrete with a less conceptual connotation. During the period 2002-2012, the discussion on the importance of sustainability in the economics model continued to develop. It is important to also mark the creation of the Commission on the Measurement of Economic Performance and Social Progress (2008), based on the request of the French President Nicolas Sarkozy. The name of the commission comes from of its president Joseph Stieglitz. The Nobel Prize winner Amartya Sen, along with 22 other prestigious collaborators, was a member of this commission. The Stieglitz Commission in 2009 issued a report in which it examined the central role that GDP in defining the well-being of a nation. The results highlighted that there are some cases when the GDP growth does not lead to a growth of well-being. The report proposes twelve recommendations that should lead to social well-being in its many dimensions. The core aspect is *sustainability*: "The assessment of sustainability is complementary to the question of current well-being or economic performance, and must be examined separately. This may sound trivial and yet it deserves emphasis, because some existing approaches fail to adopt this principle, leading to potentially confusing messages. For instance, confusion may arise when one tries to combine current well-being and sustainability into a single indicator. To take an analogy, when driving a car, a meter that added up in one single number the current speed of the vehicle and the remaining level of gasoline would not be of any help to the driver. Both pieces of information are critical and need to be displayed in distinct, clearly visible areas of the dashboard" Stieglitz Commission (2009).

Since then, national and international initiatives have been multiplied to "go beyond GDP".

The future of sustainable development is an integral part of the circular economy concept.[8] Circular economy is part of the Sustainable Development Goals (SDG) and more specifically the following ones: SDG6: Clean water and sanitation; SDG8: Decent work and economic growth; SDG9: Industry, innovation and infrastructure; SDG11: Sustainable cities and communities; SDG12: Responsible consumption and production; SDG13: Climate action; SDG14: Life below water; SDG15: Life on land (EC, 2016). Circular economy stimulates sustainable manufacture and consumption in order to achieve resource efficiency and waste reduction. The separate economies become more competitive and innovative globally. Especially in EC member-states, the expectations are that circular economy guarantees *green* growth through modern eco-innovations, which is highlighted in the Work programme of the European Commission for 2017.

BIBLIOGRAHIC REFERENCE

- Baker, S. (2014), Sustainable Development, Taylor & Francis Ltd – ROUTLEDGE, II ed.
- Brundtland Report (1987), available at: http: //www.un-documents.net/our-common-future.pdf.

[8] The essence of circular economy is elaborated on in Chapter 2 herewith.

- Charter of European Cities & Towns towards Sustainability (1994), http: //portal.uur.cz/pdf/aalborg-charter-1994.pdf.
- Cooper. T. (2005), “Slower Consumption Reflections on Product Life Spans and the “Throwaway Society”, Journal of Industrial Ecology, vol. 9 issue 1-2, pp. 51-67.
- Cox, S., Griffith S., King G. (2013) “Consumer Understanding of Product Lifetimes”, Conservation and Recycling Journal, vol. 79, pp. 21–29.
- Declaration of the United Nations Conference on the Human Environment, 16 June 1972, U.N. Doc. A/Conf.48/14/Rev. 1 reprinted in 11 ILM 1416 (1972) avaiable at: http: //www.un-documents.net/aconf48-14r1.pdf.
- EC (2016) Communication from the Commission to the European Parliament, the Council, The European Economic Social Council and the Committee of the regions: Next steps for a sustainable European future-European action for sustainability, COM(2016) 739 final: 22.11.2016, pp. 2-18.
- Eco-innovation Observatory (2011) Introducing eco-innovation: from incremental changes to systemic transformations, Eco-innovation brief, July, pp. 1-4.
- Eurostat Statistical Books (2015) available from: http: //ec.europa.eu/eurostat/documents/3217494/6975281/KS-GT-15-001-EN-N.pdf.
- Eurostat (2016) Sustainable development in the European Union-a statistical glance from viewpoint of the UN Sustainable development goals, 2016 edition, pp. 3-168.
- Eurostat (2017) Sustainable development in the European Union: Overview of progress towards SDGs in the EU context, European commission, pp. 1-22.
- General Assembly of UN (2012) Resolution adopted by the General Assembly: The future we want 66/288, July, 27, pp. 1-52.
- Göteborg Council (2001) available at: http://www.regeringen.se/49bb96/contentassets/12c56698e57e4d4b865331ae3b2a5b51/summary-in-english.

• Kyoto Protocol (1997) available from: http: //unfccc.int/resource/ docs/convkp/kpeng.pd.

• Lisbon Strategy 2000-2010: available at: http://www.europarl. europa.eu/document/activities/cont/201107/20110718ATT24270/20110718ATT24270EN.pdf.

• Meadows D., Meadows D., Randers J., Behrens W. (1972), The Limits to Grow, available at: http: //www.donellameadows.org/wp-content/userfiles/Limits-to-Growth-digital-scan-version.pdf.

• MLTM (2012) Water and green growth, Ministry of Land, Transport and Maritime Affairs of Republic of Korea, pp. 9-176.

• OECD (2011), "Towards Green Growth": available at: https: //www.oecd.org/greengrowth/48012345.pdf.

• OECD (2012), Green Growth and Developing Countries: A Summary for Policy Makers, available at: https: //www.oecd.org/dac/ 50526354.pdf.

• OECD/European Commission/Nordic Innovation Joint Workshop (2012), "The Future of Eco-Innovation: The Role of Business Models in Green Transformation" available at: https: //www.oecd.org/innovation/ inno/49537036.pdf.

• Report of the World Summit on Sustainable Development (2002), available at: https: //www.are.admin.ch/are/en/home/sustainable-development/international-cooperation/2030agenda/un-_-milestones-in-sustainable-development/2002—un-world-summit-on-sustainable-development—johannesburg.html.

• Report COP Paris (2016), available at: https: //unfccc.int/resource/docs/2015/cop21/eng/10.pdf.

• Scarpellini, S., Ortega-Lapiedra, R., Aranda-Usón (2017) Human capital in the eco-innovative firms: a case study of eco-innovation projects, International Journal of Entrepreneurial Behaviour and Research, vol. 23, Issue 6, pp. 919-933.

• Stieglitz Commission (2009) available at: http: //www.stat.si/doc/drzstat/Stiglitz%20report.pdf.

• Steurer, R. and G. Berger (2010) The Lisbon strategy and sustainable development strategies across Europe: how different governance arrangements shape the European coherence of policy documents, Discussion Paper 1 of the Institute of Forest, Environmental and Natural resource policy, pp. 1-22.

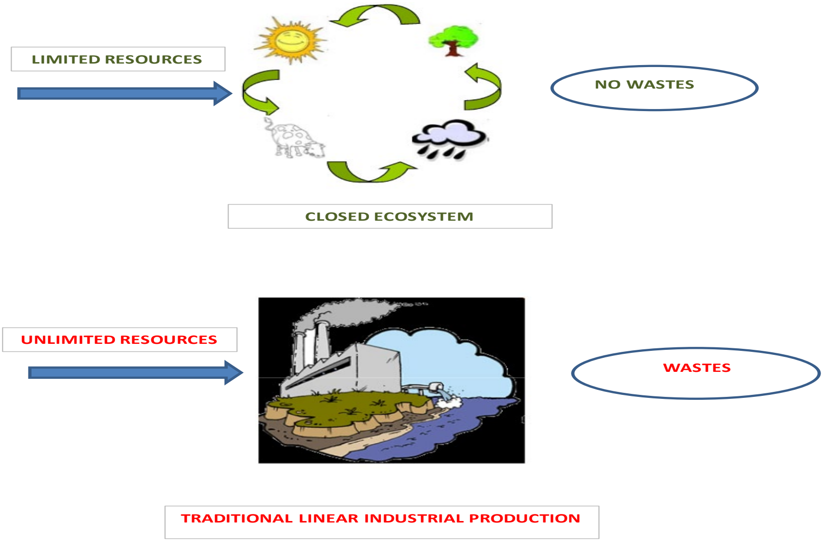
- UN General Assembly (2000) Declaration of Millennium Development Goals
- UN (2015) The Millennium Development Goals Report, pp. 3-72.
- UNCD (1992) available at: https: //sustainabledevelopment.un.org/content/documents/Agenda21.pdf.

SECOND CHAPTER
CONCEPTS LINKED TO CIRCULAR ECONOMY

1. The Concept of Industrial Ecology

Over the past years, other key concepts have been coupled with sustainable development. Industry, academia, media, public administration and NGOs have been using *industrial ecology* and *environmental management* more frequently. As already underlined, sustainable development involves the integration of society's social, economic and environmental goals in order to maximize the well-being of the present without compromising the ability of future generations to meet their needs. It is now widely acknowledged that industrial activity plays an essential role in a sustainable society. The awareness of environmental issues associated with industrial development has led to identifying management tools for companies and organizations in sustainable operations as drivers of change. These studies have led to the definition of the concept of industrial ecology as the study of interactions between industries and their environment (Ayres, 2002). That is, technological and management studies for the reconfiguration of industrial activities in order to preserve natural resources and reduce pollution approaches (Figure 2.1).

Fig. 2.1:
Comparison between traditional linear production and the natural ecosystem



Source: Personal elaboration of the authors.

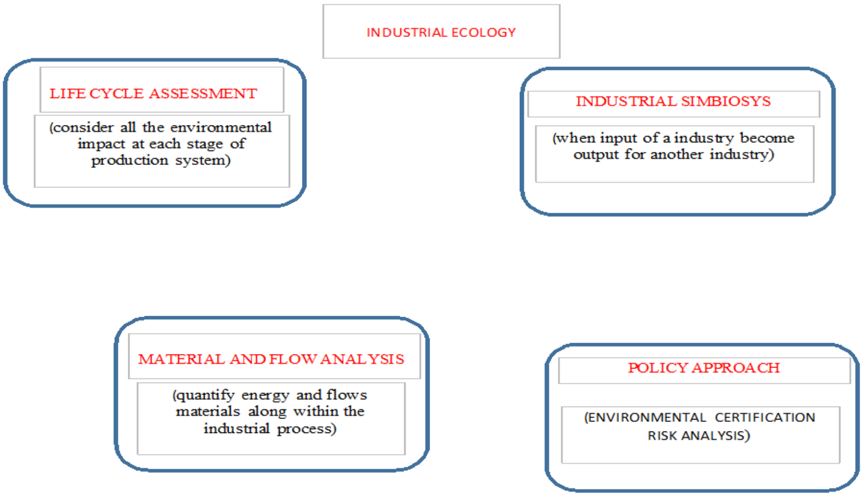
As shown in Figure 2.1, the operational strategy of industrial ecology is the creation of closed systems – as in the circular economy model – in order to reduce losses throughout the conventional industrial system, dematerialize and decarbonise industrial processes by developing and implementing renewable energies.

There is no generally accepted unique definition of industrial ecology. However, most definitions include similar characteristics with different accentuations. One of the most often cited industrial ecology publications defines it as follows: "Industrial ecology is the means by which humanity can approach and maintain deliberately and rationally a desirable carrying capacity, given continued economic, cultural and technological evolution." (Thomas, 1998) The concept requires that an industrial system be viewed not in isolation from its surrounding systems, but in concert with them. It is a system view in which one seeks to optimize the total materials cycle, from virgin material, to finished material, to product, and to ultimate disposal. Factors to be optimized include resources, energy and capital.

The concept of industrial ecology (industrial ecosystem) was introduced in the early 1990s by Robert Frosch as an analogy between natural ecosystems and industrial ecosystems. According to Frosch, by analogy with natural ecosystems, an eco-industrial system should maximize the efficient use of waste materials and end-of-life products as inputs for other production processes. (Frosch, 1992) Such a system can be triggered, according to Frosch, only if you have the interaction of a number of factors. As part of the actions that can be taken to move towards an eco-industrial system, Frosch includes, among others, product design for end-of-life recycling/reuse, internalization of waste disposal costs for products and processes, manufacturer's responsibility, etc. The main goal of industrial ecology is to promote sustainable, global, regional and local development. Fundamental to achieving this goal is the recognition of the interrelation between industrial and natural systems. The transition from fine process solutions to preventive approaches is an example of this. The key principles on which industrial ecology is based are through analogy with natural ecosystems, introducing the concepts of *industrial metabolism* and *industrial symbiosis*. Industrial metabolism is the chain of physical processes that transform raw materials and energy, in addition to work, into products and waste. One of the goals of industrial metabolism is to study the flow of materials through the company in order to better understand the sources, causes and effects of emissions. Industrial symbiosis, as part of the emerging field of industrial ecology, pays attention to the flows of matter and energy through regional economies. Industrial symbiosis involves traditionally separated industries with an integrated approach aimed at promoting competitive advantages through the exchange of matter, energy, water and/or by-products. The key aspects of industrial symbiosis are the collaboration between companies and the synergy opportunities available in a suitable geographical context. Industrial ecology therefore involves different sectors and different integrated skills: environmental, technological, organizational and logistical skills, cross-analysis capabilities of systems and networks, e.g. the analysis of

MFA (Material Flow Analysis) clean technologies, industrial metabolism, and industrial symbiosis (Figure 2.2).

Figure 2.2:
Different Aspects in the Application of Industrial Ecology



Source: Personal elaboration of the author

A core concept of industrial ecology is the study *of material and energy flows* and their transformation into products and waste along industrial systems. One of the strategies of industrial ecology is to reduce the amount of material waste and waste energy produced as negative impact on ecological systems. Recycling efforts might thus minimize waste. Efforts to use waste as input material or energy source for some other industry can potentially improve the overall efficiency of the industrial system and reduce negative environmental impacts. Industrial ecology seeks to turn industrial activities into a more closed system, by reducing the dissipation or dispersion of materials from anthropic sources (in the form of pollutants or waste) arising from human activity.

Industrial ecology draws an *analogy between industrial and natural systems*, and suggests that the goal is to stimulate the evolution of the industrial system, which has the same characteristics as described above in relation to natural systems. The evolution of the industrial system from a linear system (where resources are consumed and harmful wastes are dissipated into the environment), to a more closed system (analogous with natural systems). One of the goals of industrial ecology is the achievement of the same balance and level of reciprocity which exists in nature.

Let us give an example. There is an eco-industrial park in the city of Kalundborg, in Denmark. (Ehrenfeld et al., 1997) It represents an attempt to create a closed system: the companies in the park are integrated among themselves to use waste products from a single company as a source of energy or raw materials for another. The direct benefits of the Kalundburg system are many and versatile: a) Financial benefits – for a total investment of 80 million USD, a saving of around USD 170 million has been recorded; b) Environmental benefits – the average annual saving is equal to USD 15 million, essentially linked to the reduction of resource consumption: fuel oil savings: 19,000 tons; coal savings: 30,000 tons; less water consumption: 600,000 cubic meters; emissions reduction: 130,000 tonnes of carbon dioxide (CO2) and 3,700 tonnes of sulphur dioxide (SO2); reused 135 tonnes of light ashes, 2,800 tonnes of sulphur; 80,000 tonnes of plaster, 800,000 tonnes of nitrogen contained in the sludge.

The indirect advantages are identified as reduction of incoming traffic to the territory; reduction in the transport of materials; better air and environmental quality in general; high quality and competitive territorial profile, linked to this innovation.

Since industrial ecology is based on a holistic approach, vision systemised application requires that knowledge from a variety of fields – law, economics, business, public health, natural resources, ecology, engineering, etc. – contribute to the resolution of environmental problems caused by industry. Along with the design and implementation of appropriate technologies, changes in national policy and legislation as well as individual behaviours will be needed in order to offset environmental impacts (Hutchison, 1997, Desrochers, 2001).

Industrial ecology includes several important strategies, or it offers new approaches for reduction of the overall environmental impact caused by all elements within the industrial system, namely:

- Waste minimization: which means any practice that reduces the amount of a dangerous, polluting or contaminating substance into the environment prior to recycling, treatment or disposal.
- Introduction of total Environmental Quality Management (TQEM) to monitor and improve the environmental performance of a company. Based on consolidated principles of total quality management, TQEM integrates environmental considerations into all aspects of a company's decision-making process, operations, and products. All employees are responsible for implementing TQEM principles. This is a global approach, while at the level of the single enterprise.
- Adopting the Cleaner Production concept – a term coined by the United Nations Environmental Program in 1989, which is widely used in Europe. Cleaner production means the application of an integrated environmental prevention strategy applied to processes, products and services to increase overall efficiency and reduce risks to the environment.
- Eco-industrial parks: an industrial park can turn into an eco industrial park through the combination of collective synergies resulting in optimized exchanges between companies with the aim to minimize waste, effluents and emissions. "The term eco-industrial park has become the umbrella term for practising collective environmental initiatives in their design construction and ongoing operation and management "(UNIDO, 2016).
- Green Chemistry: design and application of chemical products and processes to reduce or eliminate the use and generation of hazardous substances. The development of new materials and energy sources to replace non-renewable and polluting substances is in itself part of the chemistry as a science. Industrial ecology plays an important role in evaluating the wider implications of proposed system solutions such as biofuels or genetically modified organisms (such as industrial enzymes). The areas for the development of green chemistry are the use of

alternative raw materials, the use of harmless reagents, using natural processes, the use of alternative solvents.

2. The Concept of Green Economy

Green economy is a part of economy which is able to support its environmental impact, which has to be obviously very low. To do this, green economy has to go hand in hand with technological development and knowledge because only in this way will it be able to adopt the best solutions. Surely, an important item of green economy is the use of alternative energies. Wind, solar, geothermal, but also biomass and hydroelectric power are just some of the alternative solutions to traditional energies to incentive sustainable consumption. Green economy promotes a solid and sustainable economy based on the reduction of harmful emissions, energy saving and respect for the environment. Industry experts argue that green economy will save the world from poverty and make natural resources accessible to all.

Green economy and sustainable development do not have the same meaning. Green economy is a tool (and the means) to implement sustainability in a "transitional phase" in order to manage the change towards a sustainable development model. At the same time, green economy leads to a new economic model stably sustainable. To make this transition, specific conditions, such as specific national regulations, ad hoc policies, subsidies and support incentives and investments are necessary. Green economy is an economic system that is not only concerned with adopting low environmental impact solutions but also with doing business. It works in some sectors, such as waste recycling and alternative energy. Sustainable development, on the other hand, is more than an economic principle because it is based on environmentally friendly productive development. The difference between green economy and sustainable development is represented by the fact that the green economy has the goal of producing business, carrying on a business and promoting earnings.

The term "green economy" dates back to 1989 when three important environmental economists Pearce, Barbier and Markandya

(Pearce, Markandya and Barbier, 1989) named a report for the British Government "Blueprint for a Green Economy". This report became the basis of environmental economics. The report highlighted how the economy could stimulate environmental policies and how economic development could be reconciled with environmental protection.

Green economy covers different sectors (Chapple, 2008), including among others:

- renewable energy (e.g. solar, wind, geothermal);
- green building and energy efficiency technology;
- energy-efficient infrastructure and transport;
- recycling and waste-to-energy.

Green economy recognizes the importance of preserving the natural capital, considering biodiversity as being strategic for our planet, because it provides free valuable resources contributing to human well-being. The latter is the so-called "ecosystem services" and it is mainly represented in nature as public goods which are economically invisible and therefore undervalued and poorly managed. For this reason, a green economy estimates the economic value of these ecosystems and considers them as assets on the economic market. Table 2.1, for instance, shows the deforestation trend occurring over the past years. Green economy suggests "*that investing 0.03% of GDP between 2011 and 2050 in paying forest land holders to conserve forests and in private investment for reforestation could raise value added in the forest industry by more than 20% as compared to business as usual*" (Towards a Green Economy, 2011).

Table 2.1.

Worldwide Trends in Deforestation

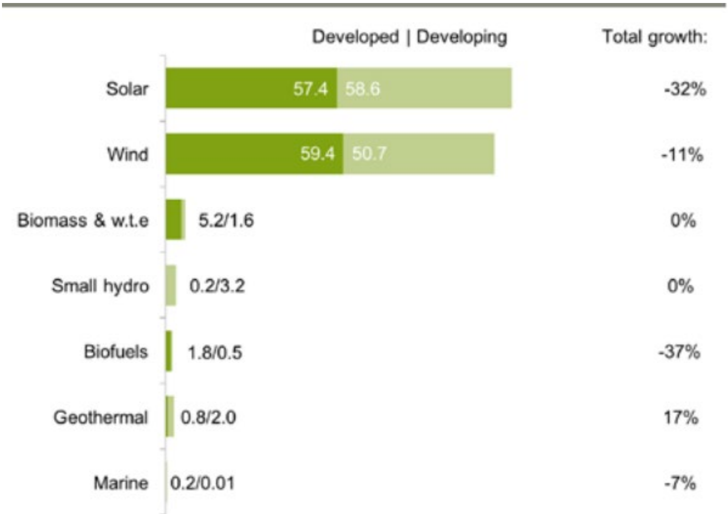
Forest Cover	1990	2010
World forest area (hectares)	4.17 billion	4.03 billion
World planted forest area (hectares)	178 million	264 million
Deforestation	**1990-2000**	**2000-2010**
Annual net forest loss (hectares/year)	8.3 million	5.2 million
Annual deforestation (hectares/year)	16 million	13 million
Annual increase in planted forest (hectares/year)	3.36 million*	5 million

Source: UN: Towards a Green Economy (2011)

As cited above, one important sector which green economy invests in is green energy. The purpose is to replace fossil fuels with renewable and low-carbon emission energy sources. The current energy system based on fossil fuels is responsible for two-thirds of greenhouse gas emissions and generates high costs to be incurred in terms of adaptation. The right direction is to increase the supply of renewable energy that reduces the risk of rising prices and the volatility of fossil fuels mitigating climate change. Renewable energy is the core business of green economy with important future opportunities (see Figure 2.3).

Figure 2.3:

Global new investment in renewable energy: developed vs. developing countries, 2016, and total growth in 2015, $bn[9].



Source: Global Trends in Renewable Energy Investment, 2017

Green economy requires investments to replace fossil fuels with clean energy and clear energy efficiency policies. It is clear that in this context, government policies and increased investments play a fundamental role for the support of renewable energy incentives, together with the various international agreements on carbon trading and energy efficiency.

3. The Concept of Bioeconomy

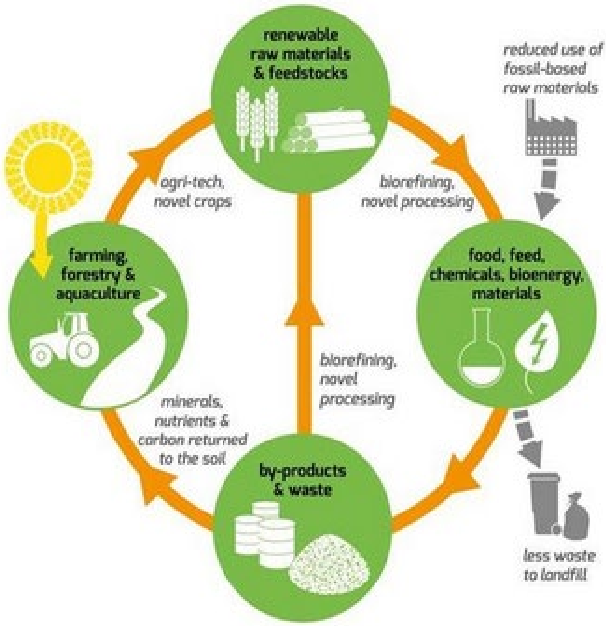
In February 2012, the European Commission announced its strategy for a sustainable bio-economy to ensure smart green growth in Europe. The strategy and action plan was called «Innovating for Sustainable Growth: a Bioeconomy for Europe» (European Commission 2012a).

[9] Key English language terms: *developed countries*; *developing countries total growth; solar energy; wind energy; biomass and w.t.e. (waste to energy); small hydro power stations; biofuel*; *geothermal energy*; *marine energy*.

From the green economy concept, we have moved toward the "bio-economy" concept which is broader than green economy. Bioeconomy covers the set of economic activities related to development, production and use of products and biological processes with the aim to make more sustainable both the health and the agricultural sectors (Figure 2.4).

Figure 2.4:

The Bioeconomy Concept

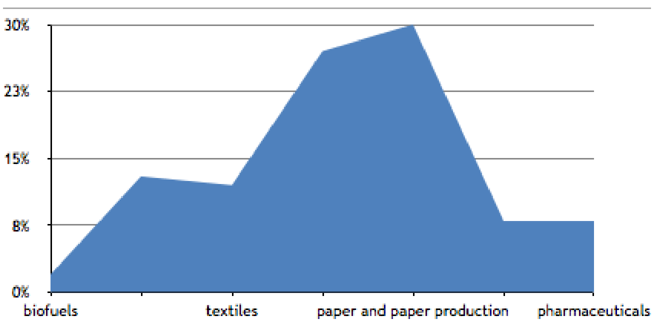


Source: EuropaBio (2011)

Bioeconomy can be defined as an economy that uses biological resources, from land and sea, as input for energy production, industry, food and animal feed. An example is the bioplastic bag that we find today in the supermarket, which is derived from renewable raw materials. But even many intermediate chemicals with applications in the pharmaceutical, cosmetic or food industry today derive in whole or in part from renewable raw materials. Bio-economy aims to free the economic processes from the use of fossil fuels, which represents a structural paradigm – not only economic but also cultural (Esposti 2012, Esposti 2013). Bio-economy, thanks to its enormous innovative potential, may be an answer to many of the global challenges we will be faced with in the coming years, from environmental remediation to the problems of climate change, the invention of new drugs, the need to feed a world where the food requirements will increase by 70% by 2050. Bio-economy directly links innovation to economic growth. This has to involve many stakeholders – in particular farmers, foresters, fishermen and policy makers involved in the supply chain, as well as consumers. There are many benefits: the opportunity to replace a commodity produced by fossil fuels with a bio based product, contribute to the safeguarding of rural and coastal areas, developing bio-refineries or developing aquaculture infrastructures. Figure 2.5 represents the turnover (in percentages) of biobased economy in 2013, totalling 600 billion Euro.

Figure 2.5:

Turnover of Biobased Economy in 2013, in %



Source: Biobased report (2016)

The prospects for further growth are even more promising: according to an OECD study (OECD, 2009; Clever, 2010) it is estimated that in 2030, in developed countries, biotechnology will account for 35% of chemical and industrial products, 80% of pharmaceutical products and diagnostics and 50% of agricultural products. In a nutshell, the bioeconomy could ensure the environmental and economic sustainability of our societies. However, the technological solutions alone are no guarantee of success. In fact, the global challenges require a deep change both in policy making and in the research sector. On the one hand, global challenges require a shift from sectorial policies and governance mechanisms to a much more integrated approach (EuropaBio, 2011). On the other hand, the multidisciplinary nature of the bioeconomy offers a unique opportunity to face in a comprehensive and systemic way the interconnected challenges. This approach is clearly present within the Europe 2020 Strategy of the European Commission, which states that the creation of a bio-based economy by 2020 is a key factor for the creation of an economy based on knowledge and innovation. The same goes for "Horizon 2020" (European Commission, 2011), the new Framework Programme for Research and Technological Development for the period 2014 – 2020, and the recent European Commission communication on "Innovation for Sustainable Growth: a Bioeconomy for Europe "(European Commission, 2012b). The common aim behind all these documents is the reorientation of the European development model, promoting bio-economy as a tool to enhance growth and job creation. At the same time, it is important to refocus the research system and university education. This is already happening at different levels, as shown, for example, during the presentation of the Horizon 2020 EU funding programme, where initiatives were boosted in the field of this research at the international level, in order to preserve future systems of natural resource use, both within and beyond agriculture. This also needs multi-stakeholder partnerships involving a broad range of civil society groups, including farmers, scientists, SMEs and consumers in addition to representations of the various sectors of bio-based industry problems, such as those that are placed by the current challenges (Schmid, 2012; Sckokai 2012; Viaggi 2012)

4. The Concept of Circular Economy

Circular economy is economy where waste from production processes and use is used circularly, i.e. it is put in back in the same or another production process. This enhances the flow of goods and services. When a product reaches the end of its life cycle, the resources remain within the system, so that this product can be reused several times over within the production process and create added values. (European Parliament Research Service, 2015)

The idea of circular flows of materials as a model for the economy in conditions of limited resources envisages the concepts of industrial ecology, industrial symbiosis and green economy. Circular economy can be considered as the focal part of green economy, because it deals with the management and prevention of waste and resource efficiency, while green economy is a broader concept that also includes the human being and the resilience of ecosystems. (EPPD, 2015) The circular economic model is based on both the *feeding on biological resources,* as well as on *technical materials,* including fossil fuels. It is recommendable to use biological resources for a number of reasons: mainly because the use of biological resources supports bioeconomy. The reuse and recycling of biological waste leads to the creation of biologically based products which prevent such mishaps as leaks and other negative external phenomena. Secondly, the recycling of biological waste does not compromise the production of foods and protects the ecosystem.

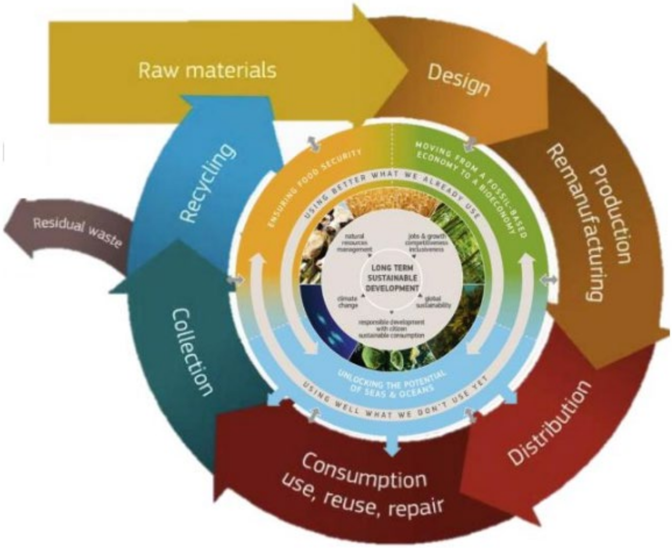
Other very important aspects interconnected with the CE are: a) the cascade cycle: it connects different companies, also to local platforms, so that waste coming from a firm becomes an input for another firm, in this way becoming usable for manufacturing new products. For this reason, it would be better to implement short cycles in order to recover the costs of collection, treatment and product return; b) the multiple cycle: it aims at keeping products longer in use, with more cycles of use including reuse, reparability and maintenance.

From a business point of view, circular economy represents a new model of business which aims to keep products, components, and materials at their highest utility and value at all times. CE aims to overturn the concept of waste as “rubbish”, recognizing that everything has a value. In other words, circular economy is the better way for achieving improvement in resource productivity and eco-efficiency through the creation of a circular system of development.

Figure 2.6 represents the typical view of the concept of circular economy where the recycling model creates production and consumption systems in which everything that used to be considered waste is revived for other uses. According to a report study developed by Lacy in 2015 (Lacy et al.), the forecast of implementing the circular economy business model worldwide will equal $4.5 trillion by 2030.

Figure 2.6:

Schematic Model of Circular Economy



Source: McArthur Foundation 2015

The most authoritative definition comes from Ellen MacArthur Foundation: "[circular economy is] “an industrial economy that is conceptually regenerative and reproduces nature to improve and optimize actively the systems through which it works. This means that the concept of eco-effectiveness proposes the transformation of products and their associated material flows in such a way that they form a supportive relationship with ecological systems and future economic growth. The goal is not to minimise the cradle-to-grave flow of materials, but to generate cyclical, *cradle-to-cradle* ‘metabolisms’ that enable materials to maintain their status as resources and accumulate intelligence over time (upcycling). This inherently generates a synergistic relationship between ecological and *economic systems*, a positive recoupling of the relationship between economy and ecology" (McArthur foundation 2015).

The circular economy concept was presented in December 2015 by the European Commission in the form of a packaging directive, as well as four legislative proposals amending the following legal acts: Waste Framework Directive; Landfilling Directive; Packaging Waste Directive; directives on end-of-life vehicles, batteries and accumulators and waste batteries and accumulators, and on waste electrical and electronic equipment (WEEE).

A commentary report issued in 2015 by the European Parliament (EPSAC, 2015) outlined the main aspects for achieving benefits incorporating the circular economy concepts in the business economy. In particular, the reports explored three economic sectors for evidencing both material savings and increment benefits. The sectors are: food and beverage, clothing and packaging. To shift towards circular economy different factors, have to be taken into account and Table 1 summarizes the main policy measures and tools which guide the circular economy process.

Table 2.2.

Circular Economy Measures and Instruments

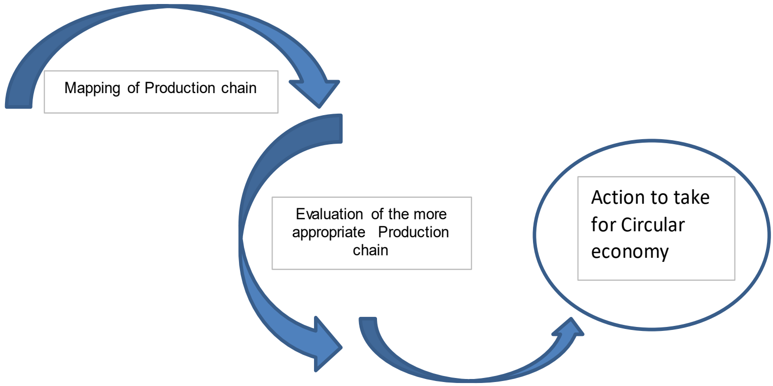
Policy measure	Instruments
New political rules New business models Training/information	Input/output analysis LCA study Eco-process innovation (ecodesign) Industrial symbiosis

Source: Personal elaboration of the author

The suggested measures and instruments create a production chain including different steps for achieving circular economy and for closing the loop (mapping, assessment, particular action), as shown in Figure 2.7.

Figure 2.7.

Approach for Assessment of Circular Economy in the Different Sectors



Source: Personal elaboration of the author

As issued in the report prepared in 2014 by Ellen MacArthur Foundation and McKinsey & Company, the "*Circularity in manufacturing could yield net materials cost savings of up to US$ 630 billion p.a. in the EU alone*". The sectors of which the greatest success is expected in implementing the circular economy principles are motor vehicles, machinery and equipment, incl. medical precision and optical equipment, electrical power and equipment office machinery and computers, etc. (Ellen MacArthur Foundation and McKinsey & Company, 2014).

Circular economy aims to combine innovation, competitiveness and environmental protection. It is necessary to start a transition phase that will trigger a new industrial policy aimed at sustainability and innovation that can increase the competitiveness of the product and at the same time develop new business models. Consequently, a revision of the Community legislation is necessary in the light of the concept of a circular economy, especially with regard to waste. Even if green economy already considers waste a solution and no longer a problem, according to the current regulatory framework, waste is still considered a problem to be managed and this limits the intrinsic potentials. The solution is that legislation should consider rejection of only what "does not have an economic value" for the market, for which it should be provided with ad hoc legislation that in any case provides controlled disposal aiming to prevent its dispersion into the environment. Since this is a very broad field with heterogeneous applications, one of the main challenges regards the defining of criteria to stimulate the circularity of the various projects or products, so as to be able to identify areas for improvement and define objectives. For this reason, the four directives of the "circular economy package" have come into force, modifying the six previous directives on waste (2008/98 / Ce), Packaging (1994/62 / Ce), Landfills (1999/31 / Ce), Electric and Electronic Waste (2012/19 / EU), End-Of-Life Vehicles (2000/53 / Ce) and Batteries (2006/66 / Ce). Member States will have to implement them by 2020 and adopt recycling targets by 2025 for at least 55% of the municipal waste (60% by 2030 and 65% by 2035 are also included in the objectives of the new directives). Landfilling must be reduced to a maximum of 10% by 2035. 65% of all packaging must be recycled by 2025 and 70% by 2030. Textile waste and household hazardous waste (such as paints, pesticides, oils and solvents) must be collected separately from 2025 and again from 2025, biodegradable waste must be collected separately or recycled at home through composting. As for landfilling, the share of municipal waste to be disposed of is determined at a maximum of 10% by 2035. The long-term strategy is twofold: a high incentive for companies to make products with entirely reusable materials and therefore not generate waste, on the other hand – manage the waste produced through re-use and recycling, avoiding disposal in landfills. The new rules provide for greater use of economic instruments and other measures of proven effectiveness to facilitate the application of the waste hierarchy. In this transition, an important role is also assigned to the producers, who will be held responsible for their products when they become waste. Furthermore, the new legislation places particular emphasis on prevention and introduces important targets for food waste in the EU also for marine waste, in order to contribute to achieving the United Nations sustainable development goals. Other aspects to consider from a circular economy perspective are certainly the efficiency in the use of resources. This criterion means raw materials that can facilitate the process of circularity of the production processes respecting the environment. To achieve this goal, it is necessary to develop an appropriate monitoring that is able to assess the quality, quantity and types of resources used throughout the supply chain and for the duration of the product or service life cycle. This implies an ex ante evaluation of the products to be designed by applying eco-design strategies, which means evaluating whether the choice to use certain resources guarantees economic sustainability with respect to the durability, repairability and recyclability of a product. The economic component, together with the environmental component, makes it possible to obtain an overall picture in terms of "efficiency of circularity" and therefore to evaluate concretely the economic aspect. Measure the circularity of the circular economy. As already mentioned, the aspect of circularity is essential to start a virtuous path that allows both to monitor the waste and to find different solutions for their disposal. As a whole, circular economy poses a serious challenge for the different sectors of European economy; moreover, there is no universal indicator for the so called circularity of the processes. According to data from the European Commission, annually in the economy of the European Union are used more than 8 bn tonnes of raw materials, of which only 0.6 bn come from recycled products. In the production cycles in the European Union are generated 2.2 bn tonnes of waste of which only 0.6 bn are reused. The remaining 1.6 bn tonnes remain as waste. That is why the monitoring of the principles of circular economy in the European Union is of key importance. In 2018, it is performed in four directions: production and consumption; waste management; use of recycled products; competitiveness and innovation. (European Commission, 2018) The specific indicators for assessment of these directions and the achievement for 2018 are given in Table 2.3.

Table 2.3.

Main Indicators for Monitoring of the Achieved Results in Circular Economy in the European Union for 2017 at Macro level

Indicators for Monitoring of Circular Economy in the European Union at Macro level	Achievements of Circular Economy in the European Union for 2017
Share of key raw materials for which the European Union does not depend on foreign markets.	The European Union is self-sustaining in respect of certain raw materials, e.g. building materials. For other raw materials, it is strongly dependent on import.
Share of green public procurement, as per the standards for environmental accreditation.	The data for this indicator are still surveyed.
Percentage of generated waste, incl. Municipal, per capita.	8% decrease of municipal waste for the period 2006-2016, or 480 kg/p.c. are generated p.a.
Percentage of generated food waste.	7% decrease of food waste for the period 2012-2014, or 155 kg/p.c. are generated p.a.
Share of recycled materials for reuse.	The percentage of recycled materials is increased from 62% in 2008 to 66% for 2015.
Percentage of recycled municipal waste.	The percentage of recycled municipal waste is increased from 37% in 2008 to 46% in 2016, and the goal is to reach 65% by the year 2030.
Percentage of specific recycled waste (plastic, wood, electrical equipment, etc.).	40% recycling of such waste, which is deemed as a low share. The share of recycled biomass is increased in 2016 with 23%, as compared to 2007. The data relating to the recycling of building materials is quite satisfactory, and its percentage is expected to grow to 70% by 2020.
Import and export of recycled materials.	The European Union s a net exporter of basic recycable materials – plastic, paper, copper, nickel, aluminium, iron, etc.
Private investment, number of employed and added value in the	15 bn Euro private investments, or 0.1% of the GDP of the European Union for

sectors working in circular economy.	2014; 3.9 mln new jobs for 2014, or an increase of 2.3% as compared to 2012; 141 bn Euro added value in 2014, or an increase of 6.1% as compared to 2012.
Number of patents relating to waste management and recycling.	35% increase in the number of patents for the period 2000-2013; 44 % of the patents are for recycling of glass, 18% for recycling of plastic and 23% for recycling of paper.

Source: European Commission, 2018

The results in Table 2.3 show that the EU has been working in the lines of establishing a methodology for assessing circular economy over the past years, recording the particular achievements in the different sectors. But, at the same time, a certain incompleteness exists in the definitions for these particular indicators, in the collection of information from certain spheres; and certain non-comparability between the periods, which makes the overall assessment of the effects of circular economy in the European union member states more difficult. Over the following years, the European commission is extending its efforts towards the development of new indicators, including green public procurement, for food waste. It is also expected that Eurostat improve their database of accompanying statistical data and publish referent values.

In the last years, the different initiatives in implementing the principles of circular economy in the European Union member states have multiplied. In Italy, for instance, there are several private initiatives with excellent and important results. Table 2.4 contains some companies operating in the circular economy sectors and the results achieved.

Table 2.4:
Examples of Circular Economy Initiatives in Italy

Company Name	Type of Activity	Outcome	Website
Relight	Electronic waste recovery	Turnover of 7 million Euro. Involved in several European projects for the implementation of environmental technologies in order both to commercialize eco-products and recover high value metals.	www.relight.com
100% Campania	Sustainable packaging by paper collection	It is possible to save 9,000 kWh of energy, 37,000 litres of water and 110 kg of CO_2	www.packagingsostenibile.com
Nova Mont	Bio plastics produced from raw materials coming from agricultural food	16 0000 tonnes of CO_2 saved in 2014. 3 factories in Italy	www.novamont.com
Compostiamo	Production of compost from municipal waste	CO_2 saved for 2016 – between 35 and 47 tonnes	www.compostiamo.com

Source: Personal elaboration of the author based on the company websites.

In Europe during 2018, different projects and private initiatives on CE have been recorded. In 2018, thanks to a joint initiative of the European Commission and the European Economic and Social

Committee a web platform with good practice on CE. In this web platform there is a specific section which includes relevant practices, innovative processes and 'learning from experience' examples provided by the stakeholders themselves. These initiatives aim at stimulating activities in this aspect, highlighting the relevant results. This web platform is continuously updated and promotes a discussion forum and stakeholder conference for swapping ideas and experiences. Table 2.5 reports some project initiatives at the European level.

Table 2.5
Projects/initiatives at the European Level in Circular Economy

Project Private initiatives	Description	Main actions	Website
Project: C-SERVEES: Activating Circular Services in the Electric and Electronic Sector	Project that aims to boost a resource-efficient circular economy in the electrical and electronic sphere (E&E).	Eco-leasing of electrical and electronic equipment (EEE), product customisation, improved management of waste electrical and electronic equipment (WEEE), and ICT services to support other eco-services.	www. cserveesproject.eu/
Project. ReWeee: Reducing Waste Electrical and Electronic Equipment in Greece	A project that aims to reduce WEEE in Greece by preventing the production of WEEE itself, and also by demonstrating, via appropriate paradigms, that WEEE can be efficiently managed	A web platform to facilitate donation and exchange of EEE. Repair cafés have been organised to give the public the chance to repair their appliances with the help of technicians.	www.reweee.gr/en

Private initiative: Circular cement: processing waste to create cement in a circular economy	Every year, 2.5 billion tonnes of waste is produced in Europe. To tackle waste production, waste needs to be diverted from incineration and landfill to reduce environmental pollution and create a more sustainable and circular economy.	By using the high amounts of energy from waste as a fuel to heat the kiln. By replacing primary mineral materials in cement with fractional mineral traces from waste.	Cembureau: The European cement association
Project: Food waste combat	The organisational model is very simple and builds on the well-established food bank system: excess food is collected from supermarkets and restaurants in a specialised van for food transport, which is then stored in a logistics centre, distributed to local social charities or processed for daily meals in homeless shelters.	Seven tonnes of food, worth at least 1,400€ a month were re-directed to people in need between February and October 2018. Developing this partnership strengthened food resilience on a municipal level and raised awareness of the food waste issue among local authorities.	www.ircem.ro
Project Water 2 return	It promotes symbiosis between key industrial sectors (e.g. agriculture, food processing and wastewater treatment), reduces the environmental impacts of food production and improves the competitiveness of slaughterhouses by obtaining additional revenues from the generated by-products.	Product valorisation for agronomic use – formulation and optimisation of 3 APs, field tests for agronomic efficiency, APs manufacturing. Environmental, economic, social and risk assessments (LCA, LCC, social footprinting,	www.water2return.eu

		quantification of eco-efficiency of the technologies, quantitative risk assessment of potential hazards for humans. Techno-Economic Assessment (TEA) of the overall process. EU Environmental Technology Verification (ETV).	
Private initiative Sfridoo	Sfridoo.com is a B2B publishing platform for purchasing and selling scrap materials developed to include sharing economy principles in making the circular economy a reality. It is a reference point for small and medium-sized enterprises (SMEs) and large companies that are interested in recovering the intrinsic value of their production scrap.	More than 150 companies have made use of Sfridoo since it went live in September 2017.	www.sfridoo.com
Private initiative Agriprotein	A huge volume of organic waste is generated each year, which is expensive to dispose of and leads to harmful methane emissions. At the same time, there is a growing demand for high quality protein in the animal feed and aquaculture sectors. Currently, this feed is	Avoidance of costs associated with the disposal of organic matter; The carbon impact of switching from fish meal, the predominant source of feed in the aquaculture industry, to insect meal is estimated to as much as an	

	produced in a way that depends on finite resources and leads to environmental degradation.	80% reduction; The environmental cost saving has been estimated to $2000/tonne; The greatest impact could be in helping preserve wild fish stocks; at full capacity one Agriprotein factory can replace the need for 15 million wild fish.	

Source: Personal elaboration of the author based on the project websites

The examples in Tables 2.4 and 2.5 cover a variety of focal areas of interest with the objective to reduce the natural consumption of raw materials and at the same time prevent negative externalities, minimise losses and emissions. This aspect outlines the importance of private investment in eco-innovation, which means – ecologically clean technologies. The latter enhance the refinement of product ecodesign by minimising the negative effects on the environment and guaranteeing sustainability in reference to the product reuse and recovery. Currently, the European Union recognizes eco-innovation as the main driver for sustainable development, and it is precisely for this reason that it has foreseen a specific indicator that can measure the level of eco-innovation: the Eco-Innovation Scoreboard (Eco-IS). This tool, developed by the European Eco-Innovation Observatory (EIO), allows the evaluation of the performances of European countries and the comparison between the results obtained, outlining strengths and weaknesses. The Eco-IS consists of 16 indicators that are grouped into five separate components: 1. eco-innovation inputs (R&D appropriations, staff and researchers, green investments in early stages); 2. eco-innovation activities (companies that have implemented innovation activities aimed at reducing material and supplying energy per unit of output); 3. eco-innovation output (measured through patents, publications and media coverage); 4. environmental results (i.e. the benefits to the environment assessed with reference to the "productivity" of materials, energy and water, together with the "intensity" of greenhouse gas emissions); 5. socio-economic results (based on performance data of "eco-industries", including those relating to exports, employment and turnover). In this sense, eco-innovation can speed up the process of implementation of circular economy in the different sectors in the European Union member states.

The Eco-Innovation Observatory also offers a wealth of information. It develops circular economy indicators based on the principles of sustainable development and eco-innovation, namely[10]:

1) Sustainable resource management – covers the research on three main indicators: a) material footprint is a consumption-based indicator of internal resource use per capita. It is defined as „the attribution of global material extraction (biomass, fossil fuels, metal and non-metal minerals and ores, etc.) to domestic final demand of a country: homes, governments and the businesses"; b) Resource productivity measures „the quantity of materials directly used in the economy and/or for domestic consumption as compared to the GDP level"; c) generated solid municipal waste and its recycling – measured in kg/per capita.

2) Social behavior – it includes the research on the following four indicators: a) number of citizens who have chosen alternatives for the purchase of new products, incl. products from recycled materials; b) media coverage of circular economy topics, incl. number of publications; c) turnover of personal use goods which can be repaired (e.g. personal computers); d) number companies and employees engaged in the repair of personal use items.

3) Business operations – includes the research on the following six indicators: a) difficulties when implementing the principles of circular economy in the businesses; b) sources of funding operations related to circular economy; c) access to information on funding sources of activities relating to circular economy; d) percentage of companies, engaged in the recycling of products after their use; e) percentage of

[10] Information on the different EU member states for 2015 can be found on the website of the Eco-innovation Observatory.

companies which take steps to increase the life-cycle of products through eco-innovation; f) percentage of companies recycling waste and/or materials for their own needs, and selling to other companies.

These indicators also prove that the economy and businesses need new concepts, strategies, models and indicators for recording the human footprint on the environment. This Chapter reviews several basic concepts, which have led to the strengthening of the principles of circular economy. These concepts have many additional aspects – blue economy, bio-mimicry, etc.[11] (Желязкова, 2017) A generalized comparison of the essence of the main ideas underlying the specifics of industrial ecology, green economy, bioeconomy and circular economy is given in Table 2.6:

Table 2.6.

Main Characteristics of Industrial Ecology, Green Economy, Bioeconomy and Circular Economy

Concept	Main Idea
Industrial Ecology	Creation of a "closed loop" for maintaining the needed level of resources for production, analogous to ecosystems.
Green Economy	Efficient use of natural resources, incl. flexibility in the utilization of fossil fuels, maintaining residual amounts of energy and other natural resources; widening the market for green goods and services.
Bioeconomy	Replacing the renewable sources used in the production, mainly chemicals, with biological resources; encouraging innovations and support of biodiversity and agro-ecological farming systems.
Circular Economy	Implementation of the Zero Waste Concept, incl. recycling as a form of technological development and as a prerequisite for industrial symbiosis.

Source: Personal elaboration of the author.

[11] The ideas underlying blue economy and biomimicry are generally related to technological innovation inspired by nature.

The general goal of the presented concepts is to create an environmentally friendly economy which will alleviate the dependence on fossil fuels. The concept of bio economy, circular economy and green economy are complementary policy strategies and converge to economic and environmental concerns, research and innovation, and societal transition towards sustainability, but synergies could improve. The reason for this is that they all have been showing the natural way for creating circular economy since the beginning of human activity (Желязкова, 2017).

BIBLIOGRAPHIC REFERENCE

- Желязкова, В. (2017) Кръгова икономика-финансови аспекти, Издателство “Св. Григорий Богослов”, София, с.17-151.
- Ayres U., Ayres, W. (2002), Handbook of Industrial Ecology, Edward Edgar Publishers, US.
- Bio Based Report (2016), available from: http: //nova-institute.eu/
- Chapple T. (2008) available at: http: //communityinnovation. berkeley.edu/reports/Chapple%20-%20Defining%20the%20Green%20 Economy.pdf
- Clever Consult Bvba (2010), The Knowledge Based Bioeconomy (Kbbe) in Europe: Achievements and Challenges, Brussels.
- Desrochers, P. (2001), Cities and Industrial Symbiosis: Some Historical Perspectives and Policy Implications, Journal of Industrial Ecology, vol. 5, issue 4, pp. 9-44.
- Ehrenfeld, J. and Gertler, N. (1997), Industrial Ecology in Practice: The Evolution of Interdependence at Kalundborg, Volume 1, Issue 1January 1997, pp. 67–79.
- Ellen MacArthur Foundation (2015), Growth Within: A Circular Economy Vision for a Competitive Europe, available at: http //www.ellenmacarthurfoundation.org/publications/growth-within-a-circular-economy-vision-for-a-competitive-europe
- Ellen MacArthur Foundation and McKinsey & Company (2014), Towards Circular Economy: Accelerating the Scale-up across Global

Supply Chains, available at: http:/www3.weforum.org/docs/WEF_ENV_TowardsCircularEconomy_Report_2014.pdf

- Esposti R. (2012), Knowledge, Technology and Innovations for a Bio-based Economy: Lessons from the Past, Challenges for the Future. Bio-based and Applied Economics vol. 1, issue 3, pp. 231-264.
- Esposti, R. (2013), Conoscenza, tecnologia e innovazione per un'agricoltura sostenibile: lezioni dal passato, paradossi del presente e sfide per il futuro, Agriregionieuropa, n. 32.
- EuropaBio (2011), Building a Bio-based Economy for Europe in 2020, EuropaBio Policy Guide, Brussels.
- European Commission (2010), Communication from the Commission "Europe 2020: A Strategy for Smart, Sustainable and Inclusive Growth", Com (2010) 2020 final, Brussels.
- European Commission (2011), Proposal for a Council Decision establishing the Specific Programme Implementing Horizon 2020 - The Framework Programme for Research and Innovation (2014-2020), Com (2011) 811 final, Brussels.
- European Commission (2012a), Innovating for Sustainable Growth: A Bioeconomy for Europe, Brussels.
- European Commission (2012b), Commission staff working document accompanying the document "Communication on Innovating for Sustainable Growth: A Bioeconomy for Europe", Brussels.
- European Commission (2018) Communication from the Commission to the European Parliament, the Council, the European Economic and Social Council and the Committee of Regions on a monitoring framework for the circular economy, COM (2018) 29 final: 16.01.2018, pp. 1-10.
- European Parliament Policy Department 2015. Resource Efficiency Indicators, available at: http://www.europarl.europa.eu/RegData/etudes/STUD/2015/542206/IPOL_STU(2015)542206_EN.pdf
- European Parliamentary Research Service, European Parliament (2015). Understanding Waste Streams: Treatment of Specific Waste, available at: http://www.europarl.europa.eu/RegData/etudes/BRIE/2015/564398/EPRS_BRI(2015)564398_EN.pdf

- European Parliament Science Advisory Council (2015) available at: http://www.easac.eu/fileadmin/PDF_s/reports_statements/EASAC_ Circular_Economy_Web_revised.pdf
- Frosch, R. (1992), Industrial Ecology: A Philosophical Introduction, year 1;vol. 89, issue 3, pp. 800-803.
- Global Trends in Renewable Energy Investment (2017), available at: http: //fs-unep-centre.org/sites/default/files/publications/ globaltrendsinrenewableenergyinvestment2017.pdf
- Hutchison C. (1997), Building to Last – The Challenge for Business Leaders, Earthscan Publishers.
- Lacy P. and Rutqvist J. (2015), Waste to Wealth: The Circular Economy Advantages, Accenture Strategy edition
- McArthur Foudation (2015), available at: https: //www.ellenmacarthurfoundation.org/case-studies
- OECD (2009), The Bioeconomy to 2030: Designing a Policy Agenda, OECD, Paris.
- Pearce, D.W., A. Markandya and Ed. Barbier (1989) Blueprint for a green economy, LEEC, Earthscan.
- Schmid M., Padel S., Levidow L. (2012), The Bio-Economy Concept and Knowledge Base in a Public Goods and Farmer Perspective. Bio-based and Applied Economics vol. 1, issue 1, pp. 47-63.
- Sckokai P. (2012), Agricultural and Applied Economics: What is This? Bio-based and Applied Economics vol.1, issue 1, pp. 13-27
- Socaciu, C. (2014) Bioeconomy and green economy: European strategies, action plans and impact on life quality, Bulletin UASVM Food science and Technology, vol. 71, issue 1, pp. 1-10.
- Thomas, M. V., (1998), Industrial Ecology: Towards Closing the Materials Cycle, Volume 1, Issue 2, pp. 149–151.
- UN (2011), Towards a Green Economy, available at: https: //sustainabledevelopment.un.org/content/documents/126GER_synthesis_ en.pdf
- UNIDO (2016) Global assessment of eco-industrial parks in developing and emerging countries, pp. 1-24.

- Viaggi D., Mantino F., Mazzocchi M., Moro D., and Stefani G. (2012), “From Agricultural to Bio-based Economics? Context, State-of-the-Art and Challenges”, Bio-based and Applied Economics vol.1, issue 1, pp. 3-11.

THIRD CHAPTER
INSTRUMENTS FOR IMPLEMENTATION OF CIRCULAR ECONOMY

All products have an environmental impact both during manufacture and use and during their final disposal. From this arises the need to evaluate the entire life cycle of the product in order to design environmentally-friendly products. That is why this chapter illustrates a selection of developed instruments for improvement of the ecological indicators of goods and services. Therefore, it is advisable to favor the manufacture of ecological products, using the following instruments:

a. IPP, Integrated Product Policy and eco-certification;

b. Life Cycle Assessment (LCA);

c. product footprint on the environment and an organizational footprint on the environment.

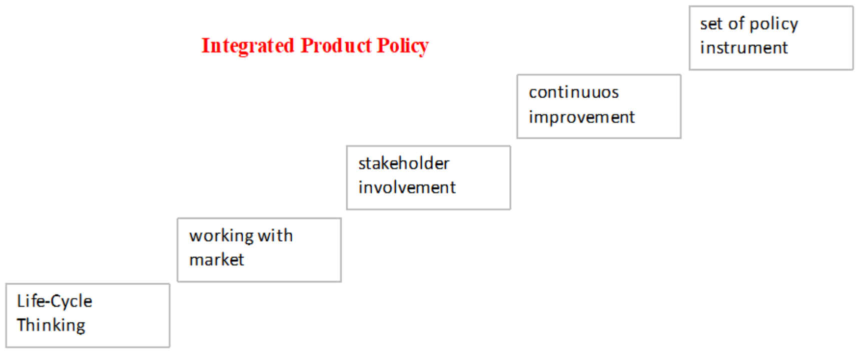
1. Integrated Product Policy (IPP)

The Integrated Product Policy (IPP) can be considered as part the EU's Sustainable Development Strategy. The IPP strategy envisages a set of tools both for preventing environmental degradation from the manufacturing, use and disposal phase and for sustaining economic growth and prosperity. The objective of this approach is to overcome the "*command and control approach*" which is a regulatory tool. Regulatory tools impose standard emissions in order to set levels of pollutants in the environment or product or process rules to encourage clean manufacturing technologies. To issue a law in order to reduce waste production and emission into the environment means adopting a command and control approach. The IPP approach can be defined as a pro-active strategy in which businesses adopt instruments, such as environmental certification or environmental managerial approach, for gaining competitiveness at the same time reducing negative externalities. This approach is to be preferred and incentivised, as it represents a way to control and reduce the environmental impacts by creating competitive advantages for the enterprises.

The IPP approach consists of five key principles, illustrated in Figure 3.1:

Figure 3.1:

IPP Principles



Source: Personal elaboration of the authors.

The major principles envisage the necessity to integrate the environmental dimension at the time of involving the market stakeholders in the process of continuous improvement of the basic product related policies. In other words, environmental sustainability can only be achieved by replacing the command-and-control approach with a shared responsibility between the various participants in the processes.

Another important step is the Communication COM/2011/0112, "*Towards a Competitive Low Carbon Economy in 2050*", approved in March 2011. The communication states an overall 80% reduction in the EU's emissions by 2050 reiterating the need to combine economic progress and environmental protection. (European Commission, 2011) It provides important information on the potential economic sectors of intervention and the key technologies for a more sustainable development. For example, investments in clean technologies will support economic growth, as well as preserve and create jobs. Clean technology is a booming sector, which other parts of the world are also investing in. Replacing operating costs due to the use of fossil fuels with investment costs in new plants could lead to concrete benefits: lower volatility of future procurement costs, security of future primary energy availability, greater energy independence and resource diversification, decreased impact on the environment. (Directorate General XI, Environment, Nuclear Safety and Civil Protection 1998).

As already noted, one of the major IPP instruments is eco-labelling. Nowadays environmental labelling represents recognised and credible tools to be used on products and in advertising, in response to consumer demand. Over the past years, businesses have increasingly focused on environmental certification mainly driven by consumer interests and economic benefits.

Environmental certification can be differentiated as voluntary (productivity-based) or mandatory (process-based). Voluntary, process-based standards simply encourage enterprises to improve their productivity by implementing an environmental management system (EMS)[12]. In contrast, process-based standards are measured by external audit, and can be used to benchmark the performance in a specific context (Chan, 2000). Voluntary standards encourage businesses to improve their performance and reduce their negative environmental impacts. The implementation of eco-labelling in tourism knits into one aspect of both voluntary and process-based standards – e.g. Ecolabel and Blue Flag[13]. Furthermore, depending on whether the life cycle of a product is appraised or not, the ecolabels can be grouped as separate types[14]. (Figure 3.2)

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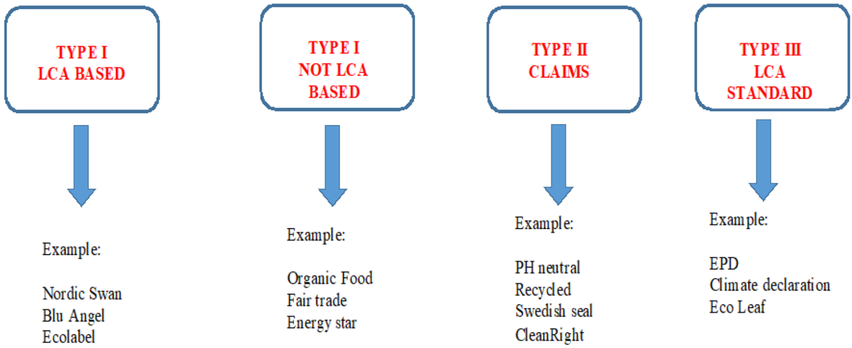
[12] The WEEE Directive (2002/96/EC) can be given as an example of a process-based standard..

[13] As a rule, *Ecolabel* is a voluntary standard for products, but receiving the green sticker for it is guaranteed by law. The *Blue Flag*, too, is a voluntary standard for beaches and marine areas, but after it is granted, it is monitored and checked on a regular basis.

[14] The methodology of life-cycle assessment is reviewed in 2 hereunder.

Figure 3.2:

Types of Ecolabels



Source: personal elaboration of the author.

Type 1 ecolabel examples:

Logo examples are based on multiple voluntary criteria which authorize and award the use of the environmental labels on a category of products or services based on life cycle study.

The *Ecolabel* certification is the best known and appreciated certification and it has a flower for its logo. *Ecolabel* has been extended to tourism and other receptive structures. This certification can protect and preserve the quality of life of residents and their relationship with tourists. *Ecolabel* has an important impact in other areas: a) marketing, allowing to acquire an environmentally-friendly target with a good spending capability; b) management system, helping to reduce negative cost externalities; c) local enhancement, promoting integrated tourism, which affects various tourist interests, such as culture, art, food and wine, environment, traditions. The purpose of the European *Ecolabel* is to encourage companies to design products which respect the environment throughout the life cycle and give consumers the opportunity to make environmentally conscious choices. *Ecolabel* is a voluntary and selective tool. It is voluntary because the request is done by the owner, and it is selective because only products able to comply with requirements are granted the right to use it.

The no logo Type II labels are characterized by self-declaration of the manufacturer on the ecological characteristics of the product and are neither validated nor certified. They don't envisage minimum performance and an audit system of control.

Type III logos are illustrated as follows:

These labels are declarations which contain a quantification of potential environmental impacts associated with the life cycle of a product/service. The documents must provide objective, comparable and credible information about the environmental performance of the product and/or service. The information contained in the environmental product declaration is only for informational purposes and the statement includes no evaluation criteria, nor preference for minimum levels to be respected. Table 3.1 summarises the main characteristics of environmental labelling.

Table 3.1

Comparison between Types I, II and III Labelling

	Type I Environmental labelling	**Type II** Self-declared environmental claims	**Type III** Environmental declarations (LCA BASED)
Information	Qualitative	Qualitative / quantitative	Quantitative
Range	Special products	All products and services	All products and services
Quality check	Verification by the eco-labelling body	None	Third-party certification
Receiver	Consumers	Consumers/ professional purchasers	Professional purchasers

Source: Elaboration of the author based on ISO standards

2. Life Cycle Assessment (LCA) Methodology

The Environmental Management System (EMS) methodologies represent the most successful voluntary tools on the path of sustainable development. Their implementation hasn't suffered declines even during the recent global economic crisis. This is because, firstly, the EMS proved to be an effective tool to continually improve the environmental performance of an organization realising important saving costs as well and, secondly, by the visibility that comes from their third-party certification (e.g. ISO 14001, EMAS).

Within the range of these tools, the most widespread is the LCA-Life Cycle Assessment taken as a standard in the ISO 14040. LCA can be defined as the core system in supporting the environmental management certification such as environmental labels and declarations of product covered by ISO 14020 standards – *Ecolabel*, EPD (environmental product declaration), Carbon and Water Footprint. In recent years a great interest was raised in Europe on environmental product brands, with the main purpose of providing information to consumers. Between 1998 and 2016, a positive trend in the growth of the total number of licenses issued was recorded mainly of products and services marked with *Ecolabel*. Even the EPD, which is an internationally recognized branding, started being interesting both in the marketing strategies and in the improvement of environmental organization.

LCA is a methodology which allows evaluating the environmental issues associated with a product, process or activity, by identifying and quantifying the consumption of material and energy and emissions into the environment. The methodology is based on a systematic approach defined from cradle-to-grave, which means analyzing each phase of its production life, including the extraction and processing of raw materials, through the production, transport and use processes, to recycling or disposal. Through a study, LCA is able to underline the *hot spot* within an organization/firm/service from an environmental point of view in order to give the information necessary to make an improvement. From a general point of view, LCA is a suitable tool to pursue sustainable development initiatives, allowing to calculate the potential environmental impacts associated with its production. LCA can be applied to communicate the environmental performance of a whole sector.

The applications of the LCA method are manifold and can be used to support decision-making related to investment, development and comparison between different products or to introduce innovative managerial planning. The user can be an industry, or a public or non-governmental organization wanting to evaluate its management strategies, increase the environmental performance of a product/service with the aim to favour competitive advantages. It is possible to define two preferential application areas: internally and externally orientated. Among the internal areas, it is possible to consider a) ecodesign: it is used to innovate existing design products through a process, which takes into account not only the technical, economic and functional variables, but environmental ones as well. The ecodesign application requires that LCA analysis is performed during the design phase in order to identify different resources consumed and relative emissions at each stage of the life cycle. In this way it is possible to compare products having the same function and to choose those more environmentally friendly; b) environmental budgeting: it is used to prepare a holistic information system in order to address investment decisions. In this case, LCA is an indispensable tool for investment decisions because it provides useful information during all the stages of the industrial process, for example, during the acquisition of raw materials or the rational use of packaging, identifying how to realize significant savings. Applications can also be externally orientated, such as the marketing of products with environmental statement: a) ecolabelling: according to the ISO 14020-14025 standards, there are three types of eco-labels: type 1 (ISO 14024), which is subjected to compulsory external certification; type 2 (ISO 14021), based on self-declarations; type 3 (ISO 14025) based on established LCA methodology (for example, the EPD, "Environmental Product Declaration"); b) marketing: LCA can also be used to create competitive advantages on the market by comparing the environmental impact of the products or product families; c) relations with institutions:

the company can use this tool to address public decisions, demonstrating how to achieve environmental objectives.

Another widespread application in the public sector is the "Green procurement", i.e. a "green purchasing policy”. This application is also growing among companies, especially those which are ISO 14001 certified. Green public procurement is a voluntary instrument, developed in order to implement a more resource-efficient economy. The goal is to establish a process “whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life-cycle when compared to goods, services and works with the same primary function that would otherwise be procured.” (Communication (COM (2008) 400). The goal is to influence our consumption and production patterns.

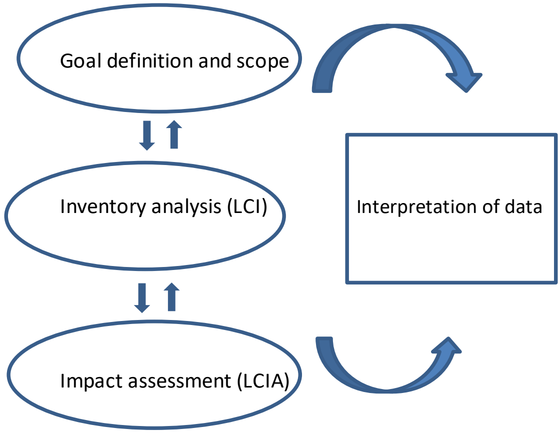
Besides the direct positive effects on the environmental impact, GPP can also stimulate innovation of environmental technologies (demand-pull effect) and serve as an example for private procurement. On the EU level, a GPP toolkit was prepared at the beginning of 2008 for green public procurement. The toolkit was based on life cycle assessment (LCA) approach.

An analysis of the life cycle takes into consideration all the input and output in the considered product system. The guidelines for preparing an LCA have been edited by Society of Environmental Toxicology and Chemistry (SETAC) and are available in the ISO standards 1404 series. In accordance with this rule, the LCA analysis is based on four sequential steps (Fig. 3.3).

Defining the objectives and goals (Goal and Scope Definition). It is the preliminary stage in which the purpose of the study and the boundaries of the system are defined. Also, at this stage the functional unit (FU) is defined. The main purpose of the functional unit is to provide reference to which to tie the incoming and outgoing flows, which is necessary in order to ensure the comparability of the results of an LCA. A system can have a large number of possible functions but the functional unit selection depends on the objective and the field of application of the LCA.

Figure 3.3

Steps for Implementing LCA Studies:



Source: Based on LCA methodology

Inventory Analysis (Life Cycle Inventory Analysis, LCI). It is part of the work devoted to the study of the life cycle of the process. The first analysis of the inventory step is to build the flow chart in which to summarize the life of the product by the processes that are to be included in the system boundaries. For each process, it then identifies the inputs, in terms of matter and energy, and outputs, in terms of emissions into the air, water, soil and waste. This phase also includes the collection of data and calculation procedures, which is important to quantify the inflows and identified output.

Analysis of impacts (Life Cycle Impact Assessment, LCIA). It is the environmental impact study of the process or activity, which aims to highlight the magnitude of the changes generated as a result of emissions and consumption of resources calculated in the inventory.

The main elements of the assessment are: classification, characterization and normalization. *Classification* consists of recognizing the matter/energy consumption and emissions and the relative effects that can cause to the environment at a local, regional or global level. The impact categories depend on the chosen valuation method among those available in the software used to perform the analysis. The environmental impact categories can be grouped into three major areas: depletion of energy resources and materials (resource depletion), effects on the health and safety (human health and safety effects), effects on the ecosystem (ecological effects). The following environmental themes can be referred to them: greenhouse effect (global warming); consumption of non-renewable resources (resource depletion); thinning of the ozone layer (stratospheric ozone depletion); acidification (acidification); eutrophication (eutrophication); formation of photochemical smog (photo smog formation); toxicity to humans and the environment (human and Eco toxicity). These groups of environmental issues, in addition, are structured in such a way that each element present in the inventory can be included in one of the impact categories. *Characterization* consists of the quantification of environmental impacts using scientific models and internationally recognized equivalence factors. After ending the classification of the different impacts caused by the process, the characterization methods determine the quantitative contribution of each emission. In this way, it is possible to express quantitatively, in an appropriate unit of measure, the contribution that each category provides. In this way it is possible to determine the values of the category indicators, defined for each considered effect. For each impact category, a quantification model has to be created. One such model is the model for quantifying greenhouse emissions. The International Panel on Climate Changes has developed a model to assess the global warming potential (GWP) of greenhouse gas expressed in kilograms of CO_2 equivalent. These potentials are calculated for each greenhouse gas taking into account the absorption of radiation and the time of permanence in the atmosphere. The GWP of a substance that has the characteristics of greenhouse gases is measured by the ratio between the contribution that the absorption of hot radiation provides from the release of 1 kg of such substance and that provided by the emission of 1 kg of CO_2, both contributions being evaluated for the same period of residence time in the atmosphere (typically a reference of 100 years). Thus, the GWP is a measure based on the concentration and on the exposure period, the potential contribution of a substance that causes the greenhouse effect, as compared to that caused by the same amount of carbon dioxide. Therefore, the characterization factor of CO_2 in the global warming category is equal to 1. In the same category, the methane characterization factor is 21, which means that the release of 1 kg of methane equals the impact on climate change of 21 kg of CO_2. Finally, normalization allows quantifying the contribution of each impact category to the environment. This operation is realized by normalizing the category indicator of the impact with respect to a nominal value of reference; generally, the average load per year in a country or region divided by the number of inhabitants is adopted in order to estimate the pollution load "per capita". Normalization is intended to highlight what impact categories have greater weight; the normalized results show the order of magnitude of environmental problems generated throughout the life cycle, as compared to the regional environmental loads.

Interpretation and improvement (Life Cycle Interpretation). It is the final part of the study which aims to propose the changes needed to reduce the environmental impact of the processes or activities in question, evaluating them iteratively with the same LCA methodology, so as not to undertake such actions which may worsen the factual conditions.

Another process related to LCA is the *calculation of the carbon footprint*. Carbon footprint is an environmental indicator which measures the human activity impact on global climate and records quantitatively the so called greenhouse gases as per the equivalent carbon dioxide (CO2-eq). The latter is calculated by multiplying each greenhouse gas emissions by its GWP. The carbon footprint is an integral part of the LCA, because it extends the measuring and reduction of the total emission of gases which change the climate during the life cycle of the product or service. The main advantages of the carbon footprint study is its relatively straightforward understanding of its meaning by the public, as well as its direct relation to the globally recognised environmental priorities. For these reasons, the study of the carbon footprint is a widely used marketing tool which not only demonstrates an engagement for reducing the negative impact on the environment, but also encourages the product sustainability policy.

3. Product Environmental Footprint (PEF) and Organization Environmental Footprint (OEF)

In 2013, the European Commission adopted a recommendation entitled "Building the Single Market for Green Products" (2013/179/UE), which proposes EU-wide methodologies for measuring environmental performance for products and organizations. The proposal suggests a methodology for measuring environmental performance throughout the product life cycle named product environmental footprint (PEF). A pilot phase, which ended in 2016, launched in 2013, involved more than 300 companies (representing 70% of the European product market on average) and over 2,000 actors (industrial organizations and stakeholders organizations in the EU and in third countries). The product categories included detergents, paper, coffee, beer, wine, pasta, meat, fish, photovoltaic panels, thermal insulation products, bottled water, leather, paints, shoes, batteries, dairy products and 2 sectors of retail and copper extraction.

The goal of this proposal is to address future policy strategies for the use and promotion of PEF. The PEF methodology was developed by the Joint European Union Research Center based on existing methods (such as ISO 14044-PAS 2050, GHG protocol, etc), with the aim of defining a common methodology at a European level for the calculation the impacts of a product. In other words, the main purpose is to create a framework for comparing the environmental performance of products belonging to the same product category. The PEF becomes not only a way of quantifying and reducing the environmental footprint of products/services, but also of communicating their environmental performance to consumers according to a standardized approach. In this way, consumers will be able to compare the environmental impacts of similar products in the future. Of course, in order to do this, it is necessary to identify the benchmark – the environmental impact of the entire life cycle of products belonging to the same category of goods. PEF is divided into 14 categories of environmental impact (including: climate change, ozone depletion, eco-toxicity – of waters; toxicity in humans – cancerogenic impact; toxicity in humans – non-cancerogenic impact; particulate matter and other inorganic substances which can be inhaled; ionizing radiation – human health impact; photochemical ozone formation; acid content increase; eutrophication – into the interior of the earth; eutrophication – in water basins; resource depletion – water; resource depletion – minerals, ores; soil transformation) and for each class of product, the most significant impact is identified and successively reported. So, companies that will be interested in calculating and communicating the PEF of their products will only focus on collecting the data needed to provide such information. Circulation analysis can bring two important results: reduce costs (LCA to date is a tool widely used by large companies); allow for greater comparison of the results obtained through stimulating green marketing strategies. Another very innovative element that can lead to major changes is the free access to so-called secondary data. In fact, one of the biggest problems and costs for companies is the access and quality of secondary data (those not directly responsible for the company's exclusivity and responsibility). These data are collected in specific databases after payment. The objective of the pilot phase for the realization of PEF is the building of databases the access to which is free of any payment. With the PEF in fact, the European Commission wants to overcome the current limits of the LCA, which is a kind of a photograph of the environmental impacts of a product.

Alongside the PEF, the OEF (Organization Environmental Footprint) is also introduced with the communication 2013/179/UE, a methodology for quantifying the overall environmental footprint of organizations, whose potential areas of application and results are the following:

- Process optimization throughout the entire product supply chain of an organization;
- Communication of environmental performance in the life cycle to stakeholders (e.g. through annual reports, sustainability reports, as a response to questionnaires by investors or stakeholders);
- Programs that create reputation by giving visibility to organizations that calculate their environmental performance in the life cycle or organizations that improve them over time;

- Programs that require environmental performance reporting over the life cycle;
- Means for providing information on environmental performance in the life cycle and achievement of objectives within the framework of an environmental management system;
- Incentives based on improving environmental performance over the life cycle, calculated according to the OEF methodology, where appropriate.

According to the guidelines for implementing PEF and OEF methodologies the EC Regulations EMAS and Ecolabe tools, could be modified including the PEF methodologies and OEF within the new Regulations.

The instruments for introducing circular economy, reviewed in Chapter Three, are standardised and internationally recognised. Moreover, it is supported by the International Organization for Standardization (ISO), and may of its principles have turned into policies implemented within the European Union. Integrated product and ecocertification, life cycle assessment and product or organization environmental footprint policies are used by the public and private sectors as a guarantee for transparency and adequacy of the achieved environmental results. Besides being strictly scientific, the methodologies of the proposed instruments are easily adopted by institutions and businesses. Their goal is to encourage sustainable development policies, production of environmentally-friendly products and make relevant choices of a green supplier of tender, administrative or other business procurement. In this sense, eco-certification, LCA and carbon footprint calculation is an investment into the future. The implementation of these instruments allows the focusing on quality environmental policies demanded by users and carry out responsible natural resource management.

BIBLIOGRAPHIC REFERENCE

- Chan, R. (2000), “The Effectiveness of Environmental Advertising: the Role of Claim Type and the Source Country Green Image”, International Journal of Advertising, Vol.19, pp.349-375.
- Communication (COM (2008) 400) available at: http //eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX: 52008DC0400
- Directorate-General XI, Environment, Nuclear Safety and Civil Protection, (1998), Workshop on IPP, available at: http: //ec.europa.eu/ environment/ipp/pdf/ippfinalreport.pdf
- European commission (2011) Communication from the Commission to the European Parliament, the Council, the European economic and Social Committee and the Committee of the regions: A roadmap for moving to a competitive low carbon economy in 2050, pp. 2-15
- ISO 14020: Environmental labels and declarations – General principles 7
- ISO 14020: Environmental labels and declarations – General principles, 4.2.1
- Recommendation 2013/179/UE in Bulgarian, available at: http://eur-lex.europa.eu/legal-content/BG/TXT/PDF/?uri=CELEX: 32013H0179&from=IT

FOURTH CHAPTER
LIFE CYCLE ASSESSMENT (LCA) APPLICATION TO DEVELOP CIRCULAR ECONOMY: CASE STUDY FROM A EUROPEAN PROJECT

1. Introduction

As discussed in the previous chapters, the industrial ecology concept is represented by the idea to utilize the waste or by-product streams as raw materials for their own process. This practice not only allows to reduce their production costs but also to minimize the use of virgin materials into the production process. This model aims at using resources more effectively as compared to the traditional linear production model. However, despite shifting to a circular economy, it is strategic to make decisions that help to valorise the value chain within the material's life cycle as a whole. In order to create sustainable resource exchanges within the productive plant, information to compare the technical aspects and environmental impacts associated with different waste utilization is essential.

Life Cycle Assessment can play an important role in comparing alternate strategies for utilizing waste resources and determining which technological alternative is more appropriate to maximize the value of the waste material. In this way, the LCA methodology is not only a method to assess environmental performance but it has also become a useful tool to understand the trade-offs between benefits and impacts. The next two chapters highlight the utility of this approach to evaluate the best technological scenario of two case studies applied to powerplants through LCA assessment, and validate the choices from an environmental and practical point of view to address circular economy.

The case study presented in this chapter is related to the analysis of a test plant built in Troia (FG-Italy), an area characterised by a high number of wind farms and photovoltaic plants, to produce hydrogen through electrolysis. This case study is inserted within a European project ended in 2017 and shows how the LCA methods can support decision makers to choose which technology is best suited to reduce energy or resource consumption, which is the goal of circular economy.

The next chapter will present another case study related to energy production from waste or biomass. In this second case study, the aim, always reviewed through LCA, has been to analyse and evaluate the environmental impacts of syngas (which is a mixture of gases comprising carbon monoxide CO and hydrogen H_2, methane CH_4 and carbon dioxide CO_2) production techniques both from residual biomass (this being called bio-syngas), from waste, and from hydrogen generation produced by a pilot plant in Puglia region, in order to make a comparison and identify the critical issues and opportunities for the production of bioenergy in a circular economic perspective. The objective has also been to determine whether the environmental impact assessment tools and scenario can play a role in planning models to be used in long- and medium-term choices. The use of LCA can complement the achievement of the circular economy approach, testing the assumption of the circular economy business model, and highlighting environmental benefits. Furthermore, identifying the incorrect assumptions can help to reconsider the business model in all life cycle phases, evaluating indicators that help measure progress towards the target of closing the loop fostering continuous improvements.

2. A case study of hydrogen power plant production

Since decades researchers are studying alternatives to current energy system, which is mostly based on fossil fuels. The challenge is to find answers able to offset negative fossil fuels impact as well as a competitive system based on a renewable source of energy (RES). It is well known that replace fossil fuels requires time and huge investment in research and development (RD). A promising alternative could be represented by hydrogen, which is very abundant on the Earth in form of hydrocarbons or in compound such as water, to be used as a major carrier in the energy supply cycle. At present hydrogen is mainly produced by fossil fuels but this way is not the best option because does not reduce the use of fossil fuels and does not reduce the production of

CO_2 in the environment. In 2010 the worldwide demand of hydrogen was roughly 43 million tons and is foreseen to reach 50 million tons by 2025. "*Asia and Pacific are the world's leading consumers of hydrogen representing 1/3 of the global consumption; followed by North America and last but not least Western Europe with a 16% of share (7 million tons of* H_2*)"* (Fraile, et al., 2015).

Despite the cost of hydrogen being still higher than most fossil fuels, ranging between 10 € kg - 60 € kg (Fraile, et al., 2015), its properties allow to be used in different application as fuel cells (FCs) which converts the chemical energy into electricity through an electrochemical reaction, (Mueller-Langer, et al, 2007, Zeng et al 2010), in aerospace applications, and in green energy production. According to existing literature, the most important technologies for production hydrogen by RES are the following: thermochemical processes from biomass; thermochemical decomposition of water; photo electro-chemical conversion and water electrolysis (Grigoriev S, et al., 2006; Barbir F. 2005, Marshall A, et al., 2007). Among those, water electrolysis technology is very promising (Ozbilen, et al., 2012; Mazloomi et al, 2012; Tymoczko, et al. 2016). The main inconvenience of water electrolysis is related to a) high energetic costs and b) the intermittence of RES.

In the first case, the energetic cost to produce hydrogen is roughly equal to 45 KWh per 1 kg of hydrogen produced by water (Chen et al, 2014). In the last years, different studies have proposed technical solutions for producing hydrogen with low energy consumption, such as using ionic activators – ethylene diamine complexes of cobalt to reduce energy consumption; using different electroactive materials, such as platinum, nickel (de Souza, 2007) to implement a system capable of realizing electrolysers to produce hydrogen from biomass –derivative alcohol solutions consuming only 18.5 kWh for the production of 1 kg of hydrogen (Chen et al, 2014). All these solutions are still experimental.

In the second case, the intermittence of RES leads to large amounts of energy generated not being fully usable because of continuous power fluctuations and intermittent generation causing problems in power grids and for humans, as well.

To summarize, electrolysis can be feasible only if technical solutions are found that allow the exploitation of renewable energies in appropriate conditions. To this aim, a European project named INGRID (High-capacity hydrogen-based green-energy storage solutions for grid balancing) was funded within the 7th Framework Program (call for ENERGY.2001.7.3-2) “Storage and balancing variable electricity supply and demand" (http://www.ingridproject.eu/). The starting point of the project was related to the issue of hydrogen energy storage. Energy storage is crucial for balancing and integrating large amounts of intermittent renewable energy and improving the efficiency and reliability of the electrical grid. The variable demand of electricity continues to be an obstacle to the spreading of renewable energy technologies and, for this reason, hydrogen storage can represent a practical way to increase the energy supply emission-free. The chosen location for building the demonstrator plant was the Municipality of Troia in Puglia Region, where over 3.500 MW of solar, wind, and biomass plants have already been installed. In the last years, the concentration of renewable energy sources in the municipality of Troia have created some problems to the network grid due to both the energy production peaks and the current insufficient transport capacity of the electrical grids.

One of the main outputs of the INGRID project was to build up a demonstrator hydrogen energy storage plant with capacity of more than 1 ton of safely stored hydrogen (the largest ever built) consisting of: water electrolyser, solid hydrogen accumulation system (HDS), fuel cells (FC) and ICT systems for real-time monitoring and control. The hydrogen plant should increase both the dispatch of hydrogen and the response to fluctuant electricity jointly with evaluating the hydrogen production in order to propose an innovative business model. Another important output of the project was to evaluate the opportunity to use the produced hydrogen as raw material for different industrial uses (fertilizers, etc.) or as alternative transportation fuel for zero emission vehicles with high efficiency, or for producing electricity. Different uses of hydrogen can address important choices, considering that hydrogen is becoming increasingly important not only in the energetic panorama but also in production processes. The authors have contributed in developing the last part of the project calculating the environmental performance generated by INGRID demonstrator plant through the Life Cycle Assessment (LCA) approach applied to three different usage scenarios: a) production of H_2 and its retransformation into electricity through FC; b) production of H_2 to supply vehicles with hydrogen fuel; c) production of H_2 as feedstock for other industrial uses.

3. Methodology and plant description

The methodology of this work is focused on the LCA methodology to estimate the environmental impacts of the three above mentioned scenarios related to the INGRID plant located in Troia (Fg) Italy.

The LCA is a very flexible methodology which allows to estimate the environmental aspects of a product or process deterioration, giving an accurate picture of the main environmental output. The LCA methodology is based on the International Organisation for Standardisation (ISO) 14040 and 14044, and is split in four main phases:1) goal and scope, 2) inventory analysis 3) impact assessment 4) interpretation (ISO 14044; 2006). The goal and scope represent the intention of the research which defines the system boundaries under investigation. The goal of the study defines the functional unit, which is the parameter to address and standardise the environmental impact categories considered. Considering that a process or a product is categorized by a subset of different process, each characterised by different emission, it is useful to split the analysis in upstream, core and downstream processes.

The inventory analysis (LCI) represents the core of the analysis. It describes the system differentiating it from inputs and outputs to be used to complete the environmental impact assessment according to the goal and scope.

The impact assessment (LCIA) converts data into environmental impacts through a specific software. Finally, the interpretation gives the recommendation and suggestion.

In literature, there are different LCA studies based on water electrolysis for hydrogen production (Granovskii et al., 2006; Grigoriev et al. 2006; Boyano et al. 2011, Brisse et al. 2008, Cetinkaya, 2012, Cetinkaya, 2012). It is not so easy to compare them both because of the different impact assessment methods which are based on different hydrogen production technologies (Bhandari et al., 2014). In the paper, the authors focus on the benchmarking of the environmental impacts coming from the three scenarios.

Considering the LCA methodology, the authors organized the study in accordance with the ISO 14040 and ISO 14044 according to the reference guideline reported in the product category rules (PCR) 171 and 173 "Electricity, steam and hot/cold water generation and distribution”. The border system was limited to the hydrogen produced by INGRID plant (see figure 1) and the goal of the study was to assess the global INGRID environmental impacts throughout its life cycle assuming three different usage scenarios:

a) production of hydrogen with electrolyser, storage in a High Density Storage system (HDS) and hydrogen retransformation into electricity through fuel cells;

b) production of hydrogen with electrolyser and its direct injection into the grid to supply vehicles with hydrogen fuel;

c) production of hydrogen with electrolyser, storage in HDS, cooling of H_2 blocks and their transport to the companies that use hydrogen as feedstock for their processes. The functional unit (FU) is equal to 1 kWh needed by an INGRID plant with a system life time of 20 years.

The impact assessment was elaborated using the software GABI v. 6.6 and Ecoinvent data band v. 3.3 and conducted using primary data for all plant components except for the electrolyser analysed with secondary data included in Ecoinvent v.3.3 appropriately scaled.

The data collected are the results both of site visits and partner interviews using structured “data collection survey” organized in three groups: materials, equipment and wastes. The results are expressed with the following parameters: Global Warming Potential (GWP) - greenhouse gas emissions expressed in CO2 equivalent; acidification potential – gas emissions expressed as sulphur dioxide equivalent (SO_2 is 0.1 part of total chemicals.) and Eutrophication Potential (EP) – emission of substances that contribute to the ozone depletion, expressed in phosphate equivalent.

Before illustrating the LCA results, a brief description of the plant is reported. INGRID demonstrator is composed by (see Figure 4.1):

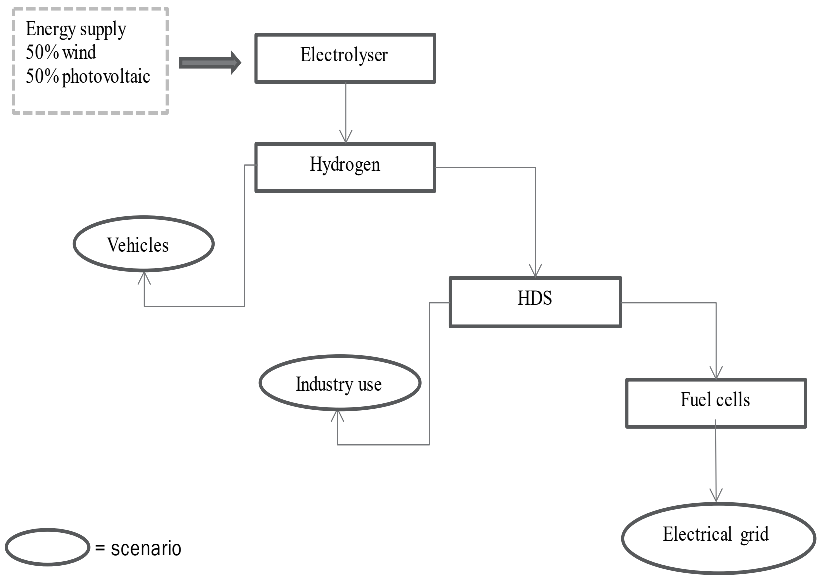
- a water electrolyser, powered by RE produced in Puglia region (with the energy mix equal to 50% photovoltaic and 50% wind) consisting of 4 sub-modular units (300 kW each) and connected in parallel, separating pure O_2 gas and H_2;

- HDS which consists of 4 filling stations (150 kW each) absorbing and storing all the H_2 obtained in solid form for subsequent use;

- 4 FCs sub-units (30 kW each), connected directly with the HDS storage unit able to convert H_2 into electricity.

Figure 4.1

Ingrid demonstrator plant flow diagram



Source: Personal elaboration of the author

According to the LCA, INGRID plant is split in upstream, core and downstream phases Figure 4.1.

The upstream phase concerns:

– creation of all components from the extraction of raw materials to the assembly in the production site of each supplier;

– plant site built up in Troia municipality;

– transport phase and installation of components on site (Troia);

The core phase refers to the usage phase of the three different scenarios: Scenario 1: production of hydrogen with electrolyser, storage in HDS and hydrogen retransformation into electricity through fuel cells. The production cycle is 4 days (the characteristics of distribution grid are omitted). Scenario 2: production of hydrogen with electrolyser and its direct injection into the grid to supply vehicles with hydrogen fuel (the impact of construction of the hydrogen system into the vehicles is omitted). The production cycle is 1 day. Scenario 3: production of hydrogen with electrolyser, storage in HDS, cooling of H_2 blocks and their transport to the companies that use hydrogen for their processes; distribution to companies located at an average distance of 250 km from the production site was hypothesized (no omission). The production cycle is 2 days.

The downstream concerns the end of the life phase:

– The end of life of the INGRID site by differentiating materials for each component. It was defined for the recovering or landfilling according to composition. For those activities Ecoinvent datasets was used.

4. Interpretation of the results

After collecting data related to upstream, core and downstream, the LCIA was carried out through GABI software v. 6.6 and Ecoinvent data band v. 3.3. In Table 4.1 are reported the sub-phases of the LCA INGRID plant differentiated in upstream, core and downstream phases.

Table 4.1.

Phases and sub-phases included in LCA INGRID demonstration plant

PHASE	SUBPHASES
UPSTREAM	*assembly of fuel cell*
	assembly of filling station
	assembly of H2 block
	assembly of water electrolyzer
	assembly of control room
	construction of site
	installation phase
PHASE	**SUBPHASES**
CORE	*tap water*
	electricity
	electrolysis
	transport
PHASE	**SUBPHASES**
DOWNSTREAM	*Recovering*
	Landifilling

Source: personal elaboration of the author

Table 4.2.

Benchmarking of the environmental impacts of the three scenarios

1 kWh of electricity needed for the power plant				
DEMONSTRATOR				
CLIMATE CHANGE (incl. Biogenic CO2) GWP kg CO2 equiv.	**SCENARIO**	**1**	**2**	**3**
	SUBPHASES		**TOTAL VALUE**	
	assembly of fuel cell	3,77E-05	1,13E-04	1,88E-05
	assembly of filling station	4,82E-06	1,45E-05	2,41E-06
	assembly of hydrogen block	6,68E-05	2,00E-04	3,34E-05
	assembly of water electrolyzer	8,95E-03	2,86E-02	4,47E-03
	assembly of control room	2,73E-06	8,19E-06	1,36E-06
	construction of site	1,22E-04	3,66E-04	6,10E-05
	installation phase	1,67E-12	5,01E-12	8,34E-13
OZONE DEPLETION *e-7 kg CFC-11 equiv.*				
	SUBPHASES		**TOTAL VALUE**	
	assembly of fuel cell	2,73E-04	8,19E-04	1,37E-04
	assembly of filling station	1,79E-05	5,37E-05	8,94E-06
	assembly of H2 block	4,64E-05	1,39E-04	2,32E-05
	assembly of water electrolyzer	6,28E-03	1,88E-02	3,14E-03
	assembly of control room	2,12E-06	6,36E-06	1,06E-06
	construction of site	5,04E-05	1,51E-04	2,52E-05
	installation phase	3,13E-12	9,39E-12	1,56E-12

1 kWh of electricity needed for the power plant				
DEMONSTRATOR				
	SCENARIO	**1**	**2**	**3**
ACIDIFICATION *e-3 mole of H+ equiv.*				
SUBPHASES			**TOTAL VALUE**	
	assembly of fuel cell	4,17E-04	1,25E-03	2,09E-04
	assembly of filling station	2,70E-05	8,10E-05	1,35E-05
	assembly of hydrogen block	3,38E-04	1,01E-03	1,69E-04
	assembly of water electrolyzer	1,10E-01	3,29E-01	5,48E-02
	assembly of control room	1,74E-05	5,22E-05	8,69E-06
	construction of site	4,99E-04	1,50E-03	2,50E-04
	installation phase	8,70E-12	2,61E-11	4,35E-12
EUTROPHICATION, aquatic, freshwater *e-4 kg P equiv.*				
SUBPHASES			**TOTAL VALUE**	
	assembly of fuel cell	3,33E-04	9,98E-04	1,66E-04
	assembly of filling stat	1,88E-05	5,65E-05	9,42E-06
	assembly of H2 block	2,82E-04	8,45E-04	1,41E-04
	assembly of water elect	1,17E-01	3,50E-01	5,84E-02
	assembly of control roo	2,52E-05	7,55E-05	1,26E-05
	construction of site	3,48E-04	1,04E-03	1,74E-04
	installation phase	1,38E-12	4,13E-12	6,88E-13

Source: personal elaboration of the author and elaboration with GABI software

Considering the three scenarios analyzed, there are no relevant differences between <u>scenario number 1</u> (industry use) and <u>scenario number 3</u> (electrical grid). This is due to the HDS sharing, which allows to store hydrogen for future possible uses (Figure 4.1.). This means better management, in terms of quantity and timing, of hydrogen production directly related to different market demands.

Scenario number 2, indicating the production of hydrogen to supply vehicles, has the greatest environmental impact. The results show that all the environmental impact categories are higher than the others. This is due to the fact that the hydrogen produced to supply vehicles is not storable. This implies that its continuous production is directly linked to the energy input. This could be mitigated by an adequate development of hydrogen-based transport system still characterized by a demand outlook difficult to assess and plan.

The longer term is less evident to assess, as many assumptions need to be made. Common to all scenarios analyzed is the end of life phase due to the high percentage of recycled materials.

The study results highlight that in the upstream phase the scenario with higher impact is related to feeding hydrogen running vehicles. This is mainly due to the infrastructure necessary for its implementation. The other two scenarios are essentially comparable. The core phase is characterized by the use of the plant for 20 years. The impacts are attributable mainly to the energy consumption associated to each phase. Scenario n.2 core phase shows higher impacts as compared to both other phases within Scenario n.2 and scenarios n. 1 and n. 3. In any case, all scenarios are characterized by high impacts on the ecosystem quality rather than on specific climate change components. This conclusion is mainly due to the electrolytic process and the energy needed to operate fuel cells. Scenario n. 1 and n.3 are those with high environmental impact in absolute terms regardless of the use. Data shows that the hydrogen production process has a strong impact in terms of utilization of process energy required for transformation and in particular those arising by electrolysis. The environmental impact category most affected by the process mainly concerns the ecosystem quality and, less involved, "human toxicity" and "climate change". That's because of the water used for the process and the energy used for the transformation process. However, these impacts are mitigated if the energy used comes from renewable sources. The results of the data interpretation of this LCA study are the outcome of the assumptions described above and the assumptions made for the construction of the model in accordance with the stated objectives. The results of the study LCA are expressions of impacts and do not predict the impact at the end of the impact categories, the exceeding of the limit values, safety margins or risks. The results are exclusively an expression of the assumptions made and are proper indicators of the LCA.

INGRID LCA results show that the higher impacts are associated with the electrolysis process and energy use. Scenario n. 2 has confirmed that the energy input is higher than in scenarios n. 1 and n. 3. However, it is believed that a more comprehensive assessment of scenario n.2 should be conducted in relation to "mobility", not only regarding the production of the energy carrier. The results of the LCA study may be used by the project partners to improve the environmental performance of each component and process from an eco design point of view and for compensating the impacts generated and the scenarios evaluation in order to develop new business models. From the point of view of the public decision makers, the study results can be used to assess the environmental impacts comparing them with the factors related to renewable productions and their enhancement.

BIBLIOGRAPHIC REFERENCE

- Bhandari A., Trudewind, A., Zapp P., (2014), Life cycle assessment of hydrogen production via electrolysis e a review, Journal of cleaner production, 85, pp.151-163.
- Boyano, A., Blanco-Marigorta, A.M., Morosuk, T., Tsatsaronis, G. (2011), Exergoenvironmental analysis of a steam methane reforming process for hydrogen production. Energy 36, pp.2202-2214.
- Brisse, A., Schefold, J., Zahid, M. (2008), High temperature water electrolysis in solid oxide cells. International Journal of Hydrogen Energy 33, pp.5375-5382.
- Cetinkaya, E., Dincer, I., Naterer, G.F. (2012), Life cycle assessment of various hydrogen production methods. International Journal of Hydrogen Energy 37, pp.2071-2080.
- Cipriani G., Di Dio V., Genduso F., La Cascia D., Liga R., Miceli R., Galluzzo G.S., (2014), Perspective on hydrogen energy carrier and its

automotive applications, International journal of Hydrogen energy, 39, pp.8482-8494.

- Chen, Y.X., Lavacchi, A., Miller, H.A., Bevilacqua, M., Filippi, J., Innocenti, M., Marchionni, A., Oberhauser, W., Wang, L.,Vizza, F. (2014), Nanotechnology makes biomass electrolysis more energy efficient than water electrolysis, Nature Communications 5, Article number: 4036.
- de Souza, R.F., Padilha, J.C., Goncalves, R.S., de Souza, M.O., Rault-Berthelot, J. (2007) Electrochemical hydrogen production from water electrolysis using ionic liquid as electrolytes: towards the best device, Journal Power Sources, 164, pp. 792-798.
- Diogo M. F. S., César A. C., Sequeira, L. Figueiredo, J.L., (2013), Hydrogen production by alkaline water electrolysis, Quím. Nova, Vol.36, No.8, http://dx.doi.org/10.1590/S0100-40422013000800017
- Ecoinvent Centre (2016), Ecoinvent database. Swiss Centre for Life Cycle Inventories [online]. Available at: http://www.ecoinvent.org/database/
- Fraile D., Lanoix J., Maio P., Rangel A., Torres S A. (2015) Overview of the market segmentation for hydrogen across potential customer groups, based on key application areas, Report of EU project CertifH, Availbale at: http://www.certifhy.eu/.
- Granovskii, M., Dincer, I., Rosen, M.A. (2006), Life cycle assessment of hydrogen fuel cell and gasoline vehicles. International Journal of Hydrogen Energy 31, pp.337-352.
- Grigoriev, S.A., Porembsky, V.I., Fateev, V.N. (2006), Pure hydrogen production by PEM electrolysis for hydrogen energy. International Journal of Hydrogen Energy 31, pp.171-175.
- IEA (2006) Hydrogen production and storage - R& D priorities and gaps. International Energy Agency (IEA), Paris
- INGRID-High-capacity hydrogen-based green-energy storage solutions for grid balancing (2017), Available at: (http://www.ingridproject.eu/).

- ISO (2006) Environmental Management — Life Cycle Assessment — Requirements and Guidelines. Geneva, Switzerland: International Standards Organization: ISO 14044.
- Marshall A, Borresen B, Hagen G, Tsypkin M, Tunold R., (2007), Hydrogen production by advanced proton exchange membrane (PEM) water electrolysers. Reduced energy consumption by improved electrocatalysis. Energy, 32 (4), pp.431-436.
- Mazloomi K., Sulaiman N., Moayedi N., (2012) Electrical Efficiency of Electrolytic Hydrogen Production, Int. J. Electrochem. Sci., 7, pp.3314-3326.
- Mueller-Langer, F., Tzimas, E., Kaltschmitt, M., Peteves, S. (2007), Techno-economic assessment of hydrogen production processes for the hydrogen economy for the short and medium term, International Journal Hydrogen Energy, 32, pp.3797-3810.
- NEEDS (2008) Generation of the energy carrier hydrogen - In context with electricity buffering generation through fuel cells. Icelandic New Energy.
- Ozbilen, A., Dincer, I., Rosen, M. A. (2012) Life cycle assessment of hydrogen production via thermochemical water splitting using multi-step Cu-Cl cycles. Journal of Cleaner Production, 33, pp.202-216.
- PE International (2010) Hydrogen production from renewable energy by electrolysis. Centre for Research into Energy for Sustainable Transport (CREST), Perth, Australia.
- Spath, L., Mann, M.K. (2001) Life cycle of assessment of hydrogen production via natural gas reforming, Technical Report NREL/TP-570-27637, National Renewable Energy Laboratory Colorado; pp.3-24.
- Stojic, D.L., Marceta, M.P., Sovilj, S.P., Miljanic S.S. (2003), Hydrogen generation from water electrolysis – possibilities of energy saving, Journal of Power Sources 118, pp.315–319.
- Tymoczko, J., Calle-Vallejo F., Schuhmann, W., Bandarenka A. S, (2016), Making the hydrogen evolution reaction in polymer

electrolyte membrane electrolyzers even faster, Nature Communications, DOI: 10.1038/NCOMMS10990

- Zeng, K., Zhang D. (2010), Recent progress in alkaline water electrolysis for hydrogen production and applications, Progress in Energy and Combustion Science, Volume 36, Issue 3, June , pp.307-326.
- Barbir F. (2005), PEM electrolysis for production of hydrogen from renewable energy sources. Sol Energy, 78 (5), pp.661-669.

FIFTH CHAPTER
SUSTAINABILITY OF SYNGAS PRODUCTION WITHIN CIRCULAR ECONOMY

1. Introduction to the energy production from waste or biomass

The energy production from waste or biomass is a topic that, especially in Italy, produces mixed reactions, as outlined by the controversies that promptly accompany the building up waste-to-energy plants. The development of agro-industrial systems that process biomass or reuse waste to obtain bioenergy can play an important economic role only if the environmental problems linked to the territory are analyzed and studied in details. There are many scientific and disciplinary sectors involved in the the environment quantification of the waste-to-energy and biomass-to-energy supply chains and this represents the need to deal with energy and environmental issues more rigorously. An example is represented by the evolution of legislation in Italy on the possibility of obtaining bio-energy: the law published in the Official Gazette no. 262 of 11 November 2014, (called Sblocca Italia) "Urgent measures for the opening of construction sites, the construction of public works, the digitization of the country, the simplifying of bureaucracy and the emergence of hydrogeological instability: Article 35 of the above law, envisages the importance of building up a national network of waste-to-energy plants capable of covering the energetic needs of regions. Particularly, this decision should have involved the construction of eight waste incineration plants, mostly located in the south and on the islands. This law has sparked different negative reactions from stakeholders, citizens and environmentalists who de facto have frozen the construction sites. The negative reaction is a logical result to the fact that the environmental consequences in terms of pollution of the territory and impact on the health from products and emissions associated with the combustion and incineration phase are quite unknown. In other words, the regions should work to achieve the objectives set by Europe, in particular to achieve 65% separate waste collection and the circular economy package. The circular economy package, which came in force on 4 July 2018, amended 6 directives on waste, packaging, landfills, electrical and electronic waste (WEEE), end-of-life vehicles and batteries. With these directives, the European Union members are directed towards recycling targets, which are:

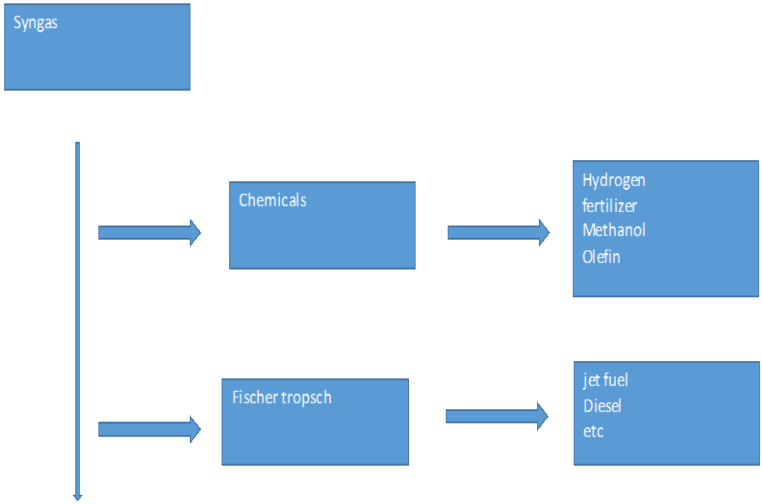
- urban waste: at least 55% by 2025, 60% by 2030 and 65% by 2035;
- landfills: up to a maximum of 10% by 2035;
- recycling of packaging: 65% of packaging by 2025 and 70% by 2030;
- textile waste and household hazardous waste: must be collected separately as of 2025;
- biodegradable waste: by 2024 it must also be collected separately or recycled at home through composting.

As it comes out from the above directive, the policies go in the direction of an economy with low carbon emissions and of an efficient use of natural resources as a valid alternative to the limitations of our economic system based on fossil sources. For this reason, the objective to be pursued at a European level is to outline a framework for circular economy with measures that stimulate research and innovation, and the relocation of waste rather than exclusively aim at solutions at the end of the life of a product. There are different definitions of circular economy, but it is possible to summarize that the main goal is the modelling of the value chain in order to avoid waste and pollution and in the same time decreasing the raw materials consumption coming from industrial and agricultural waste flows. For this reason, the European circular economy strategy has fostered the principle to reuse and recycle the waste to be recycled in other production processes. This economic model must be based both on an understanding of the various production technologies and on the study of all phases – from design, to production, to consumption, to the end-of-life destination in order to rationalize input and incoming energy input and to minimize waste and losses, paying attention to the prevention of negative environmental externalities and the realization of new social values and territoriality. The energy recovery model should represent the last opportunity to adopt behaviour according to the circular economy paradigm. In any case in Europe and in Italy, the recycling system of the waste collection practice is not an efficient process and all member states have to set common rules guaranteeing a high level of environmental protection in the European waste recovery market. Before the circular economy package becomes effective, a transitional period should be considered, taking into consideration the environmental problems linked with energy production emissions. What can research do in this sense? Are there any technologies available to make energy production from waste or biomass fully sustainable according to the development of models related to the territory and its specificities? It is not an easy question to answer but there are recent initiatives which have promoted the study and analysis of gasification to produce a synthetic gas (syngas) avoiding fossil fuel use. From a circular economy perspective, a possible option to make effective waste to energy initiative should be based on the value supply chain using Refused Derived Fuels (RDF) obtained from urban waste for the production (syngas). The aim of this study, based on the European Union strategies on circular economy and bioeconomy, through the well-established methodology of Life Cycle Assessment (LCA), has been to analyse and evaluate the environmental impacts of syngas production techniques both from residual biomass (this being called bio-syngas), from waste, and from hydrogen generation produced by a pilot plant in Puglia region, in order to make a comparison and identify the critical issues and opportunities for the production of bioenergy in a circular economic perspective. The objective has also been to determine whether the environmental impact assessment tools and scenario can play a role in planning models to be used in long- and medium-term choices. This analysis assesses the importance of life cycle thinking, trying to contribute to the knowledge of whether some techniques of conversion to bioenergy can be included in the circular economy strategies of the European Union.

Before explaining the results of the analysis, an introduction on syngas is made. Syngas: Considering that the amount of fossil fuels is decreasing, the research is trying to study valid alternatives to produce energy or useful compounds as an opportunity to go in the direction of circular economy initiatives. Syngas is a mixture of gases comprising carbon monoxide (CO) and hydrogen (H_2), methane (CH_4) and carbon dioxide (CO_2). Syngas is formed by a variety of processes with sources ranging from commonly-used fossil fuels to completely renewable organic compounds. In particular, biomass such as agricultural wastes, forest products, grasses, and other cellulosic material may be converted to syngas. Syngas is an intermediate in the chemical and bio-refining industries and has a vast number of uses. Syngas can be converted into alkanes, olefins, oxygenates, and alcohols, such as ethanol. These chemicals can be blended into, or used directly as, diesel fuel, gasoline, and other liquid fuels. Syngas can also be directly combusted to produce heat and power (see Figure 5.1), or is also used as an intermediate in producing synthetic petroleum as a fuel or lubricant via the Fischer–Tropsch synthesis or can be used to produce organic molecules, such as synthetic natural gas (SNG-methane). One advantage of the use of syngas to produce fuels is that syngas can be produced from waste materials that would otherwise need to be discarded. Instead of placing waste products in landfills or the ocean, these waste products can be used to generate a useful, energy rich product. This makes the syngas conversion process both an efficient means of producing energy and an environmentally friendly option for the recycling of waste products. There are other methods to produce syngas, which have been explored in literature: the pyrolysis of glycerol. Glycerol was selected as a potential source of syngas because it is estimated that the rising production of biodiesel will result in increasing amounts of glycerol as a byproduct (Van der Drift 2001; Xiao 2010; Q. Xie 2014; Pecho 2008; Van Oost 2009).

Figure 5.1

Opportunities linked with Syngas production

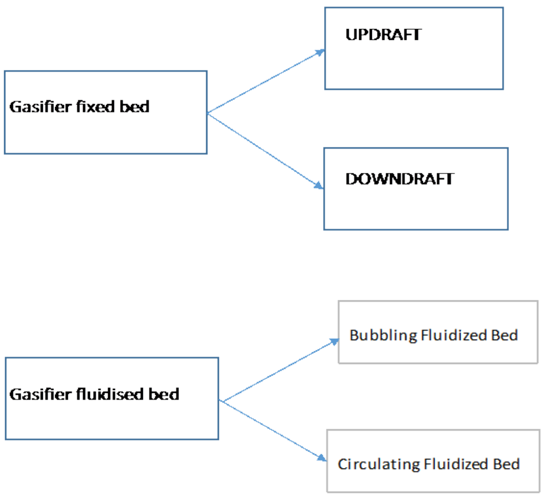


Source: personal elaboration of the author

Syngas is obtained by a thermo-chemical reaction process named gasification. Gasification transforms the carbonaceous material (biomass, waste, coal, etc) into a mixture of combustible gases, containing 20-40% hydrogen (H_2), 35-40% carbon monoxide (CO), 0-15% methane (CH_4) and 25-35% carbon dioxide (CO_2). During the process, the material is heated at a high temperature of approximately 850°C with a controlled amount of oxygen, air and/or steam (gasifying agent) and limited combustion to supply thermal energy and sustain the reaction. The gasification process takes place inside a reactor and can be divided into two stages: the first stage – pyrolysis, where the volatile components of the fuel are released by means of a series of complex reactions at temperatures below 600°C. The released volatile vapours also contain gaseous hydrocarbons, hydrogen, carbon monoxide, carbon dioxide, tar and water vapour. What remains from the pyrolysis process is mainly biochar (an agglomeration of complex nature consisting of carbon, ash, sulphur compounds and volatile hydrocarbons) and ash; the second stage of the process consists of the gasification of pyrolysis products, whose reaction with the gasifying agent leads to the decomposition of the gases and vapours that compose them, and to the conversion of the solid carbon contained in them. This last phase is the most important reaction in the gasification stage; being the slowest phase, it conditions all the kinetics of the whole process and consequently also the performance of the reactor. Syngas and biochar are the two main products from biomass gasification. Small scale gasifiers are fed by air and vapour and this can cause a decreasing of the syngas calorific value. Over the past years, some studies have been addressed at the analysis of gasifiers fed with CO_2 and vapour. In this way, the percentage of the char and CH_4 could be decreased, increasing the hydrogen percentage in the meantime. The different gasification systems can be classified as in Figure 5.2:

Figure 5.2

Different gasification systems



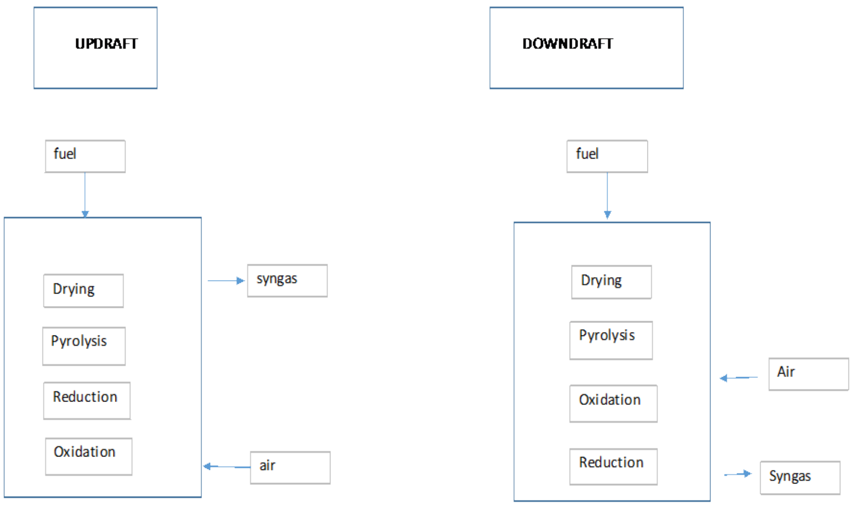
Source: personal elaboration of the author

Classification also varies according to the pressure conditions and the oxidant used.

The simple structure of this gasifier typically consists of a cylindrical reactor for the fuel feeding unit, a unit to remove ash, a gas exit and a bed of solid particles that the gasifying agent and resultant syngas move either up or down. The system operates at high carbon conversion, long solid residence time, low gas velocity and low ash carryover (Figure 5.3)

Figure 5.3

Updraft and downdraft syngas production system



Source: personal elaboration of the author

The updraft gasifier consists of a steel cylinder coated with a refractory material. The material (biomass, RDF) is loaded from above while the oxidizing agent (air) is inserted from the bottom of the reactor. Starting from the base of the reactor, the burnt material undergoes a partial oxidation process. The ashes fall downwards while the hot gases go upwards and the reduction process takes place. Going upwards, the pyrolytic section is obtained, where the volatile components are released before leaving the reactor.

In the downdraft gasifiers, the gas stream is in the same direction as the loaded material, from top to bottom. In this type of reactor there is a restriction where air is introduced crating the reduction phase.

The main differences between the two reactors are:

in the downdraft a lower tar content is formed; there are more probabilities of blockages related to the restriction; the loaded material (biomass, RDF) must have a humidity percentage lower than 20%.

The updraft reactor has a higher ash and tar content that can create blocks; a greater calorific value and a constructive simplicity.

In the gas-fluidised reactor, the gasifying agent is fed into the reactor base at a maximum speed of 2m/s. The material, also in this case biomass or RDF, is inserted laterally and then undergoes the pyrolysis process forming gases and carbonized parts, which are converted into syngas. The reactor is called a fluidized bed because bubbles are formed which go towards the upper part of the reactor improving the mixing of the phases. A fluid bed reactor means a suspension of solid particles in an upward stream of gas which, once it reaches a certain speed, behaves like a liquid. In this reactor, the temperatures are uniform (around 800°C - 900°C) and the obtained syngas has higher percentages of solid hydrocarbons, ash and sand, and for this reason more cleaning operations are required. The minimum plant size is 1 MWe and this means higher investment costs, and furthermore hot gas cleaning devices are expensive and under development. From the analysis of the literature and form the recent research studies, it was possible to verify that no type of gasifier is ideal because it depends on different characteristics, such as the type of biomass, or RDF, the reactor temperature and pressure, the gasifier agent (air, nitrogen, CO_2 or various mixtures), and from the initial cleaning of the material used in the reactor. And finally, it depends on the use of the final product to be obtained.

2. Research analysis aim

The aim of the analysis has been to provide information and environmental indications regarding the global impacts coming from the production of syngas in a pilot plant (small scale updraft gasifier) operating in northern Puglia – which required that it remain anonymous. In the present study, 3 different scenarios have been studied for the production of syngas from a pilot plant located in the north of the Puglia region (which required anonymity) having as input a) RDF; b) biomass; c) hydrogen produced in a pilot plant leased in Troia (northern region of Puglia), built as a European project within the 7th Framework Program and completed at the end of 2017. In the type c) scenario a possible district has been evaluated according to the principles of circular economy. A critical aspect of these comparisons is represented by the volumes treated, since the pilot plant for the production of syngas worked for only a short period – about three months – in order to test the functionality of the plant type. In any case, the obtained data from the functionality of the pilot plant allowed to elaborate some data for an objective comparison on the opportunities to exploit these plants to recover energy, studying whether they can represent a concrete opportunity for the territory both for the reduction of the ecological footprint and for going in the direction of circular economy.

The Life Cycle Assessment is the main operative tool of the" Life Cycle Thinking". It is an objective method of evaluation and quantification of the energetic and environmental impacts associated with a process or productive activity throughout the entire life cycle – from the acquisition of raw materials to the end of life ("from cradle to grave"). This methodology allows evaluating the environmental impacts of individual products and the methodology is constantly evolving, thanks to its innovative characteristics to be flexible, embedding in the study all the production phases. LCA methodology is based on the International Organisation for Standardisation (ISO) 14040 and 14044, and it is split in four main phases: 1) goal and scope, 2) inventory analysis 3) impact assessment 4) interpretation (ISO 14044; 2006). The goal and scope represent the intention of the research which defines the system boundaries under investigation. The goal of the study defines the functional unit, which is the parameter to address and standardise the environmental impact categories considered. Having in mind that a process or a product is categorized by a subset of different processes, each characterised by a different emission, it is useful to split the analysis in an upstream, core and downstream process. The inventory analysis (LCI) represents the core of the analysis. It describes the system, differentiating between inputs and outputs to be used to complete the environmental impact assessment according to the goal and scope. The impact assessment (LCIA) converts data into environmental impacts using specific software. Finally, the interpretation gives recommendation and suggestion – the functional unit, i.e. the product, service or function according to which to set up the analysis and comparison with the possible alternatives (kg of product, treated waste t, Kwh of energy supplied). The functional unit indicates the reference object of our study to which all input and output data will be normalized.

3. Main Impact Categories

The GWP expresses the contribution to global warming from gaseous emissions into the atmosphere. Any gas with certain characteristics is able to interact with the normal reactions occurring in the atmosphere and encourage (with negative results) the greenhouse effect. All molecules have a potential relative to the CO_2 molecule, whose potential is 1 and serves as a reference. The final value assumed by this indicator will be expressed in units of mass of CO_2eq. The gaseous mixture is considered composed of only CO_2 molecules with mass equal to the Impact Score.

AP expresses the potential for acidification of a series of substances with the ability to form protons (in the H + form). The individual contributions are calculated with reference to the SO_2 molecule, whose potential is 1 and serves as a reference. The final value assumed by this indicator will be expressed in units of mass of SO_2eq. All acidifying compounds are all summarized in an amount of SO_2 equal to the value expressed in mass of the Impact Score.

The EP is due to substances that alter the normal biological processes. The phenomenon caused is eutrophication in which some organisms derive an enormous advantage at the expense of other life forms. The main consequence is the enormous seizure of O_2 and the establishment of an anoxic situation with the consequent proliferation of undesirable anaerobic processes. The potential is defined as quantity of nutrients that exceeds the demand of biomass itself. The final value assumed by this indicator will be expressed in mass units of PO4eq.

POCP19 estimates the potential for creating photo-oxidizing agents in the troposphere. One of the most widespread problems, especially in large urban centers, is the formation of photochemical smog. The degradation of volatile organic compounds (in English, Volatile Organic Compounds, VOC) 20 in the presence of light radiation and nitrogen oxides (NOx) coming mainly from urban traffic is the cause of ozone molecules (O_3) formation in the troposphere where, however, it constitutes an element of danger for plants and animals. The indicator expresses synthetically the oxidizing power of a gaseous emission into the atmosphere, measured on the basis of the individual contributions related to the potential of the ethylene molecule (C_2H_4), set to 1. The final value assumed by this indicator will be expressed in unit mass of C_2H_4eq. The gaseous mixture is considered to be composed of only ethylene molecules with mass equal to the value of the Impact Score.

Results

The analysis has been carried out using the LCA methodology, with the GaBi software (Ecoinvent v. 3.3 of GaBi software v. 6.6). For the first scenario (syngas from RDF) data have been collected from literature, primary data (collected from the power plant), and data embedded in the database. From the second scenario (syngas from biomass) data have been collected from literature, and data embedded in the database and all have been used. For the third scenario, data have been collected from literature, primary data (collected from the power plant) and data embedded in the database. The GaBi software has allowed to recreate any flowchart by organizing it in plans, processes and flows. A plan is an object that collects a set of information (processes and flows) related to each other. A process is an object that collects data in input and data in output. Multiple processes, connected through flows, can be part of a single plan. The flows, of matter or energy, are equivalent to the data collected in the inventory and are organized into inputs and outputs in the processes with their own quantity and relative unit of measurement.

First scenario (Syngas produced from RDF)

In literature, there are several studies which have studied technical solution for converting RDF in energy and in syngas. The feedstock of a RDF is a mix of different waste typology as residual municipal, commercial and industrial wastes. The different mix of biodegradable material as well as plastics affects process design and operating conditions (Caputo 2002; Caputo 2004 Chang 1998 Hernandez-Atonal 2007, Malkow 2004 Consonni 2005; Ravelli 2018, M.S. Rao2004, Materazzi 2015; Bosmans 2013; Basu 2009; Arena and Di Gregorio, 2014, Arena 2011; Arena 2012).

According to the LCA methodology, in the scenario of the production of syngas from RDF, the functional unit has been identified in 1 kg of syngas (equal to 0, 9Nm^3). According to the LCA methodology, the emission has been calculated considering a period of 20 years (it is necessary to consider a period of average plant operation functionality). In the software, in order to obtain 1 kg of syngas 1.95 kg of RDF has been scaled. In Table 5.1 are reported the main technical characteristics of the power plant.

Table 5.1

Characteristics of the powerplant

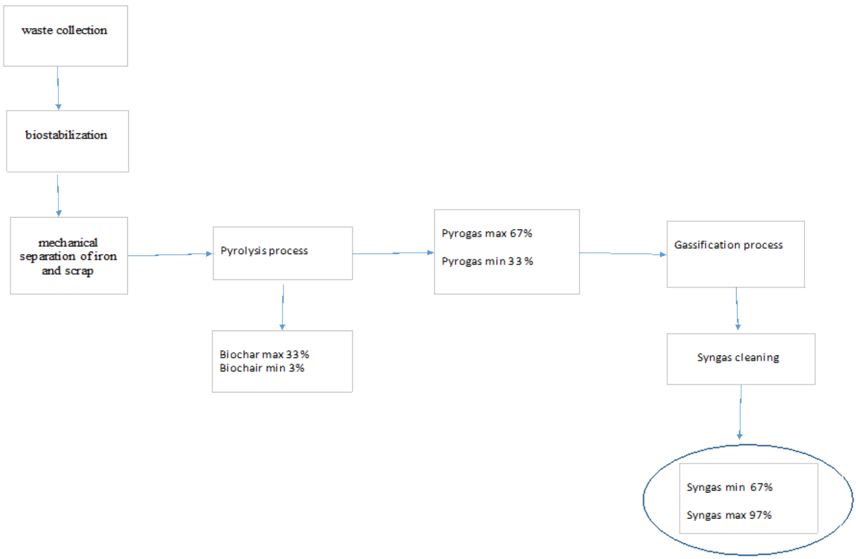
Characteristics of the powerplant	
Operation plant (average)	1000 Kg/h
Average temperature	800 °C
Gasifier agent	nitrogen
Time of permanence of the plant	20 min

Source: personal elaboration of the author

Figure 5.4 summarizes the flowchart of the syngas production process starting from the RDF.

Figure 5.4

Flow chart syngas production from RDF



Source: personal elaboration of the author

The production of the RDF is developed in the following phases:

- waste collecting;
- bio- stabilization
- mechanical separation of the inert and metallic fraction

The incoming waste undergoes a process of shredding that reduces the volume to less than 250 mm to be subsequently loaded in specific boxes for the stabilization of organic residues. The bio stabilization phase goes on for about a week and is carried out by injecting air from the bottom of the box, allowing the mass to be uniformly oxygenated, favouring a temperature of around 40^{o}C. During this phase, the weight is reduced by about 30%.

Subsequently, the material undergoes a process of mechanical separation from inert and metals, as they negatively affect the calorific value of the finished product. Once the RDF has been produced, it can be packaged in different ways according to the needs of the plants: in bales of one cubic meter of volume, in pellets of a few cm of length.

The process as a whole has an average yield of 50%, i.e. starting from a tonne of urban waste, about 500 kg of RDF are obtained. The average waste transport for this study was calculated at 150 km and it was hypothesized for the production of biochar that varies from a minimum of 3% (with the production of syngas equal to 97%) to a maximum of 33% (with the production of syngas equal to 67%). Biochar is formed from ashes (inert material) and a carbon residue. Biochar has a good calorific value and this means that can be reused in the plant.

Table 5.2 shows the product percentage of the waste that results from the production process (as underlined above, 1.95 kg for 1 kg of syngas produced has been calculated). A preliminary screening of the relevant parameters of the waste for RDF has been necessary. Taking into account the indications of the UNI EN 15359: 2011 standard, considering the intrinsic characteristics of the RDF, such as the calorific value, the content of chlorine and mercury, the RDF was suitable for the plant experiment. During the operation of the plant, a massive loss has been recorded, probably due to cellulose and plastics decomposition.

Table 5.2

Percentage of material composition of waste collected

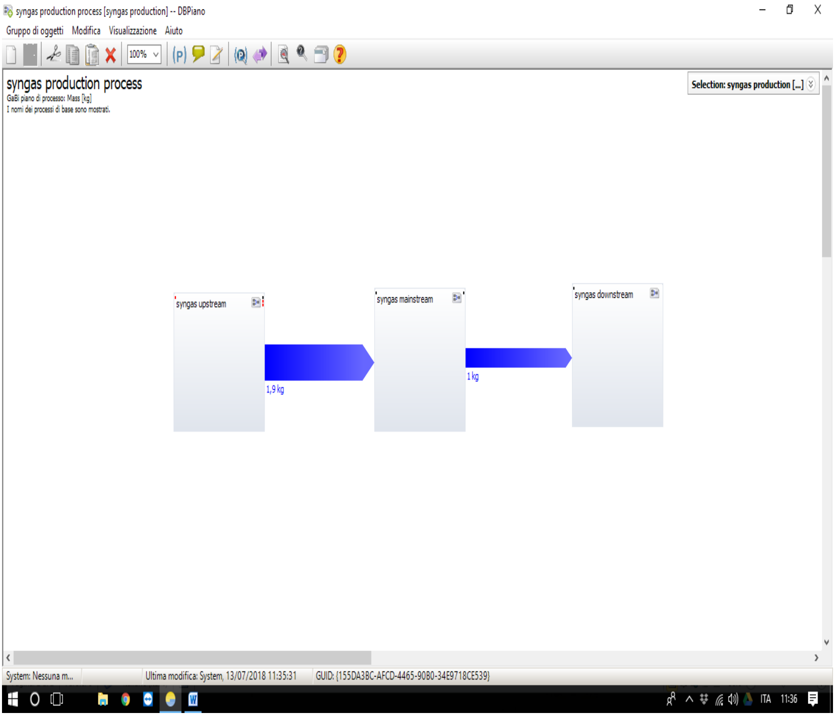
percentage of waste embedded in 1,95 kg of waste	%	kg
Wood	12%	0,23
Paper	41	0,80
Organic matter	2,5	0,05
Metals non-ferrous	2,5	0,05
Glass	1,5	0,03
Plastic	29	0,57
Textiles	11,5	0,22
RDF	*100*	*1,95*

Source: personal elaboration of the author

According to the methodology, the study has been split into upstream, core (mainstream), and downstream (see the GaBi software diagram in Figures 5.5, 5.6, 5.7 and 5.8).

Figure 5.5

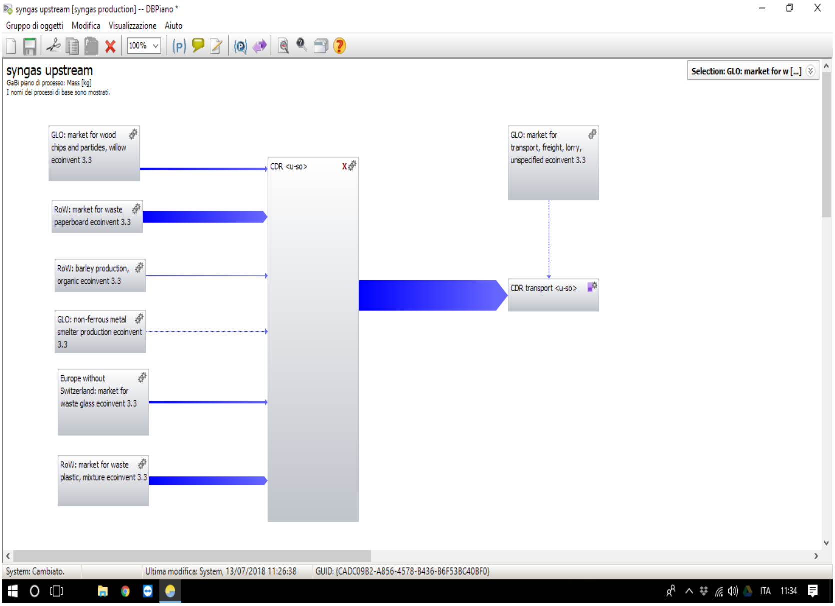
GABI diagram process in upstream, mainstream (core) downstream



Source: elaboration with GABI software

Figure 5.6

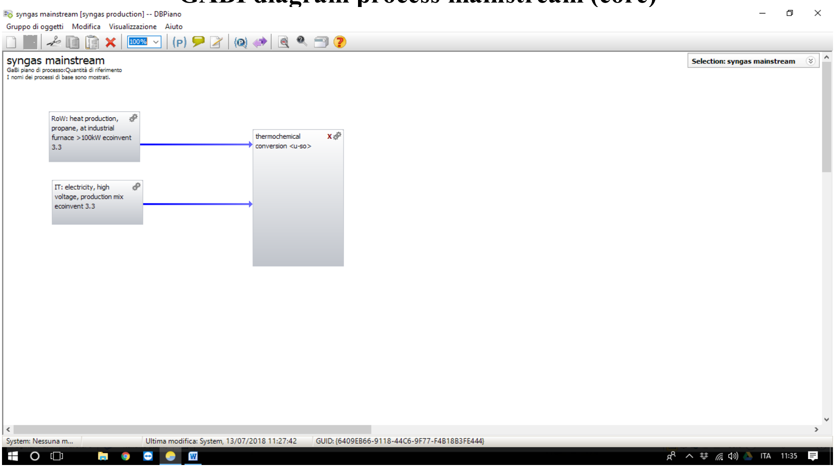
GABI diagram process upstream



Source: elaboration with GABI software

Figure 5.7

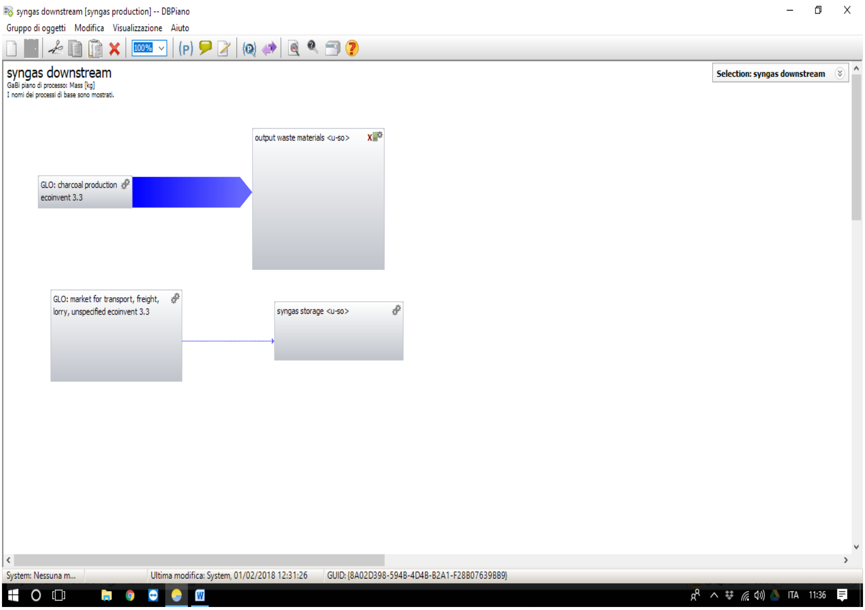
GABI diagram process mainstream (core)



Source: elaboration with GABI software

Figure 5.8

GABI diagram process downstream



Source: elaboration with GABI software

4. Analysis of results

In Table 5.3. are reported the emissions calculated with the GaBi software.

Table 5.3

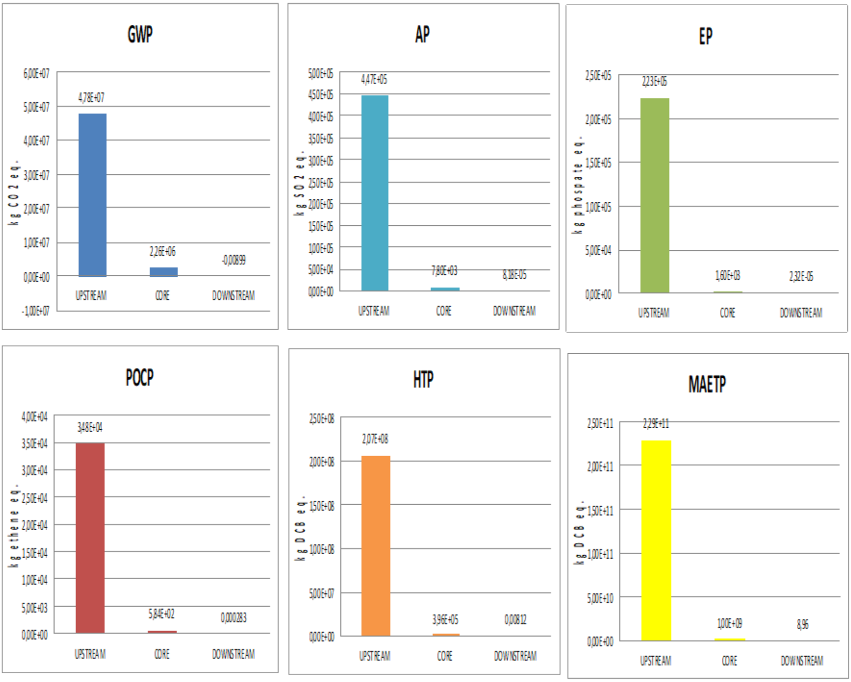
Emission from the three stages (upstream, mainstream, downstream) of syngas from RDF

UPSTREAM	CORE	DOWNSTREAM
4,78E+07	2,26E+06	-0,00899
4,47E+05	7,80E+03	8,18E-05
2,23E+05	1,60E+03	2,32E-05
3,48E+04	5,84E+02	0,000283
2,07E+08	3,96E+05	0,00812
2,29E+11	1,00E+09	8,96

Source: elaboration with GABI software

Figure 5.9

Environmental Emission of Syngas Production from RDF



Source: personal elaboration of the author and elaboration with GABI software

As outlined in Figure 5.9 the upstream phase is the more critical than environmental emission. This is important because correct management of the collection phase and the management of the arrival of the input for thermo-chemical conversion represent the most important aspects to consider for environmental emission. During the core phase, the emissions are very low, as compared to the upstream phase, and this is a confirmation that a strategy based upon the "power of syngas" can play an important role in the circular economy approach. However, it is necessary to create the preconditions to make the RDF, considering that it is the most problematic aspect of the supply chain. Emissions are strictly imputable to the movement of waste within the site, because of the bio-stabilization and selection process in order to create RDF. The intermittent steps between the different phases of the pre-treatment phase need to be improved, such as the handling of waste before the loading phase, which occurs by means of mechanical shovels.

Inside the gasifier, the main problems are related to the erosion and corrosion phenomena which can make the gasifier stop. In many cases, the problems of corrosion are due to alkaline compounds, such as potassium, which can be found both in the biomasses and in the organic waste fraction, which can react with the silicon forming silicates creating encrustations on the walls of the gasifier. This problem certainly is more enhanced because the gasifier is a small plant, but in any case it has caused the shutdown of the same. Considering the circular economy aspect, as underlined above, the use of RDF can represent a goal to be pursued. From the latest data available by the Puglia Region for 2018, (Puglia portalerifiuti, 2018) of the total of over 1,560 10^6 kg of solid urban wastes produced, about 48% are differentiated. From this data, it is necessary to find solution able to trace and treat waste in a sustainable way. As the analysis has shown, this solution can represent an option if the first phase of the supply chain is managed properly.

In the second scenario, the environmental emission of biomass as compared to syngas has been calculated. The biomass conversion into syngas depends on some factors. First of all, the type of biomass (in terms of water, carbon, nitrogen, chlorine, sulphur and ash); secondly, from the biomass availability and finally from physical and chemical characteristics. The thermochemical conversion of biomass includes 3 phases: combustion, gasification and pyrolysis: For the combustion phase, an amount of oxygen equal to the stoichiometric amount it is necessary for the oxidation of C, H and N.

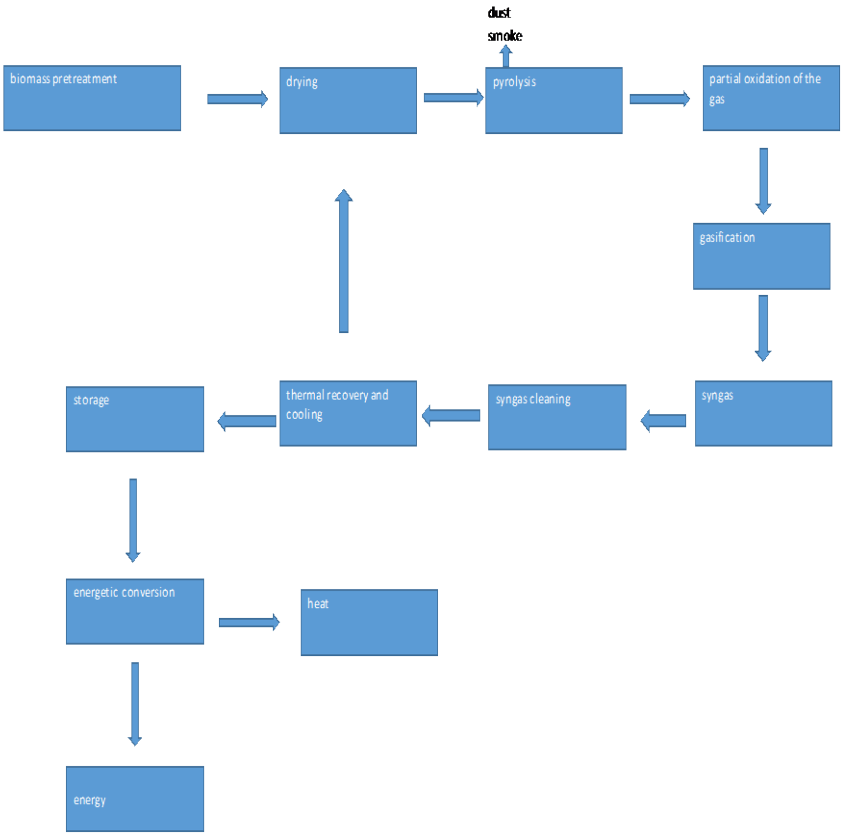
Gasification occurs through a series of reactions that develop in oxygen deficiency (with partial combustion) forming the syngas. Pyrolysis occurs in the absence of oxygen through the simple heating of the biomass, whose decomposition leads to the formation of a liquid, solid and gaseous phase (Belgiorno 2003; Devi 2003; Fourcault 2010; Gómez-Barea 2010; McKendry 2003).

Biomass availability in Puglia: from the agricultural sector, it is possible to use huge quantities of biomass for energy purposes and for the valorising of the production of syngas; in this way, crop residues would incur a cost for their treatment.

According to some studies, the potential biomass treatment suitable for energy production can be summarized as (Figure 5.10): the availability of biomass from herbaceous crops equals more than 508 t/year, whereas biomass form residual forests equals more than 124 000 m^3 (Centro studio confagricoltura Puglia – 2012).

Figure 5.10

Reports the supply chain of biomass conversion into syngas



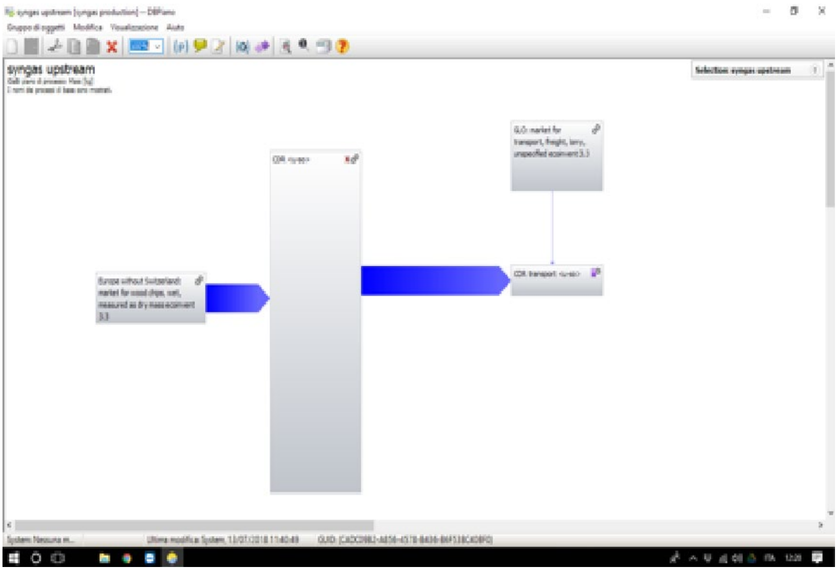
Source: personal elaboration of the author

As mentioned above, the analysis data for the environmental sustainability of syngas power from biomass has been collected from literature and data available on the GaBi software, successively scaled in order to make it comparable to the RDF scenario.

Figure 5.11 reports only the GaBi upstream process phase (because the other two process phases are similar to RDF scenario).

Figure 5.11

GaBi upstream process phase



Source: elaboration with GABI software

Table 5.4

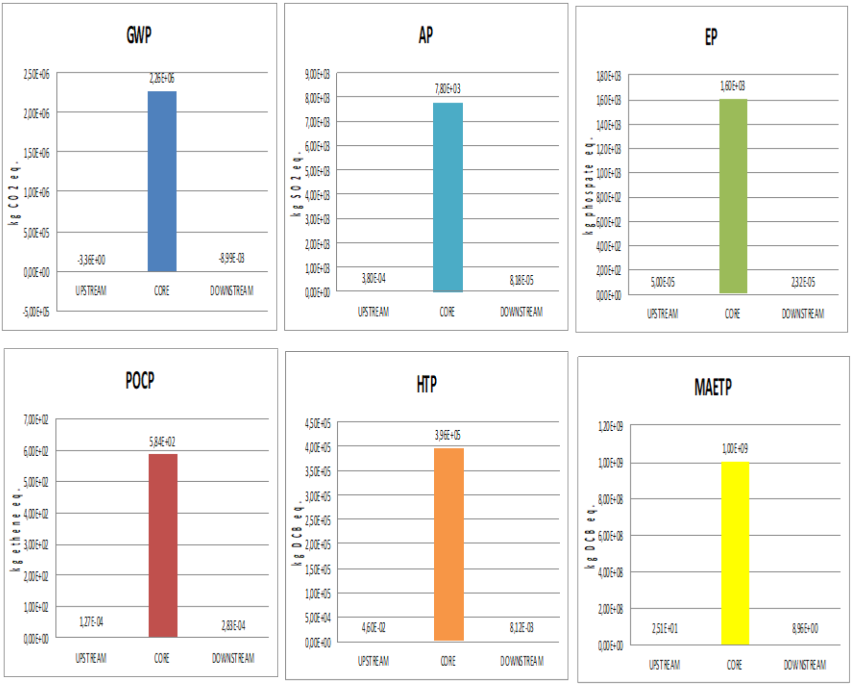
Emissions from the three stages (upstream, mainstream, downstream) of syngas production from biomass

UPSTREAM	CORE	DOWNSTREAM
-3,36E+00	2,26E+06	-8,99E-03
3,80E-04	7,80E+03	8,18E-05
5,00E-05	1,60E+03	2,32E-05
1,27E-04	5,84E+02	2,83E-04
4,60E-02	3,96E+05	8,12E-03
2,51E+01	1,00E+09	8,96E+00

Source: personal elaboration of the author and elaboration with GABI software

Figure 5.12

Environmental Emission of Syngas Production from Biomass



Source: personal elaboration of the author and elaboration with GABI software

From an environmental sustainability point of view, the core phase is the most impacting phase (Table 5.4 and Figure 5.12)

The results from the analysis have enabled us to identify the most critical phases from an environmental point of view, where an improvement of the environmental aspects can play an important role during the whole life cycle of the process. From the two scenarios, a substantial difference emerges of the environmental impacts generated by the production of syngas, even if the analysis has been scaled, considering the same operating system of the reactor. The environmental impacts generated by the plant fed with biomass are mainly concentrated during the thermochemical conversion phase inside the reactor; while the impacts generated by the RDF are concentrated in the upstream phase. In the literature, the use of biomass to produce energy or syngas is seen as a zero-emission process: this does not mean that carbon dioxide is not produced but that what is produced by combustion reactions compensates the CO_2 absorbed by the plant. This aspect is misleading, however, if we consider the whole life cycle of the biomass, including all the operations ranging from collection to storage and transport and up to the thermochemical conversion.

These first data through the LCA approach show how important it is to plan and organize the production chain both in order to optimize the efficiency of the conversion reactor by improving the technical/energy performance and to implement the raw material procurement process, which in the case of waste currently represents an element of criticality. The problems with the use of biomass to be solved are the following:

- diseases and weeds control of the raw materials;
- optimization of collection and storage of the material;
- environmental assessment of the supply chain.

5. INGRID Scenario

This study has been carried out following an analysis conducted in the framework of an European project aimed at calculating the environmental impacts (through the LCA methodology) of a pilot plant built for the production of hydrogen. The project, named INGRID (High-capacity Hydrogen-Based Green-Energy Storage Solutions for GRID BALANCING) has been funded within the 7th Framework Program (call for ENERGY.2001.7.3-2) “Storage and balancing variable electricity supply and demand” (http://www.ingridproject.eu/). The starting point of the project was related to the issue of hydrogen energy storage. The energy storage is crucial for the balancing and integrating of large amounts of intermittent renewable energy and improvement of the efficiency and reliability of the electrical grid.

One of the main outputs of the INGRID project was to build up a demonstrator hydrogen energy storage plant, with a capacity of more than 1 ton of safely stored hydrogen (the largest ever built) consisting of: water electrolyser, solid hydrogen accumulation system (HDS), fuel cells

(FC) and ICT systems for real-time monitoring and control. The hydrogen plant should increase both the dispatch of hydrogen and the response to fluctuant electricity jointly with evaluating hydrogen production in order to propose innovative business models. Another important output of the project was to evaluate the opportunity to use the produced hydrogen as raw material for different industrial uses (fertilizers, etc) or as alternative transportation fuel for zero emission vehicles with high efficiency, or for producing electricity. The different uses of hydrogen can address important choices considering that hydrogen is becoming increasingly important not only in the energetic picture but also for the production processes. The authors have contributed in developing the last part of the project, calculating the environmental performance generated by the INGRID demonstrator plant, through the Life Cycle Assessment (LCA) approach applied to three different usage scenarios: a) production of H_2 and its retransformation into electricity through FC; b) production of H_2 to supply vehicles with hydrogen fuel; c) production of H_2 as feedstock for other industrial uses.

After calculating the environmental impacts of the pilot plant with three scenarios, the final output of hydrogen production foreseen in scenario a) (production of H_2 and its retransformation into electricity through FC) has been replaced as feedback to feed the pilot plant for the production of syngas both in the RDF and in the Biomass scenario.

Fuel cells are solid structures containing an electrolyte fluid and two terminals, similar to batteries. The reactants flow into the cells, in this case – hydrogen and oxygen. They intermingle with the electrolyte to produce an electrical charge and water as a by-product. The water flows out from another port, while the electricity is siphoned off the terminals and held in gigantic multi-ton batteries. The electricity resides in the batteries until it is needed, in which case it is sent out through the local power grid just like any other type of power plant. In theory, this could be a near perfect source of energy, as it has no dangerous by-products and is just as fuel-efficient as the average internal combustion engine. The biggest problem is, and always has been, obtaining cheap supplies of hydrogen (Mazloomi 2012, Marshall A, 2007, Ozbilen 2012, Grigoriev 2006, Fraile 2015). The objective has been to verify the criticalities and opportunities of a possible supply chain based on renewable resources for the production of bioenergy in a circular economic perspective. The objective has also been to evaluate whether the tools and the environmental impact assessment scenario can play a role in the planning of models to be used in the long and medium-term terms. Before highlighting the environmental impacts generated, a description of the INGRID system is given.

To recapitulate, electrolysis can be feasible only if technical solutions are found that allow the exploitation of renewable energies in appropriate conditions. This comprises a water electrolyser, powered by RE produced in the Puglia region (with the energy mix equalling 50% photovoltaic and 50% wind energy), consisting of 4 sub-modular units (300 kW each) and connected in parallel, separating pure O_2 gas and H_2;

- HDS which consists of 4 filling stations (150 kW each) absorbing and storing all the H_2 obtained in solid form for subsequent use;

- 4 FCs sub-units (30 kW each), connected directly with the HDS storage unit able to convert H_2 into electricity.

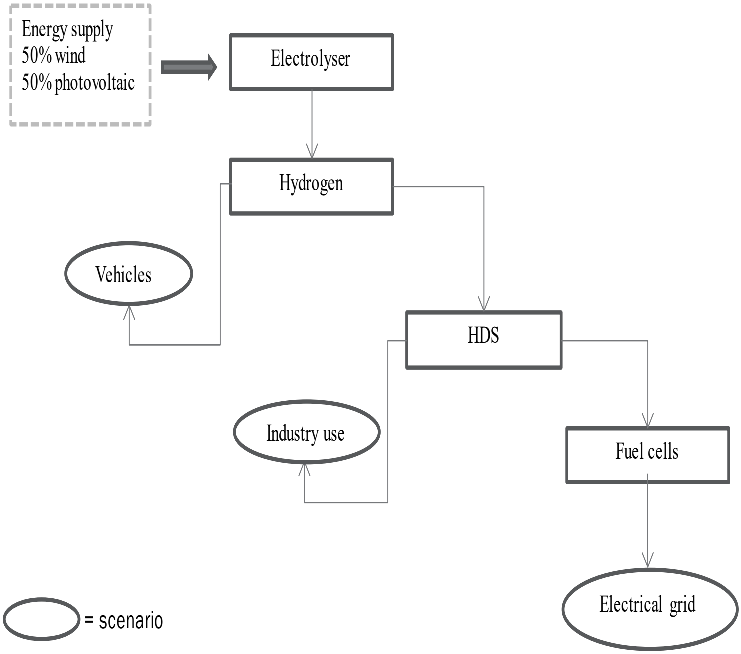
According to the LCA, the INGRID plant is split in upstream, core and downstream phases (Figure 5.13).

The upstream phase concerns:

- creation of all components from the extraction of raw materials to the assembly on the production site of each supplier;
- plant site built up in Troia municipality;
- transport phase and installation of components at the site in Troia;

Figure 5.13

INGRID Demonstrator Plant Flow Diagram



Source: Personal elaboration of the author

The core phase refers to the usage phase of the three different scenarios.

Scenario 1: production of hydrogen with electrolyser, storage in HDS and hydrogen retransformation into electricity through fuel cells. The production cycle is 4 days (the characteristics of the distribution grid are omitted);

Scenario 2: production of hydrogen with electrolyser and its direct injection into the grid to supply vehicles with hydrogen fuel (the impact of the construction of the hydrogen system in the vehicles is omitted). The production cycle is 1 day.

Scenario 3: production of hydrogen with electrolyser, storage in HDS, cooling of H_2 blocks and their transport to the companies that use hydrogen for their processes; distribution to companies located at an average distance of 250 km from the production site was hypothesized (no omission). The production cycle is 2 days.

The downstream concerns the end of life phase

• The end of life of the INGRID site by differentiating materials for each component. The recovering or the landfills according to composition has been defined. For those activities Ecoinvent dataset was used.

During the production of synthesis gas, CO_2 is also produced. The SMR process in centralized plants emits more than twice the CO_2 than the hydrogen produced. To avoid emission of CO_2 into the atmosphere, CO_2 can be concentrated, captured, and sequestered.

6. Main LCA results of INGRID

In Table 5.5. are reported the phases included in LCA INGRID demonstration plant.

Table 5.5

Phases and sub-phases included in LCA INGRID demonstration plant

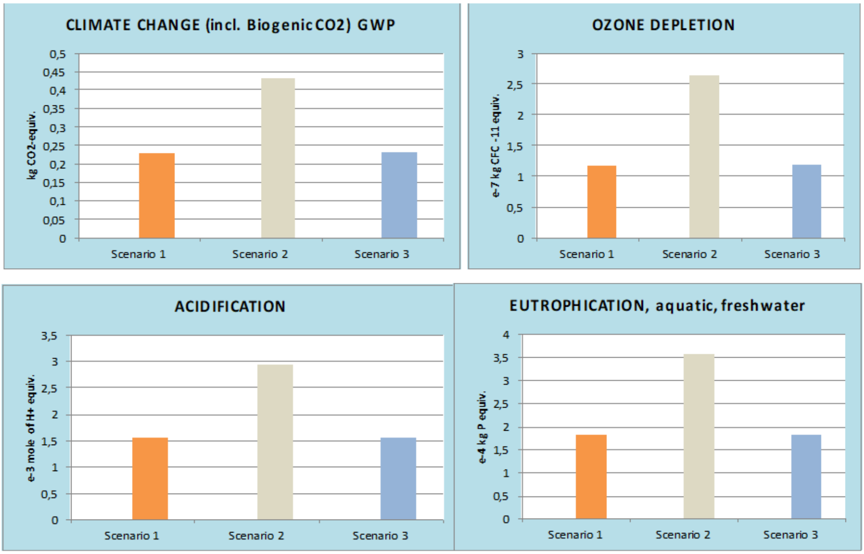
PHASE	SUBPHASES
UPSTREAM	*assembly of fuel cell*
	assembly of filling station
	assembly of H2 block
	assembly of water electrolyzer
	assembly of control room
	construction of site
	installation phase
PHASE	**SUBPHASES**
CORE	*tap water*
	electricity
	electrolysis
	transport
PHASE	**SUBPHASES**
DOWNSTREAM	*Recovering*
	Landfilling

Source: Personal elaboration of the author

The following are the main emission values for the three scenarios considered in INGRID (Figure 5.14)

Figure 5.14

Main environmental impacts related to INGRID scenarios



Source: Personal elaboration of the author

Considering the three scenarios analysed, there are no relevant differences between scenario number 1 (industry use) and scenario number 3 (Fuel cell-electrical grid). This is due to the HDS sharing, which allows the storing of hydrogen for future possible uses. This means better management, in terms of quantity and timing, of hydrogen production directly related to different market demands.

Scenario number 2, indicating the production of hydrogen to supply vehicles, has the greatest environmental impact. The results show that, all the environmental impact categories are higher than the others. The main reason is due to the fact that the hydrogen produced to supply vehicles is not storable. This implies that its continuous production is directly linked to energy input. This could be mitigated by an adequate development of hydrogen-based transport system still characterised by a demand outlook difficult to assess and plan.

As already mentioned, scenario number 3 (electrical grid) has been connected to the pilot plant for the production of syngas fed both with RDF and biomass. This requires a methodological approach and data have ben collected from primary sources and from the GaBi software. The aim is to verify whether there is a condition to create an energetic district based on renewable sources within the framework of circular economy. The following study has the goal to find out if the environmental emission can enhance these opportunities.

Table 5.6

Emission from the three stages (upstream, mainstream, downstream) of syngas produced from from INGRID + biomass and INGRID + RDF

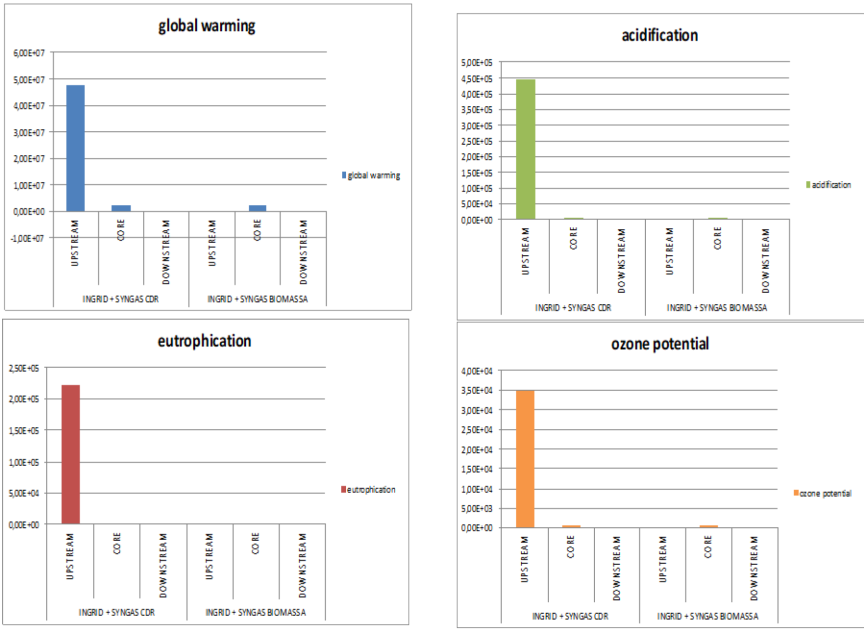
			INGRID			INGRID + SYNGAS RDF			INGRID + SYNGAS BIOMASSA		
			UPSTREAM	CORE	DOWNSTREAM	UPSTREAM	CORE	DOWNSTREAM	UPSTREAM	CORE	DOWNSTREAM
global warming	kg CO2 eq	GWP	3,18E-03	2,84E-01	-1,27E-06	4,78E+07	2,26E+06	-8,99E-03	-3,36E+00	2,26E+06	-8,99E-03
acidification	kg SO2 eq	AP	3,86E-05	1,85E-03	-4,45E-09	4,47E+05	7,80E+03	8,18E-05	4,19E-04	7,80E+03	8,18E-05
eutrophication	kg phosphate eq	EP	4,08E-06	2,21E-04	-5,27E-11	2,23E+05	1,60E+03	2,32E-05	5,41E-05	1,60E+03	2,32E-05
ozone potential	kg ethene eq	POCP	2,32E-10	1,62E-07	-1,04E-13	3,48E+04	5,84E+02	2,83E-04	1,27E-04	5,84E+02	2,83E-04

Source: personal elaboration of the author and elaboration with GABI software

From the analyses carried out, it was found that the most impactful scenario is the INGRID cycle with RDF. The cycle INGRID + Biomass is potentially more sustainable in terms of environmental impacts. The reasons are certainly linked to the criticality of the conversion phase from RDF to syngas in the upstream phase. In any case, the environmental advantages are interesting in both considered scenarios. Another important consideration is that even if renewable sources have flexible energy lower than the demand production, the energy storage allows for the achievement of economic advantages for the overall functioning of the electricity system (not evaluated here) and advantages in terms of energy diversification.

Figure 5.15

Main environmental impacts related to INGRID + RDF and INGRID + Biomass



Source: personal elaboration of the author and elaboration with GABI software

The circular economy approach is much more than simply the optimization of waste management. The transition to this model involves the abandonment of the linear economy approach "take, make, dispose" in favour of the use of renewable sources and the reuse of resources coming from different value chains. To achieve this goal, approaches and techniques are already available thanks to the innovation technologies.

The energy sector is one of the main drivers of circular economy. In fact, if the energy system does not make a strong transition towards renewable sources or towards energy recovery based on some biodegradable, even if not completely recyclable sources, there will not be a change towards sustainability. This study has allowed the highlighting from an environmental point of view the opportunities for the conversion of RD and biomass into syngas.

The third scenario, however, is more horizontal and ambitious, as it proposes an exchange platform between two pilot plants both built in Puglia, with the aim of producing energy in a sustainable manner, combining both renewable sources and the recovery of a fraction of the waste used to produce syngas.

Although this latter scenario has been developed as a methodological approach, the results are encouraging from an environmental point of view. In all the scenarios considered, the LCA approach has been a useful tool not only for the quantification of impacts, but also to highlight critical issues and improvements to be made to the production process. In the cases studied, it was possible to outline which aspects of the supply chain should be improved and implemented in order to optimize the process. For the production of syngas from RDF, it appears that the upstream aspect is critical and must be improved. Greater attention in the waste screening phase, and a careful selection of materials to be used in the plant, can improve the production process and make syngas conversion more efficient. In Puglia as already said, there are over 805 106 kg of undifferentiated wastes that are currently landfilled. It is clear that the circular economy strategy promotes a recovery and prevention approach but in the current situation a solution must be found in order to properly dispose this waste. The analysis was carried out on a small-sized plant that operated for a short period, but in any case with innovative technological and technical measures the plant could operate better. A small plant would certainly be less impactful and would create fewer social acceptance problems that currently characterize the greatest contrasts towards this type of technology. Several small plants for the first phase could also reduce the percentage of undifferentiated waste in Puglia by 30%, acting as facilitators towards a circular economy.

The biomass scenario for producing syngas is a scenario that has more publications and studies in the literature. As highlighted, biomass also faces environmental criticalities especially in the core phase due to the higher temperatures achieved in the gasifier. Also in this case, the considerations made for the RDF are valid. Better planning of the waste screening and storage is needed. The latter aspect can certainly affect positively the recycling of secondary raw materials, favoring the circularity of the economy. Therefore, the third scenario is closely connected to the conclusions of the previous scenarios. The possibilities to create a platform for the exchange of energy produced and stored by INGRID to feed a gasifier could be plausible and would favour the production of sustainable energy and the production of syngas enhancing a transition to circular economy.

BIBLIOGRAPHIC REFERENCE

- Arena, U. (2011) Gasification: an alternative solution for waste treatment with energy recovery Waste Management, 31, pp.405-406.
- Arena, U. (2012) Process and technological aspects of municipal solid waste gasification. A review Waste Management, 32, pp.625-639.
- Arena, U. and Di Gregorio, (2014) Gasification of a solid recovered fuel in a pilot scale fluidized bed reactor Fuel, 117A, pp.528-536.
- Basu, P., Kaushal, P. (2009) Modeling of pyrolysis and gasification of biomass in fluidized beds: A review Chem. Prod. Process Model, 4 (1); pp.1-45.
- Belgiorno, V., De Feo, G., Della Rocca, C. (2003) Energy from gasification of solid waste, Waste Management, 23, pp.1-15.
- Bosmans, A., Vanderreydt, I., Geysen, D., Helsen L. (2013) The crucial role of waste-to-energy technologies in enhanced landfill mining: a technology review, Journal of Cleanear Production, 55, pp.10-23.
- Chang, Y.H., Chen, W.C., Chang N.B. (1998) Comparative evaluation of RDF and MSW incineration Journal of Hazardous Materials, 58, pp.33-45.
- Caputo, A.C., Palombo, M., Scacchia F. (2004) Perspectives of RDF use in decentralized areas: comparing power and co-generation solutions Applied Thermal Engineering, 24, pp.2171-2187.

- Caputo, A.C., Pelagagge P.M. (2002) RDF production plants: II. Economics and profitability Applied Thermal Engineering, 22, pp.439-448.
- Centro studi confagricoltura Puglia (2012) La produzione di energia da biomasse in Puglia, pp.3-42.
- Consonni, S., Giugliano, M., Grosso M. (2005) Alternative strategies for energy recovery from municipal solid waste. Part A: Mass and energy balances Waste Management, 25, pp.123-135
- Devi, L., Ptasinski, K.J., Janssen, F.J.J.G. (2003), A review of the primary measures for tar elimination in biomass gasification processes Biomass Bioenergy, 24, pp.125-140.
- Fourcault, A. Marias, F. Michon, U. (2010) Modelling of thermal removal of tars in a high temperature stage fed by a plasma torch Biomass Bioenergy, 34, pp.1363-1374.
- Fraile D., Lanoix J., Maio P., Rangel A., Torres S A. (2015) Overview of the market segmentation for hydrogen across potential customer groups, based on key application areas, Report of the EU project CertifHY, Availbale at http://www.certifhy.eu/.
- Grigoriev S., Porembsky V., Fateev V. (2006), Pure hydrogen production by PEM electrolysis for hydrogen energy. Int J Hydrogen Energy, 31(2), pp.171-175.
- Gómez-Barea, A., Leckner, B. (2010) Modeling of biomass gasification in fluidized bed, Energy Combust. Sci., 36–4, pp.444-509.
- Hernandez-Atonal, F.D., Ryu, C., Sharifi, V.N., Swithenbank J. (2007) Combustion of refuse-derived fuel in a fluidised bed Chemical Engineering Science, 62, pp. 627-635.
- INGRID -High-capacity hydrogen-based green-energy storage solutions for grid balancing (2017), Available at: (http://www.ingridproject.eu/).
- ISO (2006) Environmental Management — Life Cycle Assessment — Requirements and Guidelines. Geneva, Switzerland: International Standards Organization: ISO 14044.

- Malkow, T. (2004) Novel and innovative pyrolysis and gasification technologies for energy efficient and environmentally sound MSW disposal Waste Management, 24, pp. 53-79.
- Materazzi, M., Lettieri, P., Mazzei, L., Taylor, R., Chapman, C. (2015), Fate and behavior of inorganic constituents of RDF in two stages fluid bed-plasma gasification plantFuel, 150, pp. 473-485.
- Mazloomi K., Sulaiman N., Moayedi N. (2012) Electrical Efficiency of Electrolytic Hydrogen Production, Int. J. Electrochem. Sci., 7, pp. 3314- 3326.
- Marshall A, Borresen B, Hagen G, Tsypkin M., Tunold R., (2007), Hydrogen production by advanced proton exchange membrane (PEM) water electrolysers. Reduced energy consumption by improved electrocatalysis. Energy;32(4), pp.431-436.
- McKendry, P. (2003) Energy production from biomass (part 3): gasification technologiesBioresource Technology, 83, pp.55-63.
- Ozbilen, A., Dincer, I. Rosen, M. A. (2012) Life cycle assessment of hydrogen production via thermochemical water splitting using multi-step Cu-Cl cycles. Journal of Cleaner Production, 33, pp.202-216
- Pecho, J., Schildhauer, T.J., Sturzenegger, M., Biollaz, S., Wokaun A. (2008), Reactive bed materials for improved biomass gasification in a circulating fluidised bed reactorChem. Eng. Sci., pp.2465-2476.
- Puglia portalerifiuti (2018), Available at: http://www.sit.puglia.it/portal/portale_orp/Osservatorio+Rifiuti/Osservatorio+Rifiuti+Cittadino/RSU+per+Comune/OrpCittadinoWindow?entity=rsucomune&action=e&windowstate=normal&action_com=comune&comune=074002&mode=view
- Rao, M.S., Singh, S.P., Sodha, M.S., Dubey, A.K., Shyam M. (2004) Stoichiometric, mass, energy and exergy balance analysis of counter current fixed-bed gasification of postconsumer residues Bioenergy, 27, pp.155-171.
- Ravelli, S., Perdichizzi, A., Barigozzi, G. (2018) Description, applications and numerical modelling of bubbling fluidized bed

combustion in waste-to-energy plants, Prog. Energy Combust. Sci., 34, pp. 224-253.

- Tomishige, K. and Asadullah, M. (2002) Production of Syngas by Catalytic Gasification of Biomass at Low Temperature and Synthesis of Clean Transport, Fuel Chemistry, 47(2), pp. 521-523.
- Van der Drift, A., van Doorn, J., Vermeulen, J.W. (2001) Ten residual biomass fuels for circulating fluidized-bed gasification Biomass Bioenerg., 20, pp. 45-56.
- Van Oost, G., Hrabovsky, M., Kopecky, V., Konrad, M., Hlina, M., Kavka, T. (2009) Pyrolysis/gasification of biomass for synthetic fuel production using a hybrid gas–water stabilized plasma torch Vacuum, 83, pp. 209-212.
- Xiao, X.B., Le, D.D., Morishita, K., Zhang, S.Y., Li, L.Y., Takarada, T. (2010) Multi-stage biomass gasification in Internally Circulating Fluidized-bed Gasifier (ICFG): test operation of animal-waste-derived biomass and parametric investigation at low temperature, Fuel Process. Technol., 91, pp. 895-902.
- Xie, Q., Borges, F.C., Cheng, Y., Wan, Y., Li, Y., Lin, X., Liu, Y., Hussain, F., Chen, P., Ruan, R. (2014) Fast microwave-assisted catalytic gasification of biomass for syngas production and tar removal Bioresour. Technol., 156, pp. 291-296.
- Wei, X., Schnell, U., Hein, K.R.G. (2005) Behaviour of gaseous chlorine and alkali metals during biomass thermal utilisation Fuel, 84, pp. 841-848.

SIXTH CHAPTER
CIRCULAR ECONOMY AND ITS IMPLEMENTATION IN BULGARIAN TOURISM

1. Development of tourism in Bulgaria and in Varna Municipality

Tourism is one of the main sectors in Bulgaria with a total share of 12% of the GDP of the country. In 2016 the tourism budget is about 6 mln Euro, which is 0.5% of the whole budget.

The World Travel and Tourism Council – an international institution that tracks strategic economic performance in tourism in 186 individual countries and different regions around the world – published in 2017 and 2018 its reports on Bulgaria with projections until 2027. (WTTC, 2018) According to the World Travel and Tourism Council, the direct contribution of Travel & Tourism in Bulgaria to the GDP was BGN 3,115.9 mln or 3.4% of total GDP in 2016, 4.6% in 2017 and is forecast to reach 3.6% of the GDP in 2027. The direct contribution includes economic activity generated by industries such as hotels, travel agents, passenger transportation services, activities of the restaurants and leisure industries. The total contribution of Travel & Tourism to the GDP was BGN 11,617.8 mln or 12.8% of GDP in 2016, 11.5% of the GDP in 2017 and is forecast to rise to 13.3 of the GDP in 2027. The total contribution includes effects from investments and income impacts. In 2016, Travel & Tourism in Bulgaria directly supported 98,000 jobs (3.2% of total employment). In 2017 it created 90,000 new jobs (or 3.2% of total employment) and this share is expected to rise to 4.1%, or 115,000 jobs, in 2027. This direct contribution to employment is linked with the industries which generate direct contribution to the GDP, such as hotels, restaurant, travel agencies etc. In 2016, the total contribution of Travel & Tourism to employment, including jobs indirectly supported by the industry was 11.9% of the total employment (363,000 jobs). 10.7% in 2017 (or 335,999 jobs) and is expected to reach 374,000 jobs in 2027, or 13.4% of total employment. The total contribution to employment is linked with the effects from investments and income impacts.

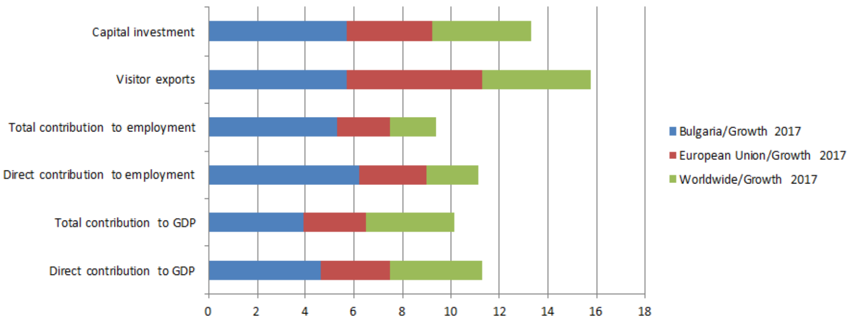
Visitor exports are a key component of the direct contribution of GDP. Visitor export of Bulgaria generated BGN 6,962.0 mln or 12.0% of the total exports in 2016, 11.7% in 2017, and will represent 12.4% of the total export in 2027. By 2027 also, international tourist arrivals are forecast to total 11,961,000, generating expenditure of BGN 12,224 mln.

Travel & Tourism investment in 2016 was BGN 1,294.2 ml, or 7.3% of the total investment. In 2017 it was 7.4%, and will represent 3.3% of the total investment in 2027.

Figure 6.1 shows some trends for 2017 and 2027 as key indicators for Bulgaria, as well as for the European Union and the world.

Figure 6.1

Comparison of Travel and Tourism Growth in Bulgaria, the EU and the world for 2017 by components



Source: Travel and Tourism Economic Impact 2017

The data illustrate that by 2027 Bulgaria will have a positive growth in the following directions for tourism development: visitor exports, total contribution to GDP and direct contribution to GDP. This means that more and more international tourists will pay for coming for personal and business trips in Bulgaria, which will contribute to more revenues and will increase the GDP of the country. Bulgaria will report some negative trends by 2027 on direct and total contribution to employment and on in-coming new investments in the sector. For the European

Union, there will be similar trends as for Bulgaria. Globally by 2027, tourism is expected to make a significant contribution to world GDP (both direct and general) and to maintain relative employment levels.

According to data from the Bulgarian Ministry of Tourism, in the period January - May 2017, the total number of foreign visitors in Bulgaria is 2 192 030. Their number is 12.8% more as compared to the same period January – May, 2016. For January 2018 alone, the total number of tourist arrivals in Bulgaria is 437,498, or 18.8% more as compared to January 2017. Recreation and holiday visits make up for 53.9% of all tourist visits (Министерство на туризма, 2018). The countries of the EU are the most important international market in Bulgaria, with a relative share of 56%. A positive trend is that the revenues from international tourism in the current account of the Bulgarian balance of payments (according to database of the Bulgarian National Bank for 2016) amounts to EUR 3,283.7 mln, which is 15.7% more than in 2015.

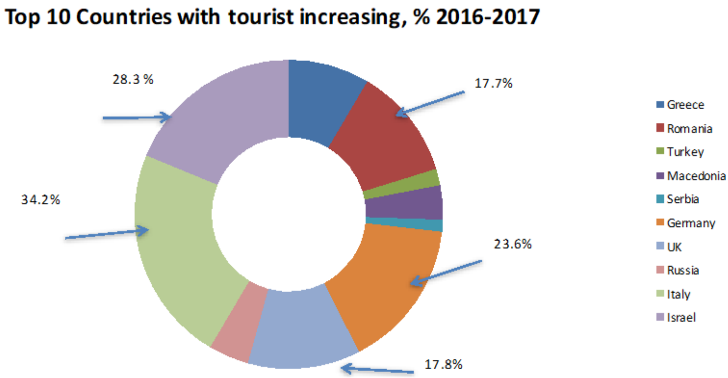
Figure 6.2 shows the change between season 2016 and season 2017 for the leading destinations from which foreign tourists arrive in Bulgaria.

The data show that the most favorable change in the number of foreign tourists in 2017 is observed among tourists from European Union countries, namely the increase from Italy (34.2%), Germany (23.6%), Great Britain (17.8%) and Romania (17.7%). Israel is also among the leading countries with a positive growth in visits (28.3%).

In 2017, the Bulgarian Ministry of Tourism published its updated version of the National Strategy for Sustainable Tourism Development in the Republic of Bulgaria for the period 2014-2030. The document corresponds with the UN idea to appoint the year 2017 as the International Year of Sustainable Tourism for Development.

Figure 6.2

Top 10 Countries with an Increase in the Number of Tourists, %, 2016-2017



Source: Министерство на туризма, 2017 (Bulgarian Ministry of tourism)

It also identifies two clear trends in the recent years, namely: increasing number of overnight stays in 4- and 5- star accommodation hotels and reduction of number of overnight stays in 3-star accommodation hotels. In order to maintain high-quality tourism in 4 and 5 star accommodation hotels. The paper also points out that in order for Bulgaria to maintain high quality tourism during the whole four seasons, it is necessary to take steps for reducing the negative impact on the environment and the local communities during high season. The updated National Strategy examines the impact of environmental factors, and in particular the effects of climate change on tourism. It is pointed out that as early as in 2014 a national report was published on "Assessment and Analysis of the Risk and Vulnerability of the Sectors in the Bulgarian Economy from Climate Change ". This report mentions the three most vulnerable sectors in Bulgaria from climate change: water management, agriculture and tourism. At the same time, tourism services in Bulgaria still have a low level of introduction and implementation of eco-innovations.

The updated National Strategy identifies some indicators for sustainable tourism on the basis of the ETIS Toolkit for Sustainable Destination Management, published in March 2016. The Environmental

Impact section in the Toolkit mentions that mechanisms will be sought to reduce the impact of transport by implementing such indicators as "average carbon footprint of tourists and of day-trip visitors" by reaching 215 kg in 2020 and 200 kg in 2030. In order to create a favourable environment for the development of sustainable tourism, the concrete Action Plan of the Bulgarian Ministry of Tourism for the period 2017-2020 provides the development of a methodology for calculating the carbon footprint of tourists in order to better manage accommodation services.

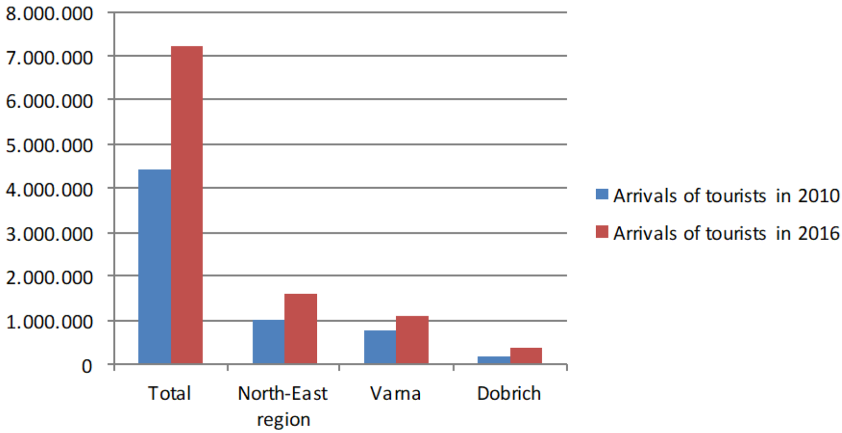
The updated national strategy identifies the important role of circular economy in the development of tourism in the context of implementing EU policies on sustainable tourism. The specific proposals relate to the following areas: (a) Environmental taxation (taxation to ensure that product prices reflect all environmental costs) and removing environmentally damaging subsidies; (b) Green Public Procurement (a procedure by which public authorities seek to obtain products, services and etc., whose environmental impact throughout their life-cycle assessment will be lower than standard products, services etc. with the same function); (c) Introduction of the principles of circular economy in the tourism industry – reuse of materials and adaptation of buildings and facilities for tourism purposes. According to the Action Plan of the updated strategy (2017-2020), until the end of 2019, a national certification system for sustainable development or national sustainable development label in tourism, for a tourist destination, should be introduced. With respect to improving the capacity and expertise of hotels, it is planned, by the end of 2020, annually to provide current information, consultancy assistance and training for the development, implementation and certification of quality management systems. It should be noted that by the end of 2020, all those above-mentioned aspects of sustainable tourism in the updated National Strategy should be analysed and studied in schools and universities. For this purpose, interaction is needed with the educational establishments in order to include in the school curricula and the curricula of students in the field of tourism subjects related to effective resource management, environmental protection, climate change and the necessary adaptation actions.

According to the Regional Development Plan for the Northeast Region of Bulgaria for the period 2014-2020 of the Ministry of Regional Development, the Northeast Region (which includes the city of Varna) ranks second in the country after the Southeast Region by the level of tourism development measured by the number of beds for accommodation (Министерство на регионалното развитие, 2013). The Northeast Region is also distinguished by a high average stay of tourists: 5 days with 35.5 BGN benefits for 1 night. The region generates 8.6 beds per 100 inhabitants and 75.9 nights per 1 bed are realized per year. The city of Varna forms an agglomeration with the municipalities of Varna, Aksakovo, Beloslav and Devnya. An agglomeration of a tourist type, except for the municipality of Varna, is also formed in Balchik Municipality (Balchik-Albena-Kranevo) and partly in Kavarna Municipality. In the districts of Varna and Dobrich are concentrated 97.36% of the beds and facilities for accommodation and 98.7% of the area's overnight stays. Figure 6.3 traces the change in the number of overnight residents in the region over a six-year period.

The trend observed in 2016, as compared to 2010, is that there is a significant increase in the number of overnight tourists in the Northeast Region with over 570,000 people, which is in line with the overall increase in overnight tourists in Bulgaria. Compared to Dobrich, Varna has a higher share of overnight tourists. The tourist facilities are located in the coastal settlements, in the resort areas and in separate village formations, such as tourist complexes and holiday villages. Some of these formations have considerable facilities – *Golden Sands Resort, Sunny Beach, Albena, St. St. Konstantin and Elena* Resort.

Figure 6.3

Comparison between Arrivals of Tourists, 2010-2016



Source: НСИ, 2017 (National Statistical Institute of Bulgaria)

In order to evaluate the tourism policy in the Northeast Region correctly, it is important to highlight two opposing trends for the region: a) depleted/limited opportunities for territorial development and economic growth in the traditional Black Sea resorts and tourist areas; b) not at all or barely used potential for tourism development (in the whole territory of the country).

Varna Municipality has an area of 237.5 sq. km, 205 of which are part of the city of Varna.

In 1948, the construction of *St. St. Konstantin and Elena* Resort was started. In 1956, the construction of *Zlatni Piasatsi /Golden Sands/* Resort began. The tourist demand of Varna is characterized by high seasonality. Almost 90% of the overnight stays in the destination are realized in the period June – September and just for the period July – August, the share of overnight stays is over 55%. A negative trend that is observed is the shortening of the average duration of stays in the tourist destination. (Туристически информационен център, 2016).

Mineral waters on the territory of Varna Municipality are also an important natural resource for the development of tourism. On the territory of Varna and the resort complexes are built 27 deep drillings with a total flow of 980 l/sec. The water is slightly mineralized with a temperature of 30-54 degrees C, with an increased content of hydrogen sulphide. Only one drilling (with a flow rate of 100 l/sec, located in *Golden Sands* Resort) is used for drinking after aeration and tempering. The rest of the drillings are used for heating, balneology and for swimming pools. In the resort of *Sts. Konstantin and Elena*, thermal mineral waters have a flow rate of 105 l/s, with a temperature of 43-51^{o}C. If the heat is pumped through heat pumps, the electricity produced will be enough to heat the whole resort and will allow a saving of over 20,000 tonnes of liquid fuel per year.

On the territory of Varna Municipality there are no major sources for the production of electricity, such as nuclear power plants (NPP), hydroelectric power plants (HPP) or thermal power plants (TPP). The only producer is a co-generating station for electricity and heat in a heating plant in Varna with a capacity of 4.4 MW. The central heating of the utility sector is only about 12%. A centralized heating network is not built in the resorts (although the use of geothermal heating sources is of interest to most of the tourist complexes).

Waste collection in Varna municipality is organized as per neighbourhoods, the organization also valid for the resorts situated in the northern part of the city. Varna Municipality plans to build a recycling waste installation in Klise Bair industrial zone, near Topoli village. The elaboration and implementation of the overall waste management strategy in the resorts is assigned to the Bulgarian Ministry of Environment and Waters (according to the updated version of the national tourism strategy 2014-2030). Regarding the ecological business practices in tourism in Varna, it is worth mentioning the results of a survey conducted in 2009 among hoteliers from Varna Municipality about their perception towards the introduction of the *green hotel* concept. The results show that 45.2% of respondents intend to implement this green step in the future by paying for certification for a green label. For high-class hotels (4 and 5 stars), the percentage is higher: 66.7%. Furthermore, 62% of all respondents have a vision of how to improve their environmental policy in the future: 78.6% are giving priority to energy saving, 14.3% are pointing to water saving, and other 7.2% are sticking to waste management. The survey summarizes the need of an information campaign within the hotels on the implementation of green practices (Маринов и др. 2015).

The Municipality of Varna has developed a Programme for tourism development for the period 2014-2020. It sets eight priorities as a tourist destination:

Priority 1: Creating a cosy and welcoming, eco-friendly environment.

Priority 2: Integrated development of the territory of the municipality as a tourist destination – improvement of tourism-related infrastructure.

Priority 3: Improvement of the tourism superstructure in the municipality of Varna.

Priority 4: Marketing of Varna Municipality as a tourist destination.

Priority 5: Cross-border cooperation and European integration.

Priority 6: Improving the competitiveness of the municipality as a tourist destination based on knowledge economy.

Priority 7: Extension of the tourist season in the Municipality of Varna through the development of year-round tourism.

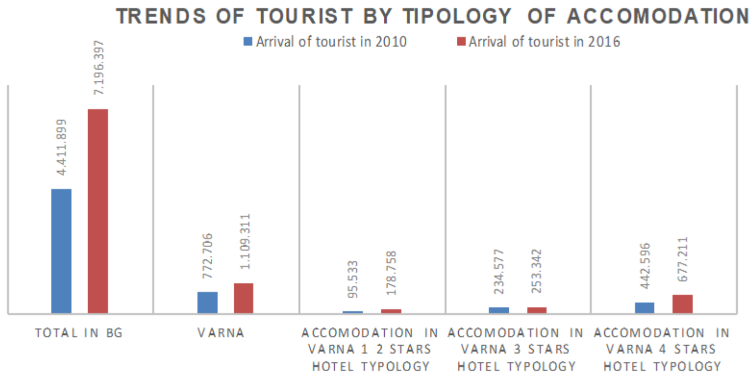
Priority 8: Control and coordination of tourism related activities.

Within Priority 6, the Municipality of Varna envisages the promotion of different opportunities for tourism innovations and investments from the municipality and the private sector. Under Priority 8, a system for monitoring the ecological impact of tourism in the municipality of Varna is set up. The update of each priority requires changes in the related national legislation as well as this of the European Union.

Varna Municipality occupies a strategic place on the tourist map of Bulgaria. Figures 6.4 and 6.5 bring out the changes in the attitudes of the arriving tourists in Varna, including foreigners in 2016 as compared to 2010.

Figure 6.4

Trends in Accommodation in Varna, 2010-2016.

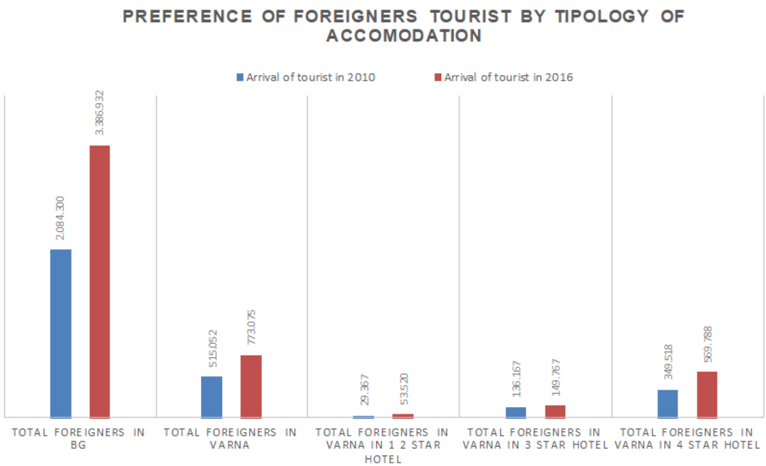


Source: НСИ, 2017 (National Statistical Institute of Bulgaria)

Figure 6.4 shows that Varna follows the trend of an increase in the number of arriving tourists, which is typical for the whole of Bulgaria. In 2016, the number of arriving tourists wishing to be accommodated in 4 star hotels is considerably higher for Varna. The share of tourists willing to be accommodated in 3 star hotels remains permanent.

Figure 6.5

Foreign tourists' preferences for accommodation, 2010-2016

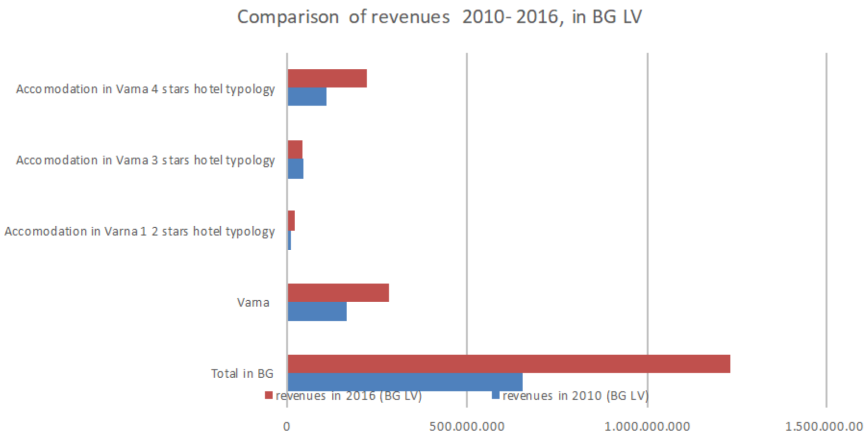


Source: НСИ, 2017 (National Statistical Institute of Bulgaria)

The indicated trend in Figure 6.5 is also valid for all foreigners arriving both in Bulgaria and in Varna. In 2016, their share increased significantly in lieu of their preferences for accommodation in 4 star hotels. According to the Tourism Development Programme of the Municipality of Varna for the period 2014-2020, Varna is a dominating place in lieu of preferences for year-round tourist accommodation and generates 97% of the revenue for the region. Figures 6.6 and 6.7give some comparison between 2016 and 2010 illustrating the differences between the revenue from tourists' nights, foreigners included.

Figure 6.6

Comparison of the Revenue from Nights as per Accommodation Categories, 2010-2016, in BGN

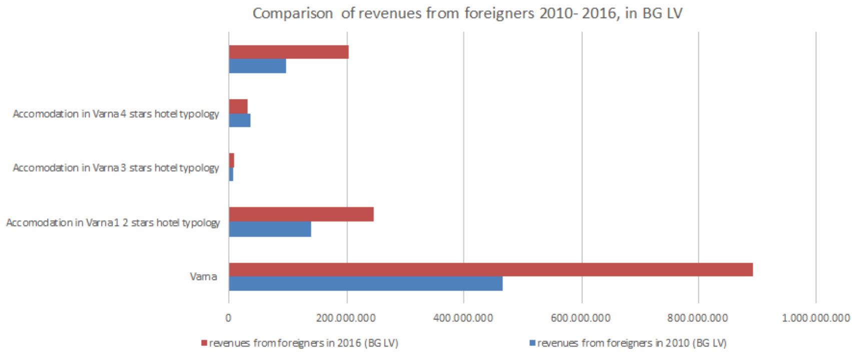


Source: НСИ 2017 (National Statistical Institute of Bulgaria)

In 2016, both in Bulgaria and in Varna, there is almost a double increase in overnight stays as compared to 2010. The share of the revenue is negligible for 2- and 3-star hotels. Revenues are significant (twice as high, in comparison with 2010), or a total of USD 221,085,739 for 2016 when the accommodation was for 4 star hotels.

Figure 6.7

Comparison of the Revenues from Overnight Stays of Foreigners for 2010-2016, in BGN



Source: НСИ 2017 (National Statistical Institute of Bulgaria)

The observed trend in the previous Figure 6.7 is even more evident for the revenues earned from the accommodation of foreigner tourists. Their share is not only increasing over the years, both for the country and for Varna, but is also very pronounced as preference for nights spent in 4 star hotels. It should be noted that 92% of the realized revenues from overnight stays in 2016 are made by foreigners.

According to data from the National Statistical Institute of Bulgaria, the total number of accommodation places in the municipality of Varna is 365 (in 2013) and the number of beds is 61,026 (in 2013). In 2016, the number of accommodation places increased to 415 and the number of beds increased to 67,561. Varna takes a 63% share of accommodation in the Northeast Region and has 12.5% of the total number of the places of accommodation in Bulgaria. Hotels with 2, 3, 4 and 5 stars in 2013 are 167 with 46,530 beds. Or, in other words, $^{4}/_{5}{}^{ths}$ of the accommodation place in Varna represent hotels. The occupancy rate of the accommodation places ranges between 45-46%, with most of the hotels operating seasonally (around 150-170 days annually).

Tables 6.1 and 6.2 show that *Golden Sands* Resort has a strategic position in the activities of the resorts in the region of Varna.

Table 6.1

Places for Accommodation in Resorts in Varna Region for the Period 2010-2016

Resorts years	2010	2011	2012	2013	2014	2015	2016
Albena	35	37	36	40	37	34	36
Golden sands	92	91	93	101	102	107	112
Sts. Konstantin and Elena	59	58	55	55	53	48	55

Source: НСИ 2017 (National Statistical Institute of Bulgaria)

Table 6. 2

Number of Beds in Resorts in Varna Region for the Period 2010-2016

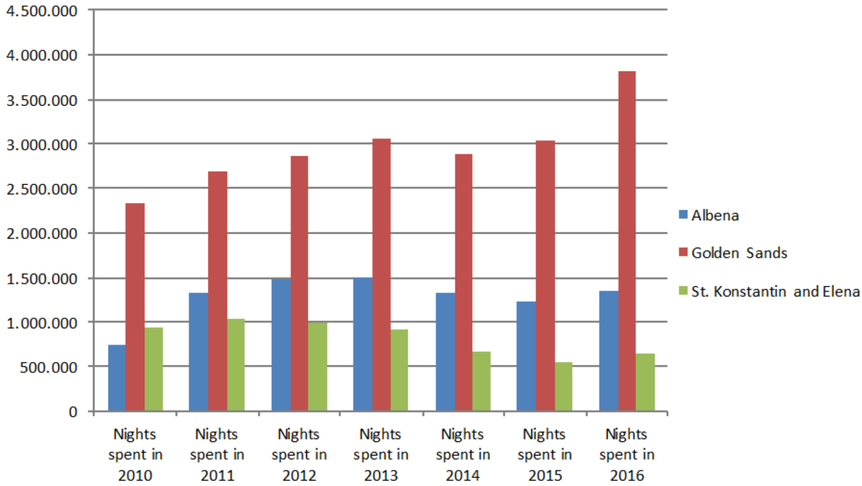
Resorts years	2010	2011	2012	2013	2014	2015	2016
Albena	13 936	15 237	18 623	19 676	18 196	15 850	16 679
Golden sands	34 424	33 547	34 108	36 894	36 246	39 944	40 519
Sts. Konstantin and Elena	10 761	10 625	11 643	11 604	10 818	9 663	9 104

Source: НСИ 2017 (National Statistical Institute of Bulgaria)

For example, in 2012, there are 93 hotels: 41% of them are 3 stars and 39% are 4 stars with a total of 34108 beds. In 2016, Golden Sands resort registered 112 accommodation places with 40519 beds, which makes it a leader by comparing with the other resorts *Albena* and *Sts. Konstantin and Elena*. The latter has the largest number of accommodation places in 2010 and its number of beds is the highest for 2012. Of the largest share of hotels in *Sts. Konstantin and Elena* Resort, 62% are 4 star hotels. *Albena* Resort registered the strongest year by number of accommodation and number of beds in 2013. Trends in the nights spent in the three resorts (*Albena, Golden Sands and Sts. Konstantin and Elena*) are shown on Figure 6.8

Figure 6.8

Trends in Nights Spent in Resorts in Varna Region, 2010-2016.



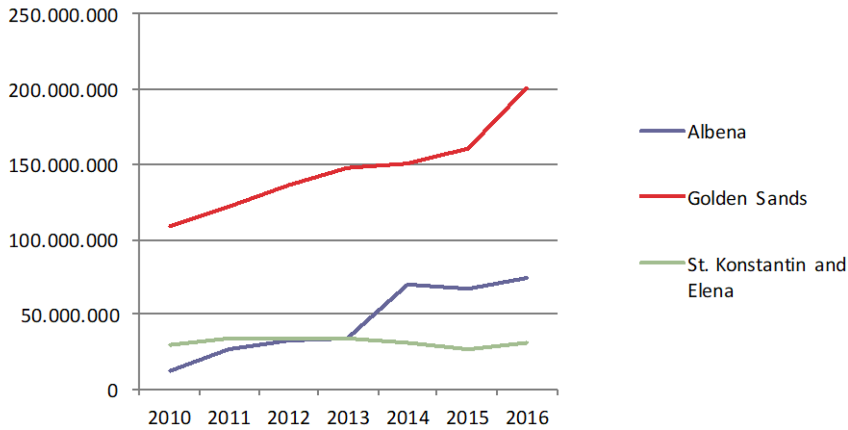
Source: НСИ 2017 (National Statistical Institute of Bulgaria)

For the period 2010-2016, *Golden Sands* Resort has the highest share of overnight stays as compared to other resorts. Best year for *Golden Sands* Resort is 2016 with 3,811,308 nights spent, of which 93% were realized by foreign tourists. In *Albena* Resort, 81% of the overnight stays in 2016 were realized by foreigners while in 2010 this share was 75%. In *Sts. Konstantin and Elena* Resort, on average, 67% of the overnight stays for the period 2010-2016 were realized by foreign tourists.

The data show that in the three resort complexes in the region there is an increase in the reported overnight stays. The biggest one is in *Golden Sands* Resort and totals 200,399,743 BGN in 2016. 95% of these revenues were realized by foreigners. In *Albena* Resort, overnight stays are almost 3 times lower overall, but 80% are also realized by foreigners in 2016. As constant value for the period 2010-2016, remains the realized revenue from overnight stays in *St. St. Konstantin and Elena* Resort, where an average of 75% of the revenue comes from foreign tourists.

Figure 6.9

Trends in Revenue from Nights Spent in Varna Region, 2010-2016, in BNG



Source: НСИ 2017 (National Statistical Institute of Bulgaria)

The structure of tourism of Varna is dominated by small and medium enterprises or a total of 99% of all tourist enterprises, with 90% of them being micro-enterprises. The tendency is typical of the whole Varna region. The results of the survey carried out by tour operators and tourist agency companies at the North and South Black Sea coasts show that 61% have a strong need for well-developed strategies and innovative management systems, also including the environmental protection requirements (Нешков и др., 2013). Currently, Varna Municipality does not have a project for development of sustainable tourism implementing circular economy.

2. The concept of Sustainable Tourism in Bulgaria

Tourism, like every human activity, affects the environment. Tourism influences and is influenced by it. So, the interrelationship between tourism and the environment is complex and constantly transformed. Tourism, involving a huge variety of areas and sectors, is in fact a difficult activity to manage. Considering the economic aspects, tourism represents the third EU largest economic activity (after the sectors of distribution and construction) with roughly 1.8 million of enterprises and with €356 billion of total turnover, equal to 5% of GDP of EU (indirectly 10% of EU GDP) (Calabrò, 2013).

Making tourism more sustainable is not just about controlling and managing the negative impacts of the industry. Tourism is in a very special position to benefit local communities, economically and socially, and to raise awareness and support for conservation of the environment. (UNEP, 2005).

Sustainable tourism can be defined as that tourist activity able to meet the needs of tourists, and the host population, without compromising the needs of the future generations, preserving and enhancing the environmental resources of a destination. This definition covers different aspects of tourism, including such resources as: natural areas (territory, climate, flora, fauna), historical and artistic resources (monuments, museums), and cultural partner resources, i.e. the way of life of a people, its traditions, its predisposition to hospitality. This means that all the actors in the tourist industry, and hence the "tourist", the "organizer" and the local host community, have to deal with a dynamic complexity in which everyone must respect, preserve (and sometimes conceive *ex novo*) the functional equilibrium of the other players in the tourist experience.

Acting in a sustainable way means preserving and giving value to different aspects of the tourism supply chain. The environment represents for tourism a primary resource, a component essential to the product offered to tourists; on the other hand, tourism represents an opportunity for the environment for its protection and for its valorization. A key element for framing the tourist activity and its complex relationships is the "carrying capacity" of a destination, which the WTO (World Tourism Organization, 2004) defines as" *the maximum number of people who can simultaneously visit a tourist destination without causing environmental, economic and cultural damage and without unduly reducing the quality of the experience enjoyed by visitors* ". (World Tourism Organization, 2004) For this reason, it is important to avoid concrete risks related to oversupply in tourism in order to measure and manage the potential and concrete risks that tourism will produce on the territory. The latter has become an important aspect to study in order to preserve the economic, environmental and social issues of a locality. Recent statistical data have highlighted the future trends and forecast that towards 2030 tourism will reach 1.8 billion of tourists. This means that, from a certain point of view, tourism will continue to be one of the major worldwide economic sectors but, from another point of view, will be one of the major sectors that have environmental impact, such as carbon dioxide pollution and production. Some scientific studies (Gössling and Peeters, 2015) have highlighted that tourism requires energy consumption equal to 1.67 *104PJ, 138 km ^{3} of fresh water, 6.2* 10^4 km 2 of land and 39.4 Mt of food (see figure 12): These data have been calculated splitting different aspects that characterize a tourism activity, such as energy per tourism/night accommodation, emission per night or per trip, etc. (Table 6.3)

Table 6.3.

Global Emission Split for Aspect Characterizing Tourism.

Aspect	Range of estimates	Global average
Energy		
- Per guest night	3.6–3717 MJ	272 MJ
- Per trip (domestic and international average)	50–135,815 MJ	3,575 MJ
Emissions		
- Per night (accommodation)	0.1–260 kg CO_2	13.8 kg CO_2
- Per trip (domestic and international average)	<0.1–9.30 t CO_2	250 kg CO_2
Fresh water, Litre per tourist per day		
- Direct (accommodation)	84–2425	350
- Indirect (fuels, food)	4500–8000	6000
- Combined	4600–12,000	6575
Land use, m^2		
–Direct, per bed	30–4580 m^2/bed	42 m^2
–Accommodation, traffic infrastructure and activities, per tourist		11.7 m^2
Food use, grams per day		
- Per tourist per day	2200–3100g	1800 g

Source: Gössling e Peeters, 2015

According to the study (Gössling e Peeters, 2015), emissions in tourism are expected to grow by 169% by 2050. All these figures and data show the importance of implementing and developing a set of indicators and parameters to evaluate the carrying capacity of a destination and, consequently, the sustainability of tourism. These are tools for the planning, implementation, and monitoring of tourist development, providing adequate and reliable information to entrepreneurship and policy makers. The main function of the indicators is to provide directions and signals about situations or problems, emerging and/or present, through synthetic data useful for the decision-making processes and for undertaking actions for correcting the impacts associated with tourism activities. After different forums and international debate, the European Commission has published in 2007 a set of indicators and principles set out in the *Agenda for Sustainable European Tourism*. Sustainable European tourism policy is defined both by the framework outlined in the Communication "Europe, the World's No 1 Tourist Destination – A New Political Framework for Tourism in Europe" (COM (2010) 352), and by the Communication "A European Strategy for more Growth and Jobs in Coastal and Maritime Tourism" (COM (2014) 86), with the framework for the current challenges being devoted to improving the sustainability and competitiveness of the sector.

With the first communication, the Commission focuses on two key concepts: a) the need for a sustainable approach and (b) the need to strengthen the competitiveness of the European tourism industry. The 2010 Communication defined a new strategy, structured in 21 specific actions, and the EU Action Plan for Tourism. Four action priorities have been identified: a) stimulate the competitiveness of the European tourism sector (promotion of tourism diversification, innovation in the tourist industry, improvement of professional skills, extension of the tourist season, consolidation of the socio-economic knowledge base on tourism); b) promote the development of sustainable, responsible and high-quality tourism (enhancing destinations that promote responsible resource management and guarantee optimal conditions for services and security, in particular for the reception of elderly people and people with reduced mobility); c) consolidate the image of Europe as a set of sustainable, high-quality destinations (to enhance the diversity of European and multinational thematic products, especially during major trade fairs and exhibitions, to highlight major cultural and sporting events – *European Capital of Culture*, *European Heritage Days*, Olympic Games or universal expositions; d) maximize the potential of EU financial policies for tourism development (on 3 April 2016, the European Commission published a Guide to Financing Programs foreseeing the 2014-2020 period, with a list of available programs).

In 2013, the European Commission proposed the European Tourism Indicator System (ETIS) and successively published it in March 2016, with the goal to offer guidelines for tourism destinations, and monitor and measure their sustainable tourism performance by using a common approach. The ETIS was based on 27 core indicators and 40 optional indicators, subdivided into four categories: Section A: Destination Management; Section B: Economic Value; Section C: Social and Cultural Impact; Section D: Environmental Impact. Sections B and C mainly assess economic, social and cultural criteria, including number of tourists, number of nights, employment percentage in the tourist infrastructure; quality and quantity of the employed in tourism; supplying tourist destinations with products and services; impact of tourist supply on the destination and the local populations; gender equality in tourism employment; accessibility of tourist infrastructure; protection of cultural and historical heritage within tourist destinations, etc.

Tables 6.4 and 6.5. give the main criteria in Sections A and D relating to the management of the tourist destination and the measuring of its environmental indicators.

Table 6.4.

ETIS Referent Destination Management Indicators

Criteria	Indicators
Sustainable Tourism Public Policies	• Percentage of tourist firms/structures using voluntary quality/environmental sustainability and corporate social responsibility certificates/eco-certificates.
Tourist Satisfaction	- Percentage of tourists satisfied with the visited destination; - Percentage of tourists who returned to the same destination (within the next five years).

Source: EC: ETIS, 2016

Table 6.5.

ETIS Referent Environmental Impact Indicators

Criteria	Indicators
Alleviating Transport Impact	- Percentage of tourists using different means for arrival at the tourist destination; - Percentage of tourists using public transport; - Average number of km a tourist travels from home to the tourist destination; - Average carbon footprint value left by the tourist from home to the tourist destination.
Cimate Change	- Percentage of tourist companies participating in climate adaptation actions – C02, lower energy schemes; - Percentage of funds for accommodating tourists in zones vulnerable to climatic changes.
Waste Management	- Percentage of tourist companies engaged in separate waste collection; - Waste generated per tourist for one night against the total generated waste per capita in the tourist destination (in kg); - Percentage of recycled waste per tourist against the percentage recycled waste per capita in the tourist destination.
Waste Water Recycling	- Percentage of recycled waste water.
Water Resource Management	- Water use per tourist per night against water use per capita in the tourist destination; - Percentage of tourist companies which have taken steps to reduce water use; - Percentage of tourist companies recycling water resources.

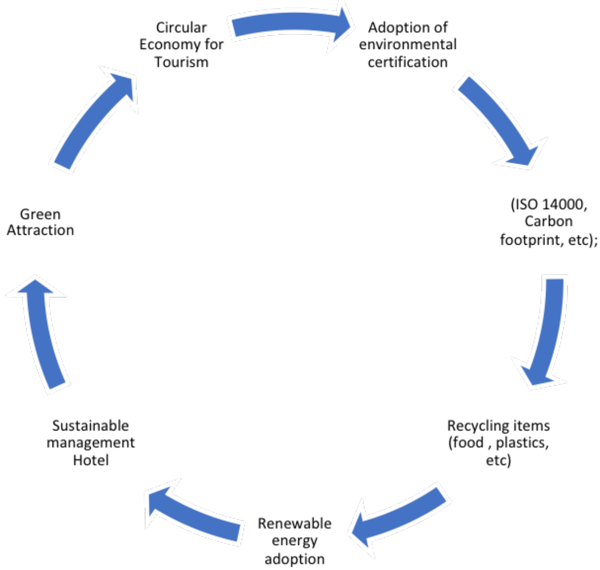
Source: EC: ETIS, 2016

It is difficult to develop sustainable tourism without the legislation and policies needed to support it. For this reason, the implementation of the circular economy concept can change the traditional model of tourism management, creating new opportunities and enhancing economic performance. Following the principle of circular economy for the realization of tourist attractions, efficient use of resources, a sustainable development model, reasonable pollution control, environmental protection and green shopping and entertainment can be developed.

Figure 6.10 gives as schematic representation of circular economy in tourism.

Figure 6.10

Scheme of circular Economy in Tourism

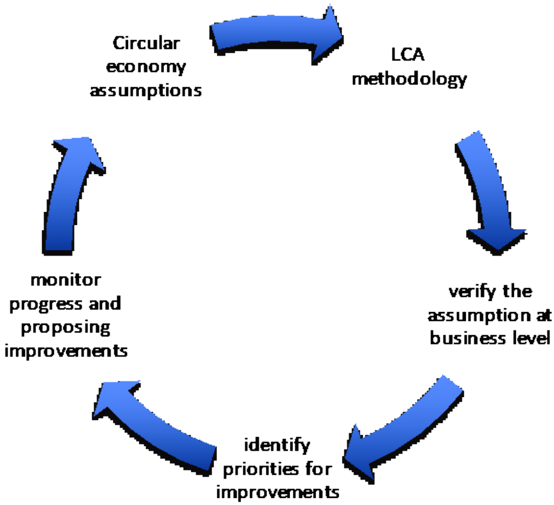


Source: Personal elaboration of the authors

As described, tourism is responsible for GHG emission and waste production, like any industrial activity, and for this reason the adoption of the suggestions coming from circular economy would help to reduce waste and mitigate some of the environmental burdens. This would suggest to the tourism sector how to better address future resource scarcity issues. Studying a more efficient innovative management method in hotels, focusing on recycling different items instead of landfilling them or reducing energy consumption can help organizations improve their carbon footprint. A number of different initiatives can be undertaken in the hotel industry. It is estimated that more than 60% of food waste in the hospitality industry is avoidable, so if this could be reduced it would massively cut costs. Furthermore, tourism and transport have regularly been addressed by the media as a contributor to climate change, and for this reason a better regulation could improve the sustainability of the touristic destination. Monitoring and measuring the carbon footprint of a hotel can lead to the implementation of new marketing strategies as well. For example, the Eurobarometer survey of July 2009 found that the majority of the European consumers are concerned about the possible negative environmental impacts of the products they purchase. 72 % of EU citizens think that a label indicating a product's carbon footprint should be mandatory in the future. This means a commitment towards the environment and it would allow consumers to make responsible choice thanks to such transparent information, in order to reduce their personal climate liability. This would enhance climate awareness among tourism businesses as they will be required to establish emission reporting systems and /or standardized benchmarks. As explained in Chapter 3 on the instruments for implementation of circular economy, life cycle assessment study (LCA) can measure the environmental performance of products or services along their supply chain and this can strengthen the propositions made by circular economy favoring the "closing of the loop "in biological or technological cycles. Practically, LCA can verify the suppositions of the circular economy business models identifying limitations and proposing alternative approaches. In this way, practical and concrete elements can be introduced at the level of business processes, with new reliable assumptions that can help measure the progress towards a target and foster continuous improvement (see figure 6.11).

Figure 6.11.

Improvements in the Circular Economy Model by Applying LCA methodology



Source: personal elaboration of the authors

For this reason, a study with the aim to identify and measure the carbon footprint of different hotels in Varna region (according to LCA methodology) would propose sustainable measures for improvement in the tourism sector.

3. Case Study of Circular Economy in the Hotels in Varna

The European Regional Development Fund is the main financing instrument for the development of sustainable tourism in Bulgaria. For the period 2008-2012, €165 million were allocated by the European Union under Priority Axis 3: *Sustainable Tourism Development* of the Operational Programme *Regional Development 2007-12* (OECD 2014). Between 2008 and 2012, different activities were developed for the promotion of sustainability in Bulgaria, as follows:

- €128 million for the development of new integrated and distinctive tourism products based on competitive and marketable attractions that contribute to the diversification of the national tourism product;

- €9.4 million for the implementation of destination marketing and encouragement of "soft" activities. The objective was to increase the number of visitors and visitor days, to improve the seasonal and territorial distribution of tourism development in different regions and localities;

- €27 million for enhancing the diversification of tourism products and markets, as well as sustainable tourism development.

From these data, it is possible to highlight that national policies do not put emphasis on environmental certification or green marketing strategies. For example, according to a research study carried out in Bulgaria (Ivanov, 2013), accommodation establishments in Bulgaria have implemented HACCP (Hazard Analysis of Critical Control Points) because it is compulsory, whereas other certifications (Ecolabel, ISO 14000, EMAS, Carbon Footprint, etc.) have not be implemented. The main reason identified by the study is that environmental certificates are not compulsory and they are based on the good will of hotel managers and owners. The environmental certification is not encouraged with specific initiatives, norms or legal requirements. Other research carried out in Spain (Segarra Oña et al., 2012) found that environmental certifications, such as ISO 14000, can be produce effect on the economic performance of a tourism destination after an informative campaign, which will make both consumers and hotel owners more proactive towards sustainability certification.

The case study reviewed hereunder illustrates the preliminary results of a case study carried out in Varna region with the aim to identify and measure the carbon footprint of different 4-star hotels according to LCA methodology in order to implement the circular economy approach. This study aims to outline the environmental benefits for Varna as a tourist destination. The important question raised before undertaking the carbon footprint research study in hotels was: ***Does the role of environmental certification in the tourist sector strategies affect their competitive performance?*** Answering this question is not easy and some preliminary conditions have to be investigated. It is true that carbon footprint labelling can give environmental information allowing companies to differentiate their products/processes or services on the basis of their carbon impact. It is also true that the market opportunities, along with the attitude of travelers to choose a destination, depend to a large extent on the focus on the environmental issues. For this reason, different literature and reports have been studied in order to understand the trends of the environmental friendly tourist destination. For instance, according to Eurobarometer (2016)*: Preferences of European Towards Tourism*, includes the main aspects influencing the choices of the European citizens travelling for tourism and their mindset when choosing a European tourist destination. Roughly 10% of the respondents who travelled once in 2015 have chosen their destination considering a tourist area that has introduced sustainable practices, whereas 10% had chosen a hotel with environmental certification. Considering that in the Eurobarometer 2012 survey relating to the interest of travelers towards environmental certification, was not cited the conclusion that the trend of sustainable practices in hotel is expected to grow to meet the current and future environmental challenges. Furthermore, according to a recent study research (Segarra-Oña et al., 2016), the findings show that the "size" of an accommodation structure is also very important. Family hotels need external experts to help owners in their development needs, while larger hotels can count on a team of specialists. Another important aspect is the location. Beach hotels or structures located near natural sights are becoming more attentive to their environmental activities, taking a more proactive role. To summarize, environmental certification can represent in the near future an asset on which to base a marketing strategy policy.

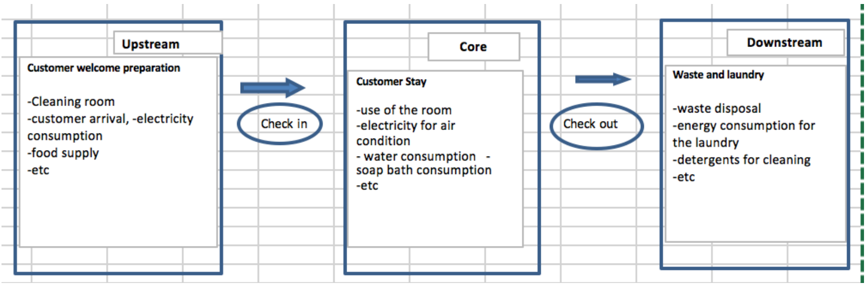
In the light of these considerations, a research study has been conducted in order to calculate the carbon footprint of typical 4-star hotels in the region of Varna. The choice of the calculation of the carbon footprint has been made because it represents an important environmental certificate useful for green marketing strategies. The carbon footprint is a measure of CO_2 associated directly or indirectly with a product, organization or service. The measurement of the carbon footprint of a product or process requires, in particular, the identification and quantification of raw materials and energy consumption in selected phases of the life cycle of same. In this regard, the experience of recent years suggests that the carbon footprint label is perceived by consumers as an index of quality and sustainability of businesses. Companies, in addition to conducting CO_2 emissions analysis and accounting, undertake to define a carbon management system for the identification and realization of economically efficient emission reductions using low-carbon technologies. Reduction measures can be implemented by carbon neutrality measures, which can be achieved through activities aimed at offsetting emissions or reducing them applying more economically efficient or more cost-effective measures (e.g. planting trees, renewable energy production, etc.).

In literature, there is a limited number of typological studies based on the carbon footprint.

In 2015, Allen H. et al published an article on the carbon footprint in the life cycle of accommodation services in some hotels in Taiwan, but the majority of the articles are based on LCA study. It is possible to cite LCA studies on accommodation services carried out in Italy considering the services provided by a 3-star hotel (Petti and Tontodonati 2002), or adopted (Chambers, 2004) to compare and analyse the differences between two package holidays in Bulgaria. A study on accommodation services was made in Italy of a 4-star hotel (Mazzoni et al. 2004). Other authors (König et al., 2007) applied a comparative LCA to the design of a hotel complex in Portugal. All these studies aim to improve performance by comparing innovative environmental technologies; to compare the environmental performance of tourist products; to sustain eco-design choices and to support green marketing" (De Camillis, 2010). Considering the lack in literature of PCR (product category rules) for hotels, different system boundaries have been reported according to the purpose of the LCA and the study object. Taking into consideration that no rules have not been proposed for product categorization of hotels, different boundaries are set, depending on the goals of the LCA. For the case of the study realized in Varna region, the chosen system boundary has been split into three main phases (see figure 1). The upstream phase, which can be identified as the phase before the checking into the hotel: such as the customer's arrival, electricity consumption for cleaning services, cleaning the room, food supply, etc; the core Phase, which is the phase related to the stay of the customers during the check in, and is linked to the use of the room: such as electricity for air conditioning, consumption of water, soap bath consumption, etc; and the downstream phase, which is the phase related to waste disposal, energy consumption for the laundry or detergents for cleaning, etc. (Figure 6.12)

Figure 6.12.

System Boundary: Hotel Accommodation in a 4-star Hotel in Varna



Source: Personal elaboration of the authors

The functional unit of the study has been defined as a *night's hotel stay in a standard room*. According to the LCA methodology, the functional unit is a quantified description of the performance requirements that the product system fulfils. In a comparative study, the functional unit has to be the same for all the compared product systems.

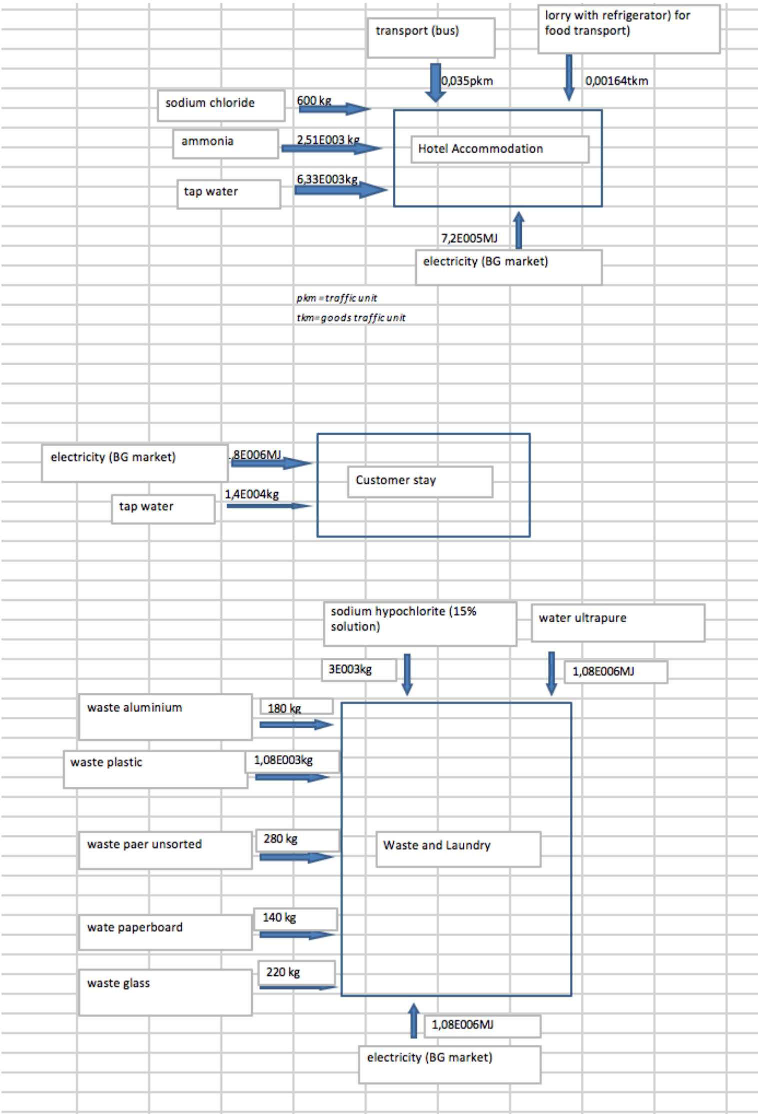
The participation in this research study was voluntary and free for the hotels in Varna. The invitation for participation in the study was distributed among the members of the Varna Restaurant and Hotel Association. The main participants are mainly 4-star hotels in *Golden* Sands Resort, or 25% of all the hotels on the territory of the resort. The analyzed data refers to the consumption of energy, the staff involved, the quantity of food, the use of cleaning products and transport for the customer and staff. To obtain this information a survey card (Appendix 4.1) was prepared and distributed to hotel managers in order to collect the needed information. Figure 6.13 illustrates the lists of inventory items for the accommodation services related to the study. The collected and analyzed data (inputs and outputs) have been standardized in averages, because of 5-7% variations between the separate hotels.

The data collection was an important phase of the process, and the data sources have been integrated with deep interviews with the managers. The required data have been collected between May 2016 and February 2017. The complete information on the hotel amenities for each guest room was difficult to obtain during the preparation of the service stage. Thus, the type and quantity of hotel amenities for each guest room were assumed. An important consideration is related to the waste management. In general, resorts and hotels generate a lot of waste from food, packaging, amenity containers, waste water from toilets, kitchens and laundry. The amount of waste that hotels produce depends on the hotel's individual policies and practices. In the case study, it wasn't considered in the phase related to waste management because garbage and waste management is committed to Varna Municipality. The hotels and resorts have the practice of collecting garbage and wastes to be managed by the Municipality. For this reason, this aspect was excluded from the calculation of the Carbon Footprint.

The collected data have been processed with *GABI Ecoinvent version 3.3* software, which is a regularly updated professional database and is derived from industry sources, scientific knowledge and technical literature.

Figure 6.13

Collection Data for the Calculation of Carbon Footprint of 4-star Hotels in Varna

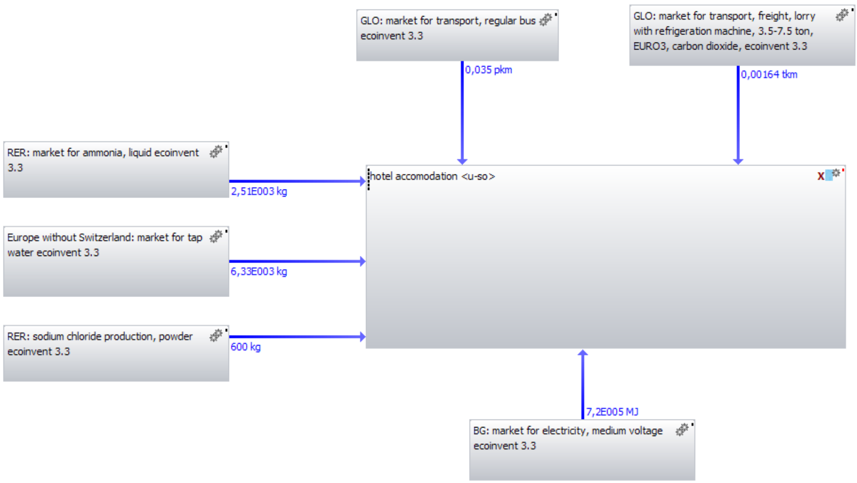


Source: Personal elaboration of the authors

The GABI software works using different plans in order to inset interconnected processes with flows. In the case study of 4-star hotels in *Golden Sands* Resort were included data arising from processes related to hotel activities, the overnight stay and the full duration of the stay of the hotel guest, as well as the waste and laundry phases. Figures 6.14., 6.15 and 6.16 outline the process flow elaborated with the software.

Figure 6.14.

Elaboration Flow of the Accommodation Phase with Quantitative Data



Source: Elaboration with GABI software

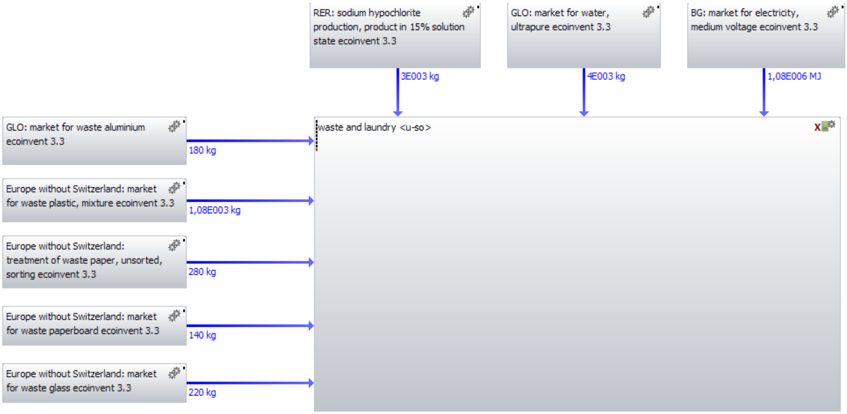
Figure 6.15.

Elaboration Flow of the Customer Stay Phase with Quantitative Data

Source: Elaboration with GABI software

Figure 6.16

Elaboration Flow of the Waste and Laundry Phase with Quantitative Data



Source: Elaboration with GABI software

The software *Gabi ecoinvent version 3.3* allowed to calculate various life cycle indicators, including the Global Warming Potential that identifies the value of CO_2eq produced during the various phases of the process. All the data and numbers in the tables and figures have been normalized in kg CO_2eq for Bulgaria. As shown in Table 6.6, the biggest single value weight is connected with the phase of the customer stay, and more specifically with emissions in the air (given in kg CO_2eq).

Table 6.6.

Carbon Footprint of 4-star Hotels in Varna and the Region

Input/Output	LCA hotel	accomodation	customer stay	waste and lau
Flows	8,47E005	1,7E005	4,21E005	2,56E005
Resources	4,23E005	8,47E004	2,1E005	1,28E005
Emissions to air	72,4	14,9	35,9	21,7
Emissions to fresh water	4,24E005	8,49E004	2,11E005	1,28E005
Emissions to sea water	0,0979	0,0208	0,0444	0,0326
Emissions to agricultural soil	0,0022	0,000676	0,000901	0,000618
Emissions to industrial soil	0,000709	0,000182	0,000316	0,000212

Source: Elaboration with GABI software

Table 6.7 gives a comparison between the study carried out in 4-star hotels in Bulgaria with another typological study carried out in 2015 (Hua, 2015). The results can be determined as similar. When using the same measure unit (kg CO2 eq), they confirm that the gust stay gives has the largest carbon foorprint.

Table 6.7

Comparison of the Carbon Footprint with Other Case Studies

Phase	Case Study in Varna	Another case study	Unit
Upstream phase	14,9	7,94	kg CO_2eq
Core phase	35,9	157	kg CO_2eq
Downstream phase	21,7	13,48	kg CO_2eq
TOTAL	72,5	178,42	kg CO_2eq

Source: Personal elaboration of the authors

Figure 6.17. shows the carbon footprint values of 4-star hotels in Varna and the region during the different phases: upstream, core and downstream. In the case study, the energy factor has the main weight in the environmental performance per a single tourist/per night.

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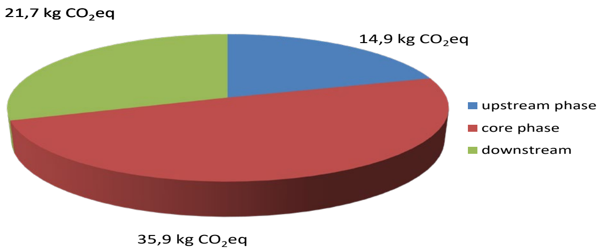
Figure 6.17

Average Carbon Footprint by Phase for 4-star hotels in Varna and the Region



Source: Elaboration with GABI software

The carbon footprint indicators show the general impact related to a single tourist/per night in 4-star hotels in Varna. It is clear from the study that the carbon footprint calculation of 4-star hotels in Varna and the region is equal to *72,5 kg CO_2eq per night per room*. The higher impact

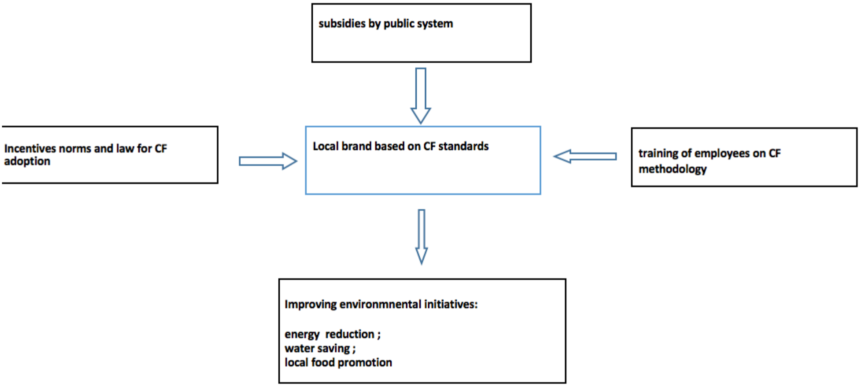
(35,9 kg CO_2eq) is correlated to the core phase. In the case study, the energy factor has the main weight in the environmental performance. Even if there were no problematic issues, it would be possible to underline some further considerations. In the light of the circular economy approach, it would be interesting to create an energy renewable area devoted to different hotels and resorts, in order to reduce their energy footprint. Considering the typology of the hotels and resorts located in Varna, it would be possible to create a sort of energy-producing zone based on biomass recycling, using waste food both from the hotels and from the municipality. In this way, it would be conceivable to stimulate the circular economy approach, implementing a waste management approach and, at the same time, reducing the carbon footprint indicators. In other words, the measurement of the carbon footprint becomes effective if it is accompanied by a common strategy which involves the policy makers, hotel owners and different stakeholders.

As explained above, the waste management phase has not been calculated because it is committed to Varna Municipality. It is important to underline that for the waste phase managed by hotels and resorts, it could be important to implement circular economy strategies. Recycling of the packaging from the breakfast, reusable bags provided for the guest's laundry and food recycling could enhance a different managerial activity favouring a shift towards a more sustainable process.

The public sector should show incentive through subsidies or public funds for the adoption of environmental certifications, such as Carbon Footprint, ISO 14000, etc., by hotels, but also a public discussion and/or forum should be planned in order to explain to the citizens the importance of addressing a managerial activity based on sustainability aspects. The most important aspect are the uninterrupted improvements in the supply chain of the tourist accommodation. This strategy should create a local brand based on environmental certifications, also implementing a green marketing strategy. (Figure 6.18)

Figure 6.18

Circular Approach for the Improvement of Hotel Accommodation, Based on Environmental Strategies



Source: Personal elaboration of the authors

Summarizing the main aspects stimulated by the research study of the Carbon Footprint in 4-stars hotels in Varna and the region, some important suggestions for the development of sustainable tourism in Varna can be outlined, as follows:

- The creation of a *Varna* brand issued on the basis of environmental certification;
- Encourage the creation of an adequate professional sustainable tourism development team to prepare up expert assessments. Formation of a national and municipal policy for scientific and practical research in the field of sustainable tourism which presupposes the inclusion of different experts, incl. International ones. This would also require updating the composition of the Consultative Council on Tourism with Varna Municipality;
- Updating the statistics database for the tourism sector at the National Statistical Institute of Bulgaria. This step may encourage the creation of a unified digital database with environmental data for destination Varna;
- In accordance with the circular economy concept, introduction of new resource capacity into the traditional tourist complexes in order to

eliminate the exhausted specialized tourist infrastructure and stop the eventual decline of the quality of tourist services or non-compliance with standards, norms etc.;

• Introduction of effective legal regulations in order to create suitable conditions for a high quality tourist product. Un this respect, the introduction of effective state, regional and municipal support for tourism in order to address such issues as quality, certification, etc, is of utmost importance. In this sense, also rethinking of the chronic shortage of funds for environmental projects for tourism in Varna;

• Stimulate the participation in specialised fairs, forums etc. on sustainable tourism, thus revitalising Varna as a tourist destination by offering sustainable tourism products that are competitive at a European and world level. It must be noted that at present, 20% of the tourist fee is set aside for participation in national and international tourism fairs;

• Rethinking the advantages and disadvantages of the stable pricing platform adopted by Varna Municipality for Varna as a tourist destination (similar to Turkey, Greece, Croatia, Cyprus), all the more compelling as the costs of the tourist services keep rising. Improving skills for strategic and tactical marketing pricing in the light of circular economy is paramount. In and environment of oversupply of standard tourist products, Varna can position itself only as a cheap destination;

• Expanding the scope of well-to-do foreign tourists preferring to reside in eco-certified hotels outside the traditional countries: Germany, Romania, Russia, etc.

• Take measures to increase foreign investments in the region of Varna in the field of environmental management and eco-innovation. Since 2009, in Varna Municipality there has been a steady trend of decline in foreign investment, which has had its negative impact on such an important sector for the region as tourism.

BIBLIOGRAPHIC REFERENCE

• Маринов, Ст., Нешков, М., Казанджиева, В., Дичев, Д., Душев, Ж., Илиева, Г., Гаврилова, Р., Николов, Т., Шипковенски, (2015) Програма за развитие на туризма в община Варна 2014-2020, разработена по договор 14000230 на 04.04.2014 между община Варна и сдружение „Култура и туризъм на българския североизток”, приета с решение 2265-6, протокол 42 на заседание на ОС Варна от 05.08.2015, Изд. ФИЛ, с. 16-142.

- Министерство на регионалното развитие (2013) Регионален план за развитие на североизточен район за периода 2014-2020, с. 1-37.
- Министерство на туризма (2017) Международен туризъм-България, с.1-9.
- Министерство на туризма (2017) Национална стратегия за устойчиво развитие на туризма в Република България 2014-2030, актуализирана версия 2017, с.1-98.
- Министерство на туризма (2017) План за действие за периода 2017-2020 към актуализираната национална стратегия за устойчиво развитие в туризма 2014-2030, с. 1-19.
- Министерство на туризма (2018) Международен туризъм-България, януари 2018, с. 1-9
- Нешков, М., Маринов, Ст., Казанджиева, В. (2013) Малките и средните предприятия в туризма на българското Черноморие, Библиотека „проф. Цани Калянджиев”, кн. 29, Изд. „Наука и икономика” на ИУ-Варна,, с. 16-227.
- НСИ (2017) Статистически данни “Туризъм”
- Туристически информационен център Варна (2016) Статистическа информация за посетителите в туристически информационен център Варна, с. 1-5.
- Calabrò, C (2013) EU Commission Sustainable Tourism within the EU Tourism Policy DG Enterprise and Industry, Tourism Policy Unit.
- Chambers, T. (2004) Environmental assessment of a “mass tourism” package holiday and a “responsible tourism” package holiday, using LCA and ecological footprint analysis, School of environmental sciences, August, pp. 9-62.
- Communication COM 86 (2014) "A European Strategy for Growth and Coastal Tourism and Jobs", available at:

http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2014%3A86%3AFIN

• Communication of EU (2010), A New Policy for Europe Tourism, available at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52010DC0352

• De Camillis C., Raggi A., Petti L. (2010) Ecodesign for services: an innovative comprehensive method. International Journal of Sustainable Economy. Vol.2, No 3, pp. 277-292

• EC (2007) Agenda for a sustainable and competitive European tourism, available at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=LEGISSUM:l10132

• EC (2016) The European tourism indicator system: ETIS toolkit for sustainable destination management, available at: http://ec.europa.eu/DocsRoom/documents/21749

• Flash Eurobarometer (2009), Analytical Report on Europeans' Attitudes Towards the Issue of Sustainable Consumption and Production. available at: http://ec.europa.eu/public_opinion/flash/fl_256_en.pdf

• Gössling, S. & Peeters, P. (2015), "Assessing tourism global environmental impact 1900-2050", Journal of Sustainable tourism, vol. 23, issue 5, pp.639-655.

• Hu H.Al., Huang Ch.-Y., Chena Ch.-F., Kuoa Ch.-H. and Hsu Ch.-W. (2015), "Assessing carbon footprint in the life cycle of accommodation services: the case of an international tourist hotel", International Journal of Sustainable Development & World Ecology, Vol. 22, No. 4, pp. 313–323.

• Ivanov, S., Ivanova, M. and Iankova, K. (2014), Sustainable Tourism Practices of Accommodation Establishments in Bulgaria: An Exploratory Study, available from SSRN: https://ssrn.com/abstract=2161586

• König H., Schmidberger E., De Cristofaro L. (2007) Life cycle assessment of a tourism resort with renewable materials and traditional construction techniques. In: Bragança L, Pinheiro MD, Jalali S, Mateus R, Amoêda R, Guedes MC (eds) Portugal SB07, Sustainable construction, materials and practices. IOS Press, Amsterdam.

- Mazzoni E., Bruzzi L., Sára B., Scimìa E. (2004) Valutazione energetico ambientale del ciclo di vita del servizio turistico ricettivo. In: Morselli L. (Ed.) Ecomondo 2004. Atti dei seminari (in Italian), 3–6 November 2004, Rimini. Maggioli Editore, Santarcangelo di Romagna, Italy.
- OECD (2014), Tourism Trends and Policies, available at: http://dx.doi.org/10.1787/tour-2014-43-en
- Petti L., Tontodonati S. (2002) The use of LCA as a tool to implement EPDs: an application to hotel services. Proceedings of the fifth international conference on Ecobalance, issie 6–8 November, Tsukuba, Japan, pp 329–332.
- Segarra-Oña, M., Peiró-Signes, A., Verma, R., & Miret-Pastor, L. (2012), "Does environmental certification help the economic performance of hotels? Evidence from the Spanish hotel industry", Cornell Hospitality Quarterly, Vol. 53, No. 3, pp. 242–256.
- UNEP (2005), Making tourism more sustainable, available at: http://www.unep.fr/shared/publications/pdf/DTIx0592xPA-TourismPolicyEN.pdf
- WTO (2004), Indicators of Sustainable Development for Tourism Destinations: A Guidebook available at:http://www.adriaticgreenet.org/icareforeurope/wp-content/uploads/2013/11/Indicators-of-Sustainable-Development-for-Tourism-Destinations-A-Guide-Book-by-UNWTO.pdf
- WTTC (2017) Travel and tourism-economic impact 2017 Bulgaria, pp. 1-24
- WTTC (2018) Travel and Tourism-economic Impact 2018, Bulgaria, pp. 2-17

SEVENTH CHAPTER
CIRCULAR ECONOMY AND ITS IMPLEMENTATION IN BULGARIAN FOOD INDUSTRY

1. The Place of Food Industry in the Economy of Bulgaria

The study is directed at the research, analysis and construing of the legal framework concerning food industry in Bulgaria; the EU Directives relating to food industry, best practices in food industry related to circular economy; the results of the readiness of the users to apply edible coatings in food technology.

Food industry is a processing industry with strong traditions in Bulgaria, which, together with the textile industry, gives the impetus for development of the overall Bulgarian industrial sector and holds a prominent place in the structure of the national economy. Food industry produces food, beverages and other products that meet the everyday needs of the population and ensure the proper functioning and development of the human body. This determines the social significance of the sector. It is also important economically, as it maintains close relations with agriculture (receives raw materials and provides animal feed), mechanical engineering (receives equipment), chemical industry (receives packages, extracts, etc.), transport, tourism, commerce and other sectors (Pelovska, D., 2015). Historically food industry emerged and developed alongside the emergence and development of cities in the middle ages. These cities concentrated in one place a large number of people engaged in crafts, trade and other activities, which were not directly related to production and processing of agricultural products and foodstuffs. This necessitated the processing of agricultural products and the production of food in industrial quantities. It started with small bakeries, dairies and butcheries, which marked the beginning of food industry. The intensification of food industry and the increased production volumes are a direct reflection of the urbanization processes. The development of food production in various sectors of the food industry in Bulgaria can be divided into three main periods:

a) 1939 – 1944: a period characterized by freedom of economic initiative. At the same time, from a political perspective, these were years of war, which restricted the development of the economic system;

b) 1944 – 1989: a period of centrally planned economy in Bulgaria. The first years saw rapid industrialization in the country, reflected in the restructuring of production in the various sectors of food industry. At the same time, as part of the former Council of Mutual Economic Assistance (CMEA), Bulgaria was specialized in the production of certain foods and beverages for the countries of Central and Eastern Europe (CEE);

c) 1989 – 2009: a period of recovery of free market relations. This was accompanied by the collapse of the existing structures and the emergence of new economic and industrial structures in their place. The period was also characterized by an increasing openness of the economy. Towards the end of this period (2007), Bulgaria became a full member of the EU, and in 2008 – 2009 the economy was hit by the greatest economic crisis in the world for the last century (Shterev, N. 2012).

d) 2009-2018 – the period after the peak consumption of 2008, and the further drop in sales; the users limit their consumption and expenses only to what is most necessary. This situation forced a significant number of the companies in the sector to get their bearings in the crisis, make new investments and seek new markets (the companies in the sector reoriented themselves to exporting ready produce) outside the country so that they can continue to progress. Some of the companies were even forced to turn to agriculture (produce canned fruit and vegetables) so that they can guarantee themselves the availability of raw materials, but more often than not import of raw materials is observed because in most cases they are cheaper. Another very important feature is the shortage of qualified personnel, well-trained and skilled for the sector.[15] During that period, it has been established that food industry is one of the sectors which actively develop and carry out projects for renovation of the technological equipment and increasing of the

[15] Exports Save Food Industry, The *Kapital* Newspaper, March 2013, Access 2.4.2018 https://www.regal.bg/novini/bulgaria/2013/03/28/2031076_iznosut_spasiava_hraniteln o-vkusovata_promishlenost/

production capacity (Procedure BG161PO003-2.1.05 “Technological Modernization of Large Enterprises”).[16]

The development of the food industry and the territorial organization of its production are influenced by a variety of factors, which may be indicatively grouped into the following categories: natural, socioeconomic and environmental. *Natural factors* have an indirect impact on the development of food industry and are mainly expressed in the provision of agricultural raw materials for the industry. The importance of raw materials for the development of food industry is also evident from the high cost of raw materials (about 76% of the production costs) in the industry. It is precisely the demand for raw material that is the basis for agribusiness. Depending on the raw material used, the sectors of the food industry are divided into: a) Sectors processing raw materials of plant origin – canning, vegetable oil processing, milling, wine, tobacco and other sectors; b) Sectors processing raw materials of animal origin – meat, dairy and other sectors; c) Other sectors – water bottling, table salt and other sectors. *Socioeconomic factors* include consumption, workforce and demographic resources as a whole, the condition of the transportation infrastructure, the availability of energy sources, environmental protection requirements, the technical conditions of the processing facilities, the existence of investments, etc. These factors affect mostly brewing, bread-making, sugar and chocolate production, production of soft drinks, production of fresh meat for human consumption, etc. The quality, pricing and marketing of the production largely depend on the level of the machinery, equipment and technologies used in the production of food and beverages. The ubiquity of food industry entrepreneurs is due to its rich resource base and the fact that food products are consumed everywhere and every day. In recent years, Bulgarian food industry has been losing its vast markets in Eastern Europe and has reoriented itself towards EU markets, where Bulgarian

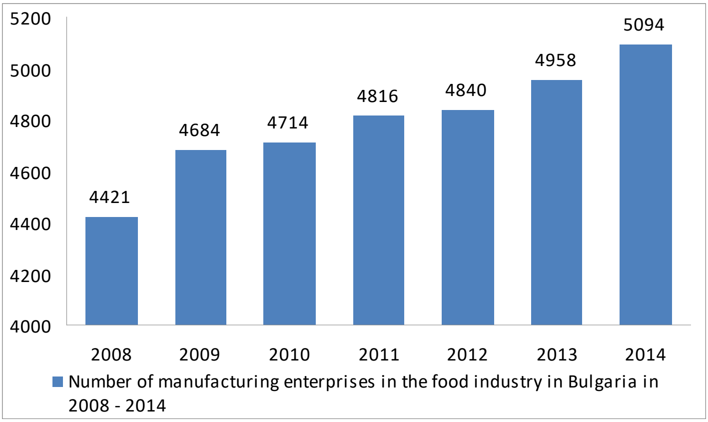
[16] Projects for Modernization of Enterprises in Food Industry funded by Operational Programmes, Engineering Review Magazine, issue 5, 2015, access 2.4.2018 http://www.engineering-review.bg/bg/proekti-za-modernizaciya-v-predpriyatiya-v-hvp-sas-sredstva-po-op-/2/2973/

producers have to compete with well-established manufacturers of food and beverage products in Western Europe. These changes in the external markets have led to reduced revenue and fewer investment opportunities in food industry. *The environmental factor* affects food industry in two aspects: a) production of ecologically clean production, and b) protection of the natural environment (soil, water, air) from contamination during the food industry's production processes. Generally, both the natural and most of the socioeconomic factors have a favourable impact on the development of Bulgarian food industry.

Food industry is a traditional industry with an important place in the economy and exports of Bulgaria. It is not the main economic activity, as it contributes to 2.6% of the gross value added, 3.5% of employment and 15% of the total industrial output. There are about 6500 micro and small enterprises active within the food industry, most of them producing bread and confectionery, beverages, meat and dairy products. Food industry creates jobs for about 14% of all people employed in the manufacturing sector and this percentage has remained stable over the last five years. The transition from a centrally planned to a market-based competitive economy has left its mark on the Bulgarian food industry. Twenty years ago the economy in Bulgaria was centrally planned, i.e. food producers were large state-owned companies managed by the government. During the transition period these companies were either privatized or went bankrupt. The new opportunities for own business gave rise to thousands of small enterprises. Meanwhile, many international companies such as Nestle, Heineken, Coca-Cola, Danone, etc., established branches here in Bulgaria, and at present the largest operators in the Bulgarian food industry are foreign companies. They are usually the market leaders in their respective sectors. Exceptions from this trend are the meat and fruit and vegetable sectors, where the largest producers are Bulgarian companies (FOOD-FIT Work Package 2 - National Report Bulgaria, 2010). *Between 2006 and 2014, the food industry developed at a higher rate than the other industries.* In 2014, the food industry output was worth (at current prices) BGN 9.6 billion. There has been a steady upward trend in the number of enterprises active in the food industry, and in 2014 they numbered 5094 (Figure 7.1).

Figure 7.1.

Number of Manufacturing Enterprises in the Food Industry in the Period 2008-2014

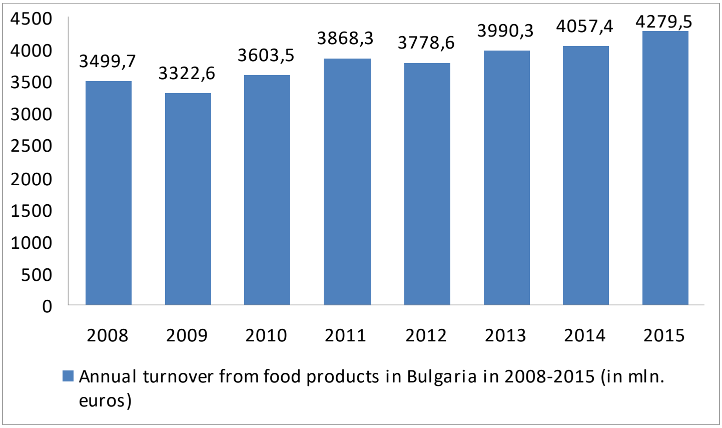


Source: https://www.statista.com, https://www.statista.com/statistics/354395/number-of-enterprises-in-the-food-products manufacturing-sector-in-bulgaria/ 30.08.2017 (date accessed).

In 2014, the three sectors with the largest and steadily growing contribution to the economy of food industry, estimated in terms of employment numbers, production volume, value added, fixed assets and investments were: production and processing of meat, excluding ready meals; bakery and pastry production and production of other food products. The food industry's contribution to the economy grows thanks to sectors *that are not directly involved in the processing of agricultural raw materials,* but use finished and semi-finished products (flour, sugar, cocoa, oil, powder milk, cream, flavourings, jams, nuts, etc.). The annual turnover of food production between 2008 and 2012 was unstable, with periodically occurring lower turnover compared to the previous year. After 2012 there was a steady upward trend of the annual turnover of production, due to the stabilization of the sectors and the influx of new funds for the development of the various sectors in the food industry (Figure 7.2).

Figure 7.2.

Annual Turnover from Food Products in Bulgaria between 2008 and 2015 (in mln. Euros)



Source: https://www.statista.com, https://www.statista.com/statistics/385941/turnover-manufacturing-food-products-bulgaria/, 30.08.2017 (date accessed)

Food production in Bulgaria increased in 2014. Compared to 2010, the increase in the physical volume of production (at constant prices) was 1.5%, with 4.6% on an annual basis. The production of beverages saw a decrease as compared to 2010 and the previous one – by 8.2% and 5.1%, respectively. Tobacco products production decreased by 0.2% as compared to 2010, but as compared to 2013 there was an increase in production by 11% at constant prices. The turnover in food production in Bulgaria increased in 2014. Compared to 2010, the growth at constant prices was 12.7%, with 1.7% on an annual basis. The turnover in beverage production increased by 12.4% compared to 2010, but shrank by 4.7% on an annual basis. Tobacco products production was marked by a 19.2% growth in turnover compared to 2010, but compared to 2013 it declined by 1.7%, at constant prices. The entire period studied is characterized by a steady trend of increase in food production. It increased by 20.7% and 9.1% as compared to 2010 and 2013, respectively. Beverage production has been relatively steady. In 2014 there was an increase by 0.2% compared to 2010, and a decrease of 4.8%

year-to-year. The tobacco sector showed a similar trend. The quantities produced remained relatively constant over the period studied.

In 2014, the trade in food, beverages and tobacco increased by 34.8% as compared to 2010. Compared to 2013, there was a 2.8% growth, entirely attributable to the increase in exports. The negative balance was reduced significantly in 2014, mainly due to the favourable effect of increased exports. Compared to 2010, the balance improved by 69%, compared to 2013 – by 70.9%. The imports of food, beverages and tobacco in Bulgaria remained at constant levels in terms of quantity during the study period. Physical imports increased by 3.8% as compared to 2010. Compared to 2013, the imports of food products, beverages and tobacco decreased by 3.9%. Between 2010 and 2014 the export of foods, beverages and tobacco products from Bulgaria has been n the increase, and the process has further increased over the past two years. The physical exports increased by 30.5% as compared to 2010 and by 13.3% as compared to 2013. (Food, beverages and Tobacco Products – Development of Production, Import, Export and Sales in Bulgaria, 2015).

Based on the above, here is an outline of the specific measures needed to unleash the potential and accelerate the development of food industry:

- Amendments in the Law on Protection of Competition to prevent unfair trade practices;
- Strengthening the control of raw materials and finished products in intra-community supplies and imports from third countries. Strengthening the control on retail fast-moving consumer goods (FMCG) and compliance with the legislation on traceability, quality, labelling and other requirements;
- Promoting exports to third countries and seeking new markets for traditional Bulgarian products within and outside the EU through a better use of EU funds for promotion of traditional products and export subsidies;
- Use of EU funds and funds from the national budget to support the transfer of knowledge from research organizations to businesses;

○ Use of funds from the National Innovation Fund for priority funding of innovative food production projects;

○ Accelerated adjustment of the amount of agricultural subsidies (EU and national) and implementation of flexible schemes to subsidize the production of raw materials of priority for Bulgaria (vegetables, fruits and animal products) in the new 2014-2020 programming period (Petrov S., N. Malamova, 2012).

The following conclusions on the development of food industry can be drawn:

- In an environment of European integration, economic and financial crisis and strong competition, the food industry has achieved a relatively dynamic development, which makes it one of the main industries in the national economy;
- The share of exports from the sector in the country's total export is increasing[17];
- Within the food industry, several sectors have emerged with high final score on competitiveness on the European market: vegetable fats and oils, grain mill products, canned fruits and vegetables, cereals, wine, lavender;
- Bulgarian food industry has a competitive advantage in terms of production efficiency. As regards gross operating surplus per unit of turnover (profit rate) and profitability of production in most sectors of the food industry, Bulgaria is among the countries with higher figures than the Community average. The shortage of raw materials hampers the development of key sectors (meat, dairy, cannery), which makes them highly dependent on imported raw materials and semi-finished products;
- The sectors experiencing the most effective development are those processing only Bulgarian raw materials: vegetable oils, ready meals and tobacco products. Moreover, Bulgaria's exports of wheat, sunflower seeds and lavender have increased greatly, enabling larger

[17] Even though the data concerning food industry is not complete, it must be noted that the Nationa Statistical Institute data for 2015 and 2016 gives a positive balance in the sector Food and Livestock. The same trend is observed in the balance of the Non-alcoholic and Alcoholic Beverages and Tobacco sector.

production volumes and more value added (Revival of the Food Industry, 2017).

The level of the food processors' and producers' awareness of problems related to the quality and safety of finished products has increased considerably in recent years. After joining the EU, Bulgaria is obliged to comply with European standards. An example in this respect is Regulation No.2073/2005 of the European Commission on microbiological criteria for foodstuffs. Almost all interested parties are aware of the EU legislation, but not all are able to conform to its requirements. It is the big producers that can be competitive in the domestic and foreign markets. The unique and traditional Bulgarian foodstuffs produced here are of high quality and fully competitive on the EU market (Vladimirov, G. 2013). At present, the interests of the suppliers in the industry are necessarily linked to compliance with the national and European legal framework for food quality and safety, including standards of the International Organization for Standardization (ISO), the requirements of good manufacturing practices (GMP) and good laboratory practice in research (GLP), as a basis for the production of safe and high quality products in line with the high requirements and needs.

Improvement of knowledge management and product control in accordance with European standards and legislation is possible through:

✓ Implementation of a regulatory strategy throughout the production chain, from the farm to the consumer, with corresponding relations among authorities responsible for food quality and safety, raw material producers, processors and distributors;

✓ Development of the food and drink industry through the integration of research activities to provide the "scientific evidence" for the declared beneficial health effects of foods;

✓ Investing the resources necessary to study the links between product quality and consumer health, as consumers tend not to rely solely on the information in the marking, and require reliable scientific evidence;

✓ Introduction of new technologies in agriculture and the food and beverage industries;

✓ Control by government bodies or authorized independent bodies on the quality and safety of foodstuffs (National Report on Bulgaria – Analysis of Key Technologies and Experts Survey of 2008, Project: Healthy and Safe Food for the Future Project for Technology Foresight for Bulgaria, Croatia, Czech Republic, Hungary, Romania and Slovakia. Abbreviation: FutureFood 6. Funded under the Sixth EU Framework program for R & D, Contract No. 43005 (FOOD).

After the accession of Bulgaria to the European Union, new rules have been introduced in the safety and quality control of foods. By the end of 2009, small producers had to reach a level of full compliance with the European food safety standards. As of 2007, all Bulgarian food producers were obliged to implement the Hazard Analysis and Critical Control Points (HACCP) system[18] and maintain this certification, which ensures food quality and traceability of agricultural products throughout the food chain. Other existing systems of quality control in the food industry and food trade in Bulgaria are ISO 22000, IFS (International Food Standard) and BRC (British Regal Consortium – mandatory for importers into the UK). However, in order to obtain IFS or BRC certification, Bulgarian producers (suppliers) must already have introduced HACCP and ISO 9001.

The institutions responsible for the implementation of all international and European food safety standards are the Food Quality and Safety Directorate under the Ministry of Agriculture, and the Food Control Directorate under the Bulgarian Food Safety Agency (BFSA). Given the tighter control and the intense competition in Europe and worldwide, employers should certify their production processes and personnel. This initiative is supported through broad European and national funding for the food industry (FOOD-FIT Work Package 2 - National Report Bulgaria, 2010).

The safety of foods is a measure of the fulfilment of requirements regarding specific properties that have the potential to be harmful to health or can cause illness within the durability periods and under the

[18] According to Art.18 (1) of the Food Act, food producers and retailers are obliged to implement, apply and maintain a food safety control system or a Hazard Analysis and Critical Control Points (HACCP) system.

prescribed storage conditions. Food products that do not meet the requirements for food safety, also fail to meet the requirements for food quality. Food safety is the assurance that the product will not cause harm to the consumer when it is prepared and consumed as intended. The assurance that a certain product will not cause harm or disease is based on the condition that: all harmful substances contained in the food are removed or reduced to an acceptable level; the food is prepared, processed and stored under controlled hygienic conditions as prescribed by laws or regulations.

There are three recognized categories of food safety hazards: biological, chemical and physical hazards, including allergens. Some authors place allergens into a separate fourth category, while ISO 22 000 treats them as part of the above three hazards. These hazards may come from substances or agents naturally occurring in food, from spoilt food or from dangerous food contamination at various stages of the production process, including during harvest, storage, processing, distribution or placement. Besides the hazards mentioned above, currently a risk assessment is made of food adulteration, including economically motivated falsification, which is growing at a rapid pace. The IFS Food and BRC Food standards now require the implementation of the so-called "food defence" (Petra, 2015). Food Defence provides protection against malicious adulteration of goods with the intent to cause harm to consumers (mainly health risks).

The Bulgarian legislation governing directly or indirectly the quality and safety of products produced in the various food industry sectors comprises laws, ordinances and rules. The *laws* relating to the food industry are acts of the national legislature (Table 7.1). They give the legal framework and requirements for the production of raw materials and finished products and for the control of the quality and safety of the finished products.

Table 7.1

Laws Governing the Food Industry

No.	NAME	PROMULGATION
1.	Bulgarian Food Safety Agency Law (BFSA).	(Prom. SG. 8 of 25.01.2011, last amended SG 58 of 18.07.2017, in force as of 18.07.2017)
2.	Food Law	(Prom. SG. 90 of 15.10.1999, last am. SG 58 of 18.07.2017, in force as of 18.07.2017)
3.	Wine and Spirits Law	Prom. SG. 45 of 15.06.2012, am. SG 15 of 15.02.2013, am. and suppl. SG 26 of 21.03.2014.
4.	Tobacco and Tobacco Products Law	Prom. SG 101 of 30.11.1993, am. SG 19 of 02.03.1994, in force from 01.04.1994, am. and suppl., SG 50 of 03.07.2012, am. SG 12 of 13.02.2015, SG 14 of 20.02.2015, am. and suppl. SG. 19 of 11.03.2016, in force as of 11.03.2016, SG 28 of 8.04.2016, in force as of 8.04.2016, corr. SG. 31 of 19.04.2016.
5.	Veterinary Activity Law	(Prom. SG 87 of 01.11.2005, last am. SG 58 of 18.07.2017, in force as of 18.07.2017)
6.	Crops Protection Law	(Prom. SG 61 of 25.07.2014, last am. SG 58 of 18.07.2017, in force as of 18.07.2017)
7.	Animal Protection Law	(Prom. SG 13 of 8.02.2008, last am. SG 58 of 18.07.2017, in force as of 18.07.2017)
8.	Livestock Law	(Prom. SG 65 of 8.08.2000, last am. SG 58 of 18.07.2017, in force as of 18.07.2017)
9.	Feed Law7Animal	(Prom. SG 55 of 7.07.2006, last am. SG 58 of 18.07.2017, in force as of 18.07.2017)
10.	Application of the Common Agricultural Market Organization in the European Union Law	(Prom. SG 96 of 28.11.2006, last am. SG 58 of 18.07.2017, in force as of 18.07.2017).

Source: Own research

The Bulgarian Food Safety Agency Law regulates the establishment and functioning of the Bulgarian Food Safety Agency (BFSA) under the Minister of Agriculture, Food and Forestry. The BFSA is the competent government authority to carry out official controls on the quality and safety of goods and foodstuffs in the Republic of Bulgaria in accordance with EU law.

The BFSA carries out official control under the provisions in special laws setting requirements for:

1. Phyto-sanitary activities, plant protection products and fertilizers;
2. veterinary medicine, animal health and welfare;
3. animal by-products not intended for human consumption;
4. animal feed;
5. raw materials and foodstuffs except for bottled mineral, spring and table water;
6. materials and objects intended to come into contact with food;
7. compliance of the quality of fresh fruits and vegetables with European Union standards for placement on the market;
8. grain quality.

The Food Law deals with specific requirements for food, production stages and conditions, rights and obligations of producers, the powers of official bodies carrying out controls, the functions and powers of the professional organizations of food producers and of the Bulgarian Association of Food and Drink Industry (BAFDI). Requirements regarding wine, vinegar and spirits are set forth in the Wine and Spirits Law, and those relating to tobacco and tobacco products are governed by the Tobacco and Tobacco Products Law. The Food Law does not apply to primary production for personal use and to home cooking, food processing and food storage for own consumption. The Law aims to: ensure compliance with regulatory requirements for the production and trade of food in order to protect consumer health and interests; ensure the application of the European Communities legislation in the field of foodstuffs and their safety at national level.

The Veterinary Activity Law regulates the carrying out, management and control of veterinary activities, and introduces the principles of the veterinary legislation of the European Union and the World Organization for Animal Health (OIE).

Veterinary activities include:

1. Implementation of veterinary requirements for: animal health and welfare; protection of human health from zoonotic diseases; extraction

and storage of germinal products; safety of raw foods of animal origin in their production and transport; safety of feed, feed additives and premixes during their production, placement, trade, import, export, transit, storage and use; protection of the environment from harmful effects of livestock breeding and related processes;

2. Monitoring of the compliance with the veterinary requirements;

3. Veterinary science, laboratory work, diagnostics and expert examination;

4. Terms and procedures for exercising the veterinary profession and veterinary practice.

The Plant Protection Law regulates issues relating to:

1. Phyto-sanitary measures under the International Plant Protection Convention, approved by the Food and Agriculture Organization (FAO) Conference held in November, 1997 (ratified through an act of legislature: State Gazette 32 of 2005) (SG 75 of 2005);

2. Protection of plants and plant products from economically important pests;

3. Integrated production of plants and plant products and integrated production controls;

4. Phyto-sanitary controls on plants and plant products and protective measures against the introduction into Bulgaria of quarantine pests on plants and plant products, and protective measures against their spread in Bulgaria as required by Council Directive 2000/29/EC of 8 May 2000 on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community;

5. Requirements for plant protection products aimed at protecting human and animal health and the environment, and for their biological testing and use as required by Directive No. 2009/128/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides (OJ, L 309/71 of 24 November 2009), and control over their production, placement, trade, repackaging and use;

6. Measures to implement Regulation (EC) 2003/2003 of the European Parliament and of the Council of 13 October 2003 relating to

fertilizers; requirements for fertilizers, soil conditioners, biologically active substances and nutrient substrates, and the control of their production, placement and use.

The Minister of Agriculture and Food implements the state policy in the field of plant protection, and the Bulgarian Food Safety Agency (BFSA) exercises control and is the competent coordinating national authority within the meaning of Art. 75, paragraphs 1 and 2 of Regulation (EC) No.1107/2009.

The Animal Protection Law governs the protection of animals and the mechanisms for its implementation. Animal protection comprises the protection of the animals' life, health and welfare, protection from inhumane, brutal and particularly cruel treatment, provision of appropriate care and living conditions tailored to their physiological and behavioural characteristics. The central and local executive authorities team up with nongovernmental organizations to develop and implement educational programs to raise awareness of animal protection and to teach about the cultivation, breeding, training and trade of animals in accordance with the provisions.

The Livestock Law regulates the organization and management of livestock; livestock breeding; production of livestock and livestock ova and embryos; placing on the market of live animals; the status, operation and support of livestock breeders' organizations. This law aims to create the conditions and prerequisites for: sustainable development in agriculture; management of genetic resources and their use for efficient production of animal products; production, preservation and improvement of livestock populations adapted to the various agro-ecological regions in Bulgaria; harmonious development of livestock breeding in order to protect the environment and the health of people and animals; efficient quality management and control in the production and placing on the market of live animals, ova and embryos.

The Animal Feed Law sets forth the requirements for feed, measures and conditions to ensure its hygienic safety, packaging, labelling, presentation, including advertising; conditions and requirements for all stages of the production, processing, storage, transportation, placing on the market and use of feed; rights and obligations of the feed business operators; rules for official controls, including control for compliance with regulatory requirements; powers of the official control bodies; functions and powers of the professional organizations of feed business operators; the competent authority to implement and enforce the European Community legislation on feed; the implementation of the European Community legislation on feed and of the directly applicable European Union acts adopted on its basis.

The Implementation of the Common Organization of Agricultural Markets in the European Union Law prescribes the procedures for implementation of market measures included in the Common Market Organization (CMO) of agricultural products of the European Union; state aid measures that are part of the Common Agricultural Policy (CAP) of the European Union; functions of the authorities and organizations competent to implement measures, to the extent that such functions are not defined in EU law.

Ordinances related to the food industry are documents containing instructions on how to perform specific activities related to the extraction of raw materials and the manufacturing of food products, on their control and on the operations of the various sectors of the food industry (Appendix 7.1).

The Rules contain mandatory guidelines which all producers of goods and foods are required to follow. The most important Rules relating to the food industry are the Rules on the Structure of the Bulgarian Food Safety Agency (BFSA)[19]. They govern the structure, functions, composition and man power of the BFSA. The BFSA is the competent government authority for official controls on food quality and safety throughout the food chain.

Official controls are carried out on:

- Phyto-sanitary activities;

[19] Prom. SG 15 of 18.02.2011, in force as of 18.02.2011, am. and suppl., SG 59 of 2.08.2011, in force as of 2.08.2011, amended SG 1 of 3.01.2012, SG 48 of 26.06.2012, in force as of 26.06.2012, am. and suppl., SG 91 of 18.10.2013, in force as of 18.10.2013, SG 29 of 04.21.2015, in force as of 21.04.2015, SG 68 of 4.09.2015, in force as of 4.09.2015, SG 26 of 1.04.2016, in force as of 1.04.2016, SG 71 of 09.13.2016, in force as of 10.01.2016.

- Plant protection products, fertilizers, soil conditioners, biologically active substances and food substrates;
- Veterinary activities, identification, animal health and welfare;
- Veterinary medicinal products (VMP);
- Disinfection, disinsectization, deratization and disinfestation;
- Raw materials and food, with the exception of bottled mineral, spring and table water;
- Animal by-products not intended for human consumption, and products derived from them;
- Feed;
- Genetically modified organisms (gmos), and products containing, consisting of, or produced from gmos;
- Materials and articles intended to come into contact with foodstuffs, food additives, enzymes and flavourings;
- Conformity of the quality of fresh fruits and vegetables with European Union standards;
- Grain quality.

The Bulgarian Food Safety Agency performs:

- Assessment of the conformity of the qualitative characteristics of foodstuffs with international, European and national standards, standards developed by professional organizations and approved by a competent government authority, and technical documentation;
- Laboratory diagnostic, reference and research activities;
- Risk management and communication;
- Training and qualification.

The Community legislation relating to food industry consists of EU Regulations and Directives. Bulgaria, as an EU member since 2007, has adopted and implemented national legislation relating to food industry, in line with the Community requirements. The EU Regulations and Directives related to food industry outline the requirements to hygiene conditions in production, raw materials, finished products and quality and safety control of products produced in different sectors of the Bulgarian food industry (Appendix 7.2).

2. The Circular Economy Concept in Food Industry

This part analyses edible coatings and films as an opportunity to apply the principles of circular economy in food industry. As we already pointed out in Chapter Two, circular economy is an economy which aims to decrease the amount of waste and pollution in the environment (Circular Economy Overview, 2017). The concept of circular economy focuses on maintaining the value of the products and materials as long as possible, generating as little as possible waste, optimal use of resources and their keeping within the economy when the product reaches the end of its life cycle, and there are reused multiple times for creating added value. This economic model stimulates the production of innovative products that provide monetary savings and an improved quality of life (European Commission – Information Document: Circular Economy Package: Questions & Answers, 2015).

According to European Commission data for 2017, 80 mln tonnes of foods for 143 bn Euro turn into food waste. Food waste is "food intended for human consumption, either in edible or inedible status, removed from the production or supply chain to be discarded - including at primary production, processing, manufacturing, transportation, storage, retail, and consumer levels, with the exception of primary production losses." (HCWH, 2017) Food waste causes the emission of large amounts of greenhouse gases because of the wide use of natural resources (land, water, fuels, energy), which are needed in food industry and the distribution of foods, and the global footprint is 4.4 Gt CO2eq (FAO, 2014). In 2015, the document: Food Waste Prevention: Integral Part of Circular Economy Package was created, and a revision of the Waste Framework Directive (COM (2015) 595) was offered. These strategic documents point out that food waste management is an important policy with which, if A FIRM INVESTS 1 Euro at the beginning of the year, at the end of the year it is going to have 14 Euros additional earnings. Additionally, a goal is set to the European Union countries to reduce by 50% their food waste until 2030. In order to implement circular economy principles in food industry, it is necessary to guarantee food safety, study best practices relating to different coatings and films, promote the understanding of the use of food waste as a primary resource for other activities, increase user informativeness about food waste management, the possible eco-innovations in the sector, etc. (Gassin, 2017)

The study of the technologies used in the various sectors of food industry covers 28 key technologies for the development of food quality and safety and includes, together with other key technologies such as active packaging, modern information systems, development and implementation of new packaging systems, new environmentally friendly, organically produced, biodegradable, recyclable and energy efficient packaging materials for food products, also edible films and coatings. (Miguel Ângelo Parente Ribeiro Cerqueira 2018). Subsection Food Packaging Technologies includes key technology 9, which deals with edible films and coatings made from natural ingredients, capable of protecting packaged food from spoilage and toxic bacteria, or of retaining the vitamins and other nutrients that enhance the nutritional value of the product. (Meritaine da Rocha, Michele M. de Souza, Carlos Prentice 2018) This once again highlights the topicality of the issue, and the need for development of food technologies and for the wider application of edible films and coatings in the various food industry sectors (National Report on Bulgaria – Key Technologies Analysis and Expert Survey, 2008). Edible films and coatings consist of a continuous thin layer of hydrocolloids (proteins, polysaccharides, lipids), antimicrobial components or a combination of them, which, once applied on the product, become an integral part of it (Embuscado, M., Huber, K., 2009). They are safe for consumption together with the food on which they are applied, and act as a good protective barrier to water, oxygen and carbon dioxide.

It is believed that edible coatings for food date back to ancient times. In 12th century China waxes were layered on oranges and lemons to slow down water loss. According to Yuba, the first edible film was developed in Japan from soy milk in the 15th century and used to preserve food (Biquet, Guilbert, 1986). There is evidence that in the 16th century foodstuffs were covered with fat to control water loss (Labuza, Breene, 1989). Hot molten paraffin has been used to cover citrus fruits in

America since 1930, and carnauba wax and emulsions of oil and water have been used as coatings for fresh fruits and vegetables since 1950 (Kaplan, 1980).

Since the late 20th century and in view of the global circular economy trends of countering environmental pollution, edible coatings have been increasingly used to preserve the quality of various foodstuffs. Edible coatings reduce the transfer of food ingredients from one layer to another or to the environment; protect against flavouring substances, water vapour, oxygen, physical and mechanical stresses; give gloss and attractive appearance of the products. Their use is a prerequisite for preserving the quality and properties of the products during the logistics operations and storage. Edible coatings can in many cases be used as a substitute for synthetic packaging and have a number of advantages over it, mainly in that they do not pollute the environment, as they are biodegradable and are consumed along with the product (Pashova, S., I. Panchev, R. Radev, G. Dimitrov, 2013). Finally, it may be concluded that the term edible films and coatings has been adopted to denote food additives and other substances used to improve the colour, aroma, texture; control the exchange of water, gas, carbon dioxide, and limit the growth of microorganisms on the surface of and inside products (Pashova, S., 2011).

The use of coatings in food technology requires that their components meet the legal requirements, that their use is permissible and that they are not toxic. According to EU regulations (Regulation (EC) 1331/2008, Regulation (EC) 1333/2008) and US regulators (FDA, 2006), edible films and coatings are classified as food ingredients, food additives, substances in direct contact with food or packaging material for food. They are an edible part of food and therefore should comply with all regulatory requirements for food ingredients. Film-forming components must have GRAS (generally recognized as safe) status after approval by the US Food and Drug Administration (FDA) (Martín-Belloso, Rojas-Graü, Soliva-Fortuny, 2009). All processes related to their preparation and application on foodstuffs should be in accordance with high hygiene requirements (Guilbert, Gontard, 1995, Nussinovitch, 2003).

The FDA in the USA has compiled a list of GRAS (Generally Recognised As Safe) approved additives whose use in the preparation of edible coatings is allowed. They must be safe and included in the GRAS list issued by the FDA, and all the components to be included in the composition of edible films and coatings must be in amounts corresponding to good manufacturing practices (GMP), and must not contain residues of heavy metals or other contaminants in excess of the limits (Cheng, Baldwin, 2012). Regulatory requirements relating to food additives are stipulated in EU standards and the Codex Alimentarius, which together constitute the main FAO/WHO regulatory body (Raju, Bawa, 2006).

In the laws and regulations governing foodstuffs, antimicrobial agents are treated as additives, and the main reason why they are used in the composition of foods is to extend the shelf life. According to regulations in the United States, organic acids (acetic, lactic, citric, malic, propionic and tartaric), their salts and some essential oils are GRAS-approved and may be used in the composition of edible films and coatings. In Europe, additives are used in food under the principle of "reasonable quantities". The names of the additives must be indicated in the marking according to the respective functional category (antioxidants, preservatives, colouring agents, emulsifiers, stabilizers, flavours, etc.) with their full name or E-number (Martín-Belloso, Rojas-Graü, Soliva-Fortuny, 2009). Regulation (EC) 1333/2008 defines food additives as substances that are not consumed separately as food and are not used as ingredients, regardless of whether they possess any nutritional value. The Regulation applies to all food additives, but not to substances added to foods to impart specific flavour or taste.

The use of food additives in the EU is carried out in accordance with Regulation (EC) 1331/2008[20]. The responsibility for food safety in the EU is entrusted to the European Food Safety Authority (EFSA).

[20] Regulation (EC) No. 1331/2008 of the European Parliament and of the Council of 16 December 2008 establishing a common authorization procedure for food additives, food enzymes and food flavourings (Text with EEA relevance) http: //eur-lex.europa.eu/legal-content/BG/TXT/?uri=CELEX%3A32008R1331, 04.09.2017 (date accessed).

EFSA assesses the safety of new food additives, reviews existing additives and performs a systematic re-evaluation of all permissible food additives in the EU. The substances allowed for use in the preparation of edible films and coatings comprise flavouring substances, colouring agents, preservatives, processing aids, food enzymes, waxes, etc. (Cheng, Baldwin, 2012).

Directive 95/2/EC[21] and Regulation (EC) No. 1333/2008[22] state that „glazing agents" are substances which, when applied to the external surface of a foodstuff, impart a shiny appearance or provide a protective coating. This indicates that the components used in the composition of edible coatings must meet the requirements specified in both these EU acts. According to Directive 95/2/EC of 1995 and Regulation (EC) No. 1333/2008 edible coatings contain nutrients, food additives, substances in direct contact with food or packaging materials for food. These are included in the edible parts of food and therefore should comply with all regulatory requirements for components contained in food. Film-forming components must not be toxic, and all processes related to their preparation and application on food should be in accordance with GMP.

Another very important issue in the legislation is the presence of allergens. Some of the edible films and coatings contain components such as milk protein (whey protein, casein), wheat protein (gluten), soy protein and peanut or walnut protein which could cause allergic reactions. Therefore, the presence of a specific allergen in the composition of an edible coating must clearly and accurately be indicated in the marking of the product (Franssen, Krochta, 2003).

The statutory framework in force in Bulgaria which governs foodstuffs (Food Law, Regulation (EC) No. 1935/2004, Regulation (EC) No. 450/2009, etc.) do not stipulate requirements for edible coatings and components used in their preparation.

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21 Directive 95/2/EC of the European Parliament and of the Council of 20 February 1995 on food additives other than colours and sweeteners, http: //eur-lex.europa.eu/legal-content/BG/ALL/?uri=CELEX: 31995L0002, 04.09.2017 (date accessed)

22 Regulation (EC) No. 1333/2008 of the European Parliament and of the Council of 16 December 2008 on food additives, http: //eur-lex.europa.eu/legal-content/BG/TXT/?uri=CELEX%3A32008R1333, 04.09.2017 (date accessed).

The worldwide best practices in food industry related to circular economy and the use of edible coatings are aimed at preserving the properties and quality of the finished product during storage:

➢ vegetables - *tomatoes* (Chauhan, O., Nanjappa C., Ashok N., Ravi N., Roopa N., Raju P., 2013, EL - Ghaouth, A., R. Ponnampalam, F. Castaigne, J. Arul, 1992), *carrots* (Avena-Bustillos, R., L. Cisneros-Zevallos, J. Krochta, M. Saltveit, 1994), *peppers* (Lerdthanangkul, S., Krochta, J., 1996), *celery* (Krochta, J., A. Pavlath, N. Goodman, 1990), *cucumbers* (Al - Juhaimi, F., Ghafoor K., Babiker E., 2012, Bahnasawy A., Khater G., 2014).;

➢ fruit - *bananas* (Malmiri, H., Osman, C. Tan, Rahman, R., 2011); *mango* (Plotto A., K. Goodner, E. Baldwin, J. Bai, Rattanapanone N., 2004); *avocado* (Maftoonazad N., Ramaswamy H., 2005); *citrus fruit* (Potjewijd, R., M. Nisperos, J. Burns, M. Parish, E. Baldwin, 1995); *apples* (Anghel, R., 2011, Alleyne, V., Hagenmaier R., 2000, Ochoa, E., Saucedo - Pompa S., Rojas - Molina R., Garza H., Charles - Rodríguez A., Noé Aguilar C., 2011); *tangerines* (Hassan, Z., Lesmayati, S., Qomariah, R., Hasbianto, A., 2014).;

➢ other food products - *dietary sponge cake without sugar* (Baeva, M., I. Panchev, 2007); *nuts* (Panchev, I., K. Nikolova, M. Zlatanov, S. Sainov, 2007); *eggs* (Suppakul P., K. Jutakorn, Y. Bangchokedee, 2010); *meat* (Khan M., Adrees M., Tariq M., Sohaib M., 2013); *sausages* (Trevisani, M., Cecchini, M., Siconolfi, D. Mancusi, R., Rosmini R., 2017); *fish* (Coma, V., 2010).

Increased consumer demands are the main reason why researchers develop alternatives to petroleum-based packaging materials. They use recyclable and edible materials, and even recovered agricultural products. Edible films, gels and coatings are biopolymers with a wide range of valuable properties. They consist of polysaccharides, lipids, proteins, exclusively or in combination with other materials. Furthermore, biopolymers are obtained from other sources, including exopolysaccharides (pulan) or by-products from fermentation processes in certain sectors of the food industry (polylactic acid). When applied together with other components, they not only improve the quality and safety of foodstuffs, but also slow the changes, increase the shelf life and, in some cases, give the desired properties (colour, aroma) (Pashova, S., 2011). Most of the edible films act as an active packaging material for food, changing the permeability to water vapour and oxygen. Table 7.2 presents the advantages of coatings used in food industry, the application of edible coatings based on proteins, polysaccharides and lipids, and their role in maintaining the quality and safety of various commodities on which they are applied (walnut fruits, fish, meat, fresh fruits and vegetables, fried foods, etc.).

Table 7.2

Application of EDIBLE FILMS

Edible films	Application	Advantages of the use of the film
Casein	peeled carrots	reduces the release of moisture and the occurrence of white patches on the surface (Avena-Bustillos, Cisneros-Zevallos, Krochta, Saltveit, 1993; Avena-Bustillos, Cisneros-Zevallos, Krochta, Saltveit, 1994)
Casein, acetylated glycerides	celery (stalks)	reduces the release of moisture (Krochta, Pavlath, Goodman, 1990)
Sodium caseinate	green pepper	decreases the penetration of oxygen and carbon dioxide (Lerdthanangkul, Krochta, 1996)
Zein (from cereals)	walnut fruits tomatoes	delays the oxidation processes (oxidation of fat) (Swanson, Miers, Schultz, Owens, 1953) slows changes in colour and texture, and diminishes natural losses (wastage) (Park, Chinnan, Shewfelt, 1994)
Wheat gluten	egg shell	improves the strength of the shell, reduces contamination of the eggs by microorganisms (Xie, Hettiarachchy, Ju, Meullenet, Wang, Slavik, Janes, 2002)
Whey Protein	frozen salmon egg shell	reduces water loss and oxidation processes (Stuchell, Krochta, 1995) improves the strength of the shell, reduces contamination by microorganisms (Xie, Hettiarachchy, Ju, Meullenet, Wang, Slavik, Janes, 2002)

Whey protein, acetylated monoglyceride	walnutfruits	retards rancidity of fats (Mate, Krochta, 1996)
Soy protein	apples egg shell	slows changes in texture, colour and acidity (Lerdthanangkul, Krochta, 1996) improves the strength of the shell, reduces contamination by microorganisms (Xie, Hettiarachchy, Ju, Meullenet, Wang, Slavik, Janes, 2002)
Alginate	fresh meat, poultry meat (pork meals)	reduces the change in appearance, oxidation and rancidity of fats, moisture loss, fat absorption (Kester, Fennema, 1986)
Cellulose	pepper fried chicken fried foods egg shell	decreases the penetration of oxygen and carbon dioxide (Lerdthanangkul, Krochta, 1996) reduces fat decomposition and moisture loss reduces fat absorption (Holownia, Chinnan, Erickson, Mallikarjunan, 2000; Holownia, Erickson, Chinnan, Eitenmiller, 2001) improves the strength of the shell, reduces contamination by microorganisms (Xie, Hettiarachchy, Ju, Meullenet, Wang, Slavik, Janes, 2002)
Chitosan	pepper and cucumber strawberries tomatoes	decreases air intake, changes in colour, wilting and infection by fungal diseases (El-Ghaouth, Arul, Ponnampalam, 1991) retains (delays) the natural loss (wastage) during storage (El-Ghaouth, Arul, Ponnampalam, Boulet, 1991) slows down ripening of the fruit during storage and extends the shelf life (El-Ghaouth, Arul, Ponnampalam, 1992)
Starch	stone fruits walnut fruits	extends the shelf life of fruits (Jokay, Nelson, Powell, 1967) slows oxidation and rancidity of fats (Ganz, 1969)
Starch, alginates, stearic acid	semi-finished veal pastries	controls moisture loss (Wu, Weller, Hamouz, Cuppett, Schnepf, 2001)
Starch, alginates,	semi-finished	controls oxidation of lipids

stearic acid, tocopherols	veal pastries	(Wu, Weller, Hamouz, Cuppett, Schnepf, 2001)
Dextrin	apples	reduces browning of the sliced fruit caused by oxidation of phenolic compounds (Murray, Luft, 1973)
Xanthan gum	carrots	improves the surface colour (Mei, Zhao, Furr, 2002)
Wax and fatty acids	fruits and vegetables cheese	slows the natural loss (wastage), reduces water loss (Hagenmaier, Shaw, 1991, Hagenmaier, Shaw, 1992) prevents the growth of moulds (Kester, Fennema, 1986)
Acetylated monoglycerides	frozen salmon	reduces moisture loss and oxidation of lipids (Gennadios, Hanna, Kurth, 1997, Stuchell, Krochta, 1995)

Source: Own research

The application of edible films in various food products continues to expand. Edible films have the following advantage – they contain antimicrobial components, colorants, antioxidants, flavouring agents, vitamins and probiotics. Edible films containing antimicrobial agents inhibit effectively the growth of both pathogens and putrefactive organisms in a wide variety of foods for direct consumption. These films have the ability to control the diffusion of antimicrobial agents, and also act as a barrier against oxygen and water vapour intake. Antimicrobial films restrict the spread of pathogens such as *L. monocytogenes* in ready-to-eat foods, even when packaged foods have been opened by the consumer. Although some of these films have received consumer approval, it is necessary to offer an effective method of applying antimicrobial films to packaging paper and other packaging materials (Pashova, S., 2011).

Good practices studied and described in the context of circular economy show that edible films and coatings are presently an important issue of science and practice. Their application is directly related to the development of various sectors of food industry, and their use is aimed at preserving foodstuff quality, nutritional value and properties during storage and other logistics operations. The need for use of edible films and coatings in various sectors of the food industry is directly related to the fact that they have some advantages over synthetic films. The main advantage of the edible films over traditional synthetic films is that they can be consumed along with the food products on which they are applied. Their use helps reduce environmental pollution. The films are prepared entirely from recovered, recycled edible components, so they degrade faster than polymeric materials. The films can: enhance the organoleptic properties of the underlying product, as they contain different components (flavourings, colourings, sweeteners); be used for individual packaging of small quantities of the product, especially in the case of goods that are not packaged individually, such as pears, nuts and strawberries. The films may also be applied on the inside of heterogeneous products, i.e. between layers. In this way they prevent the entry of moisture inside the product (pizza, pie, candy). The films may be viewed as a source of antimicrobial, antioxidant and anti-browning components (in the case of sliced or filleted fruit). They are most often applied on the surface of the product, thus preventing the penetration of undesired components from the surface to the inside of the product. It is also possible to include edible films in multilayer packaging materials together with non-edible films. In this case, the edible film is applied as an inner layer directly onto the product. It has been demonstrated that the preparation of edible films involves negligible waste and environmental pollution, and that their permeability and mechanical properties are superior to those of synthetic films.

Increased consumer demand for high quality foods with a long shelf life is the main reason for developing innovative technologies in food industry related to circular economy. These aim at preserving the appearance of food as long as possible, with the main requirement being that the products be safe. The packaging provides the necessary mechanical and functional protection of foods. It protects against oxidation and microbial spoilage, which has a positive impact on the shelf life. The use of synthetic packaging leads to serious environmental problems due to their inability to break down, and polymer packages thrown away after consumption of the product pollute the environment every day. This calls for the production and use of biodegradable packaging. Complete replacement of synthetic packaging is impossible, but its use may be limited through the development of edible coatings for certain commodity groups (Maftoonazad, Badii, 2009, Tharanathan, R. N., 2003). Synthetic films are used for packaging of fresh fruits and vegetables and the like, but they are not biodegradable and tend to accumulate in the environment, leading to ecological imbalance and pollution of our ecosystem. These circumstances necessitate the development of edible films and coatings, which are the best alternative to plastics (Mishra, Khatkar, Siddiqui, 2006).

At present, nanotechnology solutions used in circular economy, especially in food industry, contribute to improved health, well-being and quality of life, while simultaneously reducing the harmful effects on the environment. The application of nanotechnology in biodegradable polymers may create new opportunities to improve not only their properties, but also the cost and efficiency of their use. Studies conducted in this field (on different types of biodegradable polymer nanocomposites) have shown that these have properties suitable for a wider application (Sinha Ray, Bousmina, 2005). It has been found that the most widely tested biodegradable nanocomposites, suitable for use as packaging materials and coatings include starch and its derivatives, polylactic acid, polybutylene succinate, polyhydroxy butyrate, and aliphatic polyesters. A new generation of edible films is under development, with the main purpose to allow the combination and/or controlled release of the active ingredients using nanotechnology solutions – nanoencapsulations and a several layer system. In contemporary conditions, nanotechnology is used for improving the nutritional value of foods by means of nano-additives, nutrients and a delivery system for nanoscale bioactive components (Bouwmeester, Dekkers, Noordam, Hagens, Bulder, de Heer, ten Voorde, Wijnhoven, Sips, 2007). Micro- and nano-encapsulation of active ingredients within edible coatings aids the control of their release under specific conditions, and protects them against moisture, heat and other extreme conditions, increasing their stability and applicability. Alginates are the most widely applied, but other materials are also in use. For instance, enzymes, probiotics, prebiotics, oils from marine animals (omega-3-fatty acids) are among the most appropriate functional substances for edible coating encapsulation (Lopez-Rubio, Gavara, Lagaron, 2006).

The coating of foodstuffs with nano-laminates may be carried out by immersion in a series of solutions containing substances to be adsorbed on the surface of food, or by spraying the coating agents on the surface of the foodstuff. These nano-laminate coatings may be prepared entirely from the main components of food (proteins, polysaccharides, lipids), but may also include various substances such as antimicrobials, anti-browning agents, anti-oxidants, enzymes, flavouring and colouring agents (Weiss, Takhistov, McClements, 2006, McClements, Decker, Weiss, 2005). On the other hand, the use of the nano-laminate multilayer system, where the food surface is covered with films composed of nanolayers, looks quite promising for the future. A multilayer structure is prepared by successively immersing the substrate in two or more coating solutions containing oppositely charged particles. According to some researchers (Krzemiski, Marudova, Moffat, Noel, Parker, Welliner, et al., 2006, Marudova, Lang, Brownsey, Ring, 2005), poly-L-lysine, alginate, pectin and chitosan are the biopolymers that are most frequently found in multilayer structures. Furthermore, it is possible to use other charged particles to form a multilayer structure, such as oil droplets, solid particles, micelles and their derivatives (Vargas, Pastor, Chiralt, McClements, Gonzalez-Martinez, 2008).

In 2017, within the framework of the global project *Future's Project Distrupting Food Logistics* a number of important and promising innovations were put forward in support of circular economy. *Mazzican*, for instance, is a bottle allowing the transport and storage of milk which decreases manifold the risk of milk going bad or spilling. A hexagon called *intelligent delivery* made of nanoparticles composed of banana and coconut fiber is yet another innovation which can increase farmers' profits. American universities (e.g. Tufts University) experiment using silk fibroin and milk protein as edible films. Other innovative solutions include packaging with modified atmosphere; polymers from cereals, which can replace plastics, skin from meat instead of packaging. These innovations aim at decreasing the amount of packaging used globally by 30-50 % over the following years.

The keeping up of food technologies with modern trends requires the use of recovered and recycled natural materials to produce edible films and coatings. This helps retain and improve the properties of the product, and the efficiency of their use affects the cost and price of the product. A major advantage of the edible films and coatings over traditional synthetic films is that they are consumed together with the underlying food product. Their use reduces and limits the use of petroleum, contributes to the preservation of the ecological balance and prevents environmental pollution.

Based on the foregoing, the ***following conclusions*** can be drawn:

- The need for use of edible films and coatings in food technology is directly related to their advantage over synthetic films and to their contribution to the preservation of the properties and quality of the products on which they are applied for a longer time during storage;
- Edible films and coatings are widely used in various sectors of the food industry. When applied on the food product, they protect it from unwanted processes, ensure its quality and safety, and prolong its shelf life. Edible films and coatings are biodegradable and harmless to human health and the environment, and they can be eaten together with the food product.
- The keeping up of food technologies with modern trends requires the use of recovered and recycled natural materials to produce edible films and coatings, and the application of innovative approaches such as nanotechnology. Their use reduces and limits the depletion of natural petroleum deposits (petroleum products are the raw material for disposable packages, which pollute the environment and degrade slowly), thus contributing to the preservation of the ecological balance.

Finally, it should be noted that consumer requirements necessitate extensive research and orientation of science towards new alternatives to traditional packaging, which are not based on petroleum products, but are recyclable materials with nutritional value, derived from recovered agricultural products. Edible films, gels and coatings constitute a wide variety of biopolymers with desirable properties, composed of materials such as polysaccharides, lipids, proteins, uniformly or in combination with other components.

Modern research should be directed towards the marketing of food with edible coating, with the aim of providing broader advertising and accessible information for consumers to facilitate the commercialization of fresh-cut foodstuffs coated with edible films and coatings. Food industry needs edible films and coatings to be used more widely in its various sectors, in order to ensure greater product range, preserve the quality and extend the shelf life of the products.

3. Survey of Consumer Attitudes towards the Use of Edible Coatings in Various Sectors of Food Industry

The objective of the survey was to examine consumer attitudes towards the use of edible coatings in various sectors of the food industry (as one of the possible implementations of the principles of circular economy) and more specifically study user informativeness about related eco-innovations (Appendix 7.3).

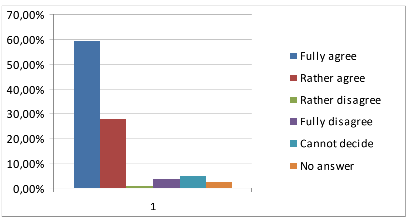
The respondents to the survey were chosen by the stochastic (random) selection method. With this method, all elements of general population have an equal chance to be included in the study sample. Thus the sample reflects with maximum accuracy the structure of the entire population. This ensures representativeness of the information obtained from the sample, within the margins of the stochastic error, which can be attributed to the entire population. The larger the absolute sample size, the greater the degree of representativeness of the data.

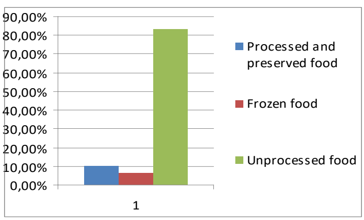
The necessary information for the study was gathered through the survey method using a questionnaire with open-ended and closed-ended questions. The questionnaire also contained additional information for the portion of the consumers who have no knowledge of and come for the first across terminology related to circular economy and edible films and coatings.

A study was conducted among consumers, where the online questionnaire was made available to 168 respondents, men and women aged between 18 and 65. Of the 168 respondents surveyed, 82 completed the questionnaire in full and 86 either did not complete the questionnaire, or completed it partially. The majority of respondents, about 66%, were women. The participants include young people aged between 26 and 35 – about 40%, and 85% of the respondents were between 18 and 45. Approximately 87% of the respondents are university graduates holding bachelor, master or doctoral degrees. The financial status of the participants was diverse, with the largest percentage (35%) of the respondents living in households whose monthly income is between BGN 1000 and 1999. Over 70% of the respondents worked full-time, and over 57% were married. The survey aims to explore the attitudes of consumers towards choosing, buying and consuming food covered with edible coatings.

The results show that foodstuffs are commercially available to consumers in unprocessed (natural) and processed state. Processed products are produced in the various sectors of the food industry using special recipes and technology and various additives. The survey showed that according to more than 87% (Figure 7.3) of the respondents unprocessed foods were extremely useful for their health, and more than 83% (Figure 7.4) claimed they consumed predominantly unprocessed foods, compared with frozen, processed and preserved foods. The respondents cited as the main reason for their choice of food the fact that unprocessed foods have unchanged composition and nutritional value, and contain no additives. Over 76% of the respondents purchase unprocessed foods once a week or more frequently (Figure 7.5).

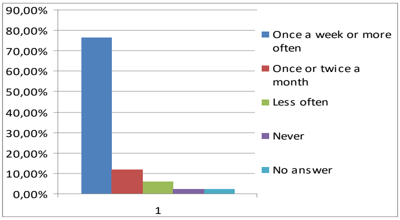
Figure 7.3 and Figure 7.4

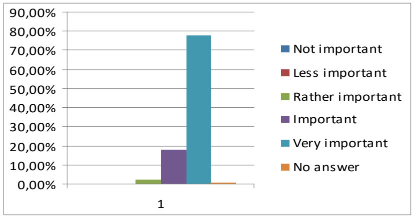




Source: Own analysis of the survey.

Figure 7.5 and Figure 7.6

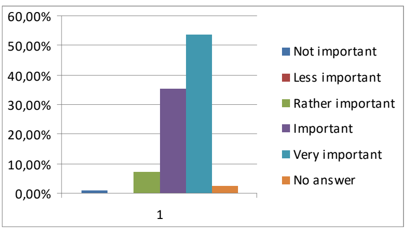


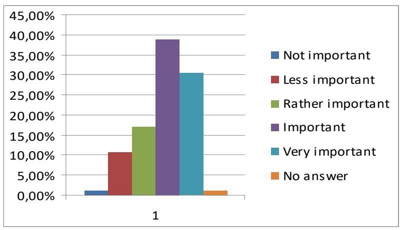


Source: Own analysis of the survey.

According to the respondents the factors with the greatest impact on their decision to *purchase processed foods* are product quality, product type (fruit, vegetables, meat, milk, etc.), manufacturer and appearance. Over 96% (Figure 7.6) defined as important or very important the quality factor, more than 89% (Figure 7.7) think that the type of the product is an important or very important factor for their choice, approximately 70% (Figure 7.8) considered the manufacturer of the product as an important or very important factor for the purchase, and 67% (Figure 7.9) said the appearance of the product was an important or very important factor for the purchase.

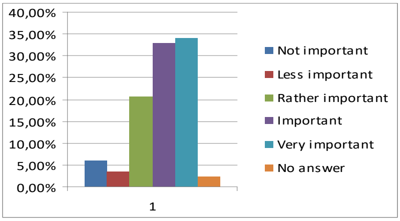
Figure 7.7 and Figure 7.8

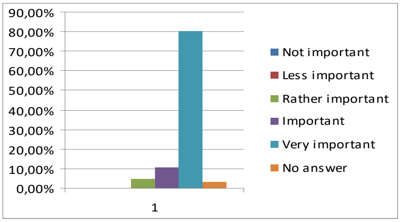




Source: Own analysis of the survey.

Figure 7.9 and Figure 7.10

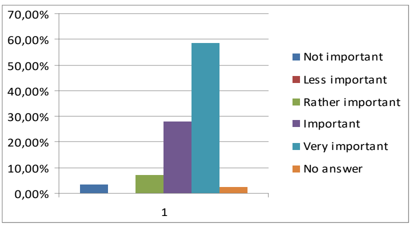


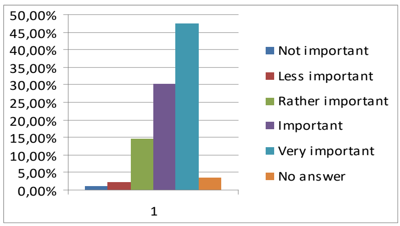


Source: Own analysis of the survey.

According to the respondents, the factors that have the greatest impact when deciding to *purchase unprocessed foods* are product quality, product type (fruit, vegetables, meat, milk, etc.) and appearance. Over 91% (Figure 7.10) identified as important or very important the quality of the product, over 86% (Figure 7.11) expressed the opinion that the type of the product is important or very important in their choice, and nearly 78% (Figure 7.12) considered the appearance of the product as an important or very important factor for the purchase.

Figure 7.11 and Figure 7.12

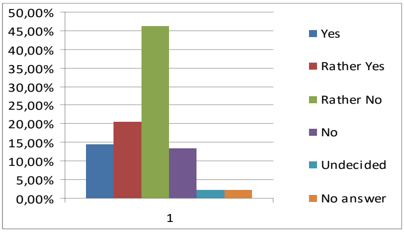


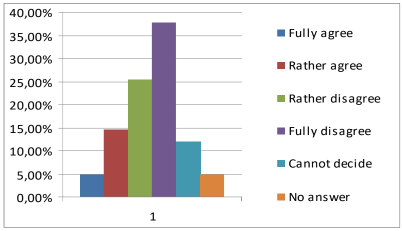


Source: Own analysis of the survey.

The quality and appearance are two of the factors that consumers identify as critical in their choice of processed and unprocessed foods. These factors may be improved in today's dynamically developing technological environment in various sectors of the food industry through the use and application of appropriate edible coatings that are safe for consumer health. This survey demonstrated that the majority of the respondents, about 60% (Figure 7.13) were not familiar with the nature of the edible coatings. After further clarifications from the authors of the survey, the respondents stated that edible coatings should influence the following most important food properties: quality and shelf life – 64%; better appearance of the foodstuff– nearly 57%.

Figure 7.13 and Figure 7.14

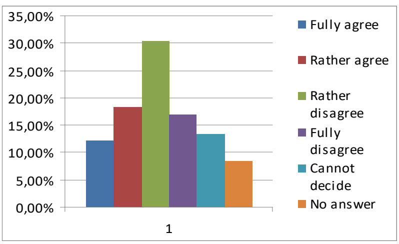


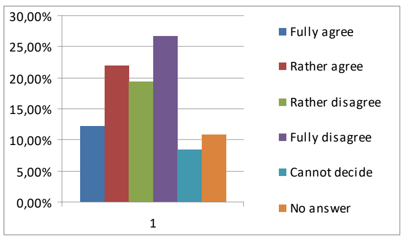


Source: Own analysis of the survey.

Despite the clarifications made and the proven positive effects from the use of edible coatings in food industry, more than 63% (Figure 7.14) of the respondents answered negatively to the question whether they would rather consume foods with edible coatings and less than 20% - that they would consume such food. A similar question: whether they would replace processed food with food with edible coatings showed the same trend in the answers, over 47% (Figure 7.15) responded negatively and about 30% responded positively. About 34% (Figure 7.16) of the respondents would buy foodstuffs with edible coatings if their prices do not differ substantially from the food they usually buy, and only 13% (Figure 7.17) would buy foodstuffs with edible coatings, regardless of price.

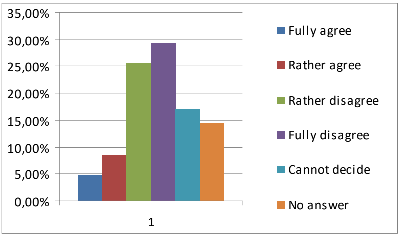
Figure 7.15 and Figure 7.16

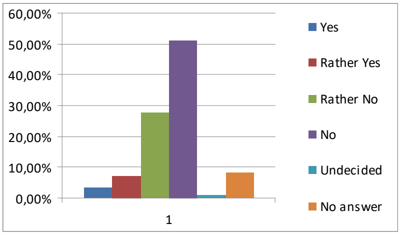




Source: Own analysis of the survey.

Figure 7.17 and Figure 7.18





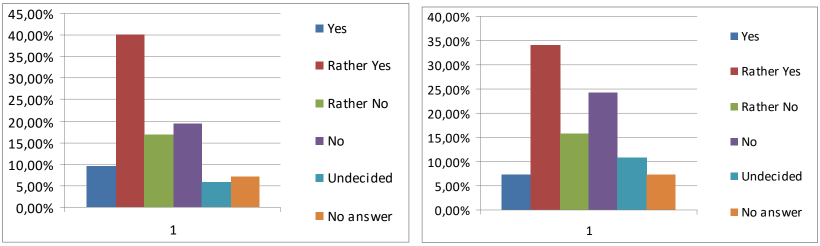
Source: Own analysis of the survey.

The high percentage of respondents who would not consume foods with edible coatings or would not replace the processed foods they now consume with foods with edible coatings can be explained by the fact that the majority of the respondents (over 60%) had no knowledge of edible coatings prior to the study and had never tried such products. The positive effects of the use of edible coatings in the food industry are described here above as best practices, but a substantial number of consumers have had no opportunity to choose and consume foods with edible coatings, and it is therefore necessary to gradually implement this new technology in the production of various foodstuffs, in order to meet the high consumer expectations and to introduce such foods gradually in the diet of the various consumer groups.

This study demonstrates that approximately 80% (Figure 7.18) of the respondents were not aware, and only 10% believed they had some knowledge of eco-innovation. After a brief introduction to eco-innovation, the respondents identified three main aspects that would affect their choice in purchasing food products: 50% (Figure 7.19) of them stated that if the producer of foodstuffs with edible coatings generated an insignificant amount of waste or collected separately its manufacturing waste, this would affect their consumer choice; about 41% (Figure 7.20) said that if a producer of foodstuffs with edible coatings has implemented eco-innovations and an Eco Management and

Audit Scheme (EMAS)[23] or environmental certification ISO 14001: 2015[24], etc., this would sway their purchasing choice; less than 30% thought that the understandable information in the marking of foodstuffs with edible coatings was an incentive for the purchase of the relevant product.

Figure 7.19 and Figure 7.20



Source: Own analysis of the survey.

Based on the survey of consumer attitudes towards the use of edible coatings in food technology, we have made the following conclusions:

➢ Over 87% of the respondents believe that unprocessed foods are extremely beneficial to their health and over 83% say they prefer these foods to frozen, processed and preserved foods;

➢ The factors that have the greatest influence in the decision to purchase unprocessed and processed foods are product quality, product type (fresh fruits and vegetables, meat, milk, etc.), name of producer and appearance of the product;

➢ About 60% of consumers are not familiar with the nature of edible coatings, and this is the main reason why they would rather not

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[23] The EMAS is an EU voluntary instrument for environmental management, established by Regulation (EC) No. 1221/2009 of the European Parliament and of the Council of November 25, 2009 voluntary participation by organizations in a Community eco-management and audit scheme (EMAS).
- http: //ec.europa.eu/environment/emas/index_en.htm.;
- https: //www.consejo.bg/emas_11_148. Accessed on 11.09.2017

[24] BDS EN ISO 14001: 2015. Environmental Management Systems - Requirements with guidance for use -https: //www.iso.org/iso-14001-environmental-management.html. Accessed on 11.09.2017.

consume foods with edible coatings. Some 30% of the consumers state categorically they would replace processed foods with foods with edible coatings. Around 34% of the respondents would buy foods with edible coatings if their prices do not differ substantially from those of the foods they now buy without coatings, and only 13% would buy foods with edible coatings, regardless of their price;

- About 80% of the respondents are not aware of any eco-innovations that producers of foods with edible coatings should implement to reduce waste generation. According to this part of the respondents, there are three main factors that would affect their choice in purchasing food:1) the producer of foods with edible coatings generates a negligible amount of waste or collects the waste separately;2) the producer of foods with edible coatings has introduced eco-innovations, has implemented an EMAS or holds a certain environmental certification, etc; 3) the presence of clear and understandable for consumers information in the marking of foods with edible coatings.

It should be noted that consumer requirements necessitate an expansion of the legal framework at the national and Community level in parallel with topical issues related to the introduction of new technologies in the food industry and the production of innovative goods that meet consumer requirements. All this requires more intensive research and the orientation of science towards new alternatives to petroleum-based packaging materials, namely the developing of new technologies and in particular new packaging materials, which are degradable and have nutritional properties, and which are made from recycled agricultural products. Edible films, gels and coatings are made of a wide variety of biopolymers with desirable properties, and consist of a variety of materials including polysaccharides, lipids and proteins – uniformly or in combination with other components.

Modern research should also be oriented towards the presentation of foodstuffs with edible coatings commercially, with the aim of providing more advertising and visual information to aid the commercialization of various foodstuffs and fresh-cut fruit and vegetables covered with edible films and coatings. The food industry needs edible films and coatings which will expand the range of food products without increasing the price of the relevant product; which will preserve the quality and ensure the safety of the product, and will extend the shelf life of the product.

BIBLIOGRAPHIC REFERENCE

- БАБХ, Документи, Европейско законодателство, Директиви, Достъпни на http://www.babh.government.bg/bg/Page/102/index/102/Директиви, [Достъпна на: 27.08.2017].
- БАБХ, Документи, Европейско законодателство, Регламенти, http://www.babh.government.bg/bg/Page/118/index/118/Регламенти. [Достъпна на 27.08.2017].
- Баева, М., И. Панчев (2007) Изследване влиянието на хранителните покрития от полизахариди върху физичните и механичните показатели на диетичен пандишпанов блат без захар в процеса на съхранение, Машиностроене и машинознание, 2, Издателство на Технически университет, Варна, с. 84- 87.
- Владимиров, Ж. (2013) Внедряване на европейските стандарти за качество и безопасност на храните в България (икономически и социални ефекти), сп. ХВП, бр. 9/10, стр. 41-45; стр.54-56.
- Възраждане на ХВП, http://fpim-bg.org/?p=4150, [Достъпна на: 30.08.2017].
- Европейска комисия - Информационен документ. Пакет от мерки за кръговата икономика: Въпроси и отговори, Брюксел, 2 декември 2015 - http://europa.eu/rapid/press-release_MEMO-15-6204_bg.htm. [Accessed: 11/09/2017].
- Национален доклад за България - Анализ на ключови технологии и анкетиране на експерти (2008) Проект: Здравословни и безопасни храни за бъдещето Проект за технологичен форсайт за България, Хърватия, Чешката Република, Унгария, Румъния и Словакия. Абревиатура: FutureFood6. Финансиран по линия на Шестата рамкова програма на ЕС за НИРД, Договор № 43005 (FOOD).

• Панчев, И., К. Николова, М. Златанов, С. Съйнов. (2007) Пектинови емулсионни филми със слънчогледов и пчелен восък, Научни трудове, УХТ, Пловдив, с. 387- 392.

• Пашова, С., И. Панчев, Р. Радев, Димитров. (2013) Приложение на ядивни филми и покрития в хранителните технологии, Сборник доклади от XII юбилейна научна конференция с международно участие по Стокознание, Варна, с. 292 – 301.

• Пашова, С. (2011) Приложение на растителните восъци в хранителните технологии, ИК "САФО", Ловеч, с. 193.

• Пеловска, Д. (2015) Място и роля на хранително-вкусовата промишленост в икономиката на България, Научни трудове на Русенстия университет, том 54, серия 5.1, с. 128-133.

• Петров, С., Н. Маламова. (2012) Възраждане на хранително-вкусовата промишленост в България. https://www.google.bg/search?client=opera&q=място+на+хвп+на+България+в+рамките+на+ес&sourceid=opera&ie=UTF-8&oe=UTF-8&gfe_rd=cr&ei=yLSmWbWqF4jd8AeqgZ2YBg, [Достъпна на: 30.08.2017].

• Хранителни продукти, напитки и тютюневи изделия - развитие на производството, вноса, износа и продажбите в България (2015) Годишен анализ 2014, http://sfb.bia-bg.com/index.php?srchbranchid=103, [Достъпна на: 31.08.2017].

• Щерев, Н. (2012) Развитие на хранително-вкусовата промишленост в България, Управление и устойчиво развитие, 5/36.

• Al - Juhaimi, F., Ghafoor K., Babiker E. (2012) Effect of gum arabic edible coating on weight loss, firmness and sensory characteristics of cucumber (Cucumis sativus L.) fruit during storage. Pakistan journal of botany, 44, (4), pp. 1439 – 1444.

• Alleyne, V., Hagenmaier R. (2000) Candelilla - shellac: an alternative formulation for coating apples. Horticultural science, 35, (4), pp. 691 – 693.

• Anghel, R. (2011) The influence of wax protection film on apple fruits, in order to maintain their quality during cold storage. Lucrări ştiinţifice - vol. 54, Nr. 1, seria Agronomie, 87 – 90.

• Avena-Bustillos, R., L. Cisneros-Zevallos, J. Krochta, M. Saltveit. (1994) Application of Casein-Lipid Edible Film Emulsions To Reduce White Blush On Minimally Processed Carrots. Postharvest Biol. Technology, 4, pp. 319-329.

• Avena-Bustillos, R., L. Cisneros-Zevallos, J. Krochta, M. Saltveit. (1993) Optimization of Edible Coatings On Minimally Processed Carrots Using Response Surface Methodology, Trans. Am. Soc. Agric. Eng., 36, pp. 801-805.

• Bahnasawy A., Khater G. (2014) Effect of wax coating on the quality of cucumber fruits during storage. Food processing & technology, 5 (6): pp. 339-346.

• Bouwmeester, H., S. Dekkers, M. Noordam, W. Hagens, A. de Bulder, C. Heer, S. ten Voorde, S. Wijnhoven, A. Sips. (2007) Health Impact Of Nanotechnologies In Food Production. Report 2007.014. RIKILT – Institute of Food Safety,Wageningen UR and National Institute of Public Health & the Environment; Center for Substances and Nanotechnologies in Food Integrated Risk Assessment. Available at www.rikilt.wur.nl/NR/rdonlyres/BDEEDD31- F58C-47EB-A0AA 23CB9956CE18/54352/R2007014.pdf, pp. 95.

• Biquet, B. S. Guilbert. (1986) Relative diffusivities of water in model intermediate moisture foods. Lebensm. Wiss. Technol. Food Sci. Technol., 19, pp. 208-214.

• Chauhan, O., Nanjappa C., Ashok N., Ravi N., Roopa N., Raju P. (2013) Shellac and Aloe vera gel based surface coating for shelf life extension of tomatoes. Journal of food science and technology, 52(2), pp. 1200–1205.

• Cheng G., Elizabeth A. Baldwin. (2012). Regulatory aspects of coatings, Edible Coatings and Films to Improve Food Quality, Second edition, pp. 383-417.

• Coma, V. (2010) Polysaccharide-based Biomaterials with Antimicrobial and Antioxidant Properties Polímeros, Overview, pp. 1-12.

• Costa, M. J., et. al. (2018) Use of edible films and coatings in cheese preservation: Opportunities and challenges. Review article. Food Research International, Volume 107, pp. 84-92.

- Review article. Food Research International, Volume 107, pp. 84-92.
- Circular Economy Overview - https://www.ellenmacarthurfoundation.org/circular-economy/overview/concept. [Accessed: 11/09/2017]
- El – Ghaouth, A., R. Ponnampalam, F. Castaigne, J. Arul. (1992) Chitosan Coating to Extend the Storage Life of Tomatoes., HortScience 27(9), pp. 1016-1018.
- El-Ghaouth, A., J. Arul, R. Ponnampalam. (1991) Use of Chitosan Coating to Reduce Water Loss and Maintain Quality of Cucumber and Bell Pepper Fruits, J. Food Process. Preserv., 15, pp. 359-368.
- El-Ghaouth, A., J. Arul, R. Ponnampalam, M. Boulet. (1991) Chitosan Coating Effect on Stability and Quality of fresh Strawberries, J. Food Sci., 56, pp. 1618-1620, 1631.
- Embuscado, M., Huber, K. (2009) Edible Films and Coatings for Food Applications, New York, Springer, pp.1-3.
- FAO (2014) Food wastage footprint full-cost accounting, available at: www.fao.org/3/a-i3991e.pdf
- FDA. (2006) Food additives permitted for direct addition to food for human consumption 21CFR172, subpart C. Coatings, films and related substances.
- FOOD-FIT Работен пакет 2 - Национален доклад България (2010) http://formacion2020.net/webfoodfit/files/National_report_Bulgaria_BG.pdf, [Достъпен на: 31.08.2017].
- Franssen, L., J. Krochta. (2003) Edible Coatings Containing Natural Antimicrobials For Processed Foods. In S. Roller (Ed.), Natural Antimicrobials For Minimal Processing Of Foods, pp. 250-262, Boca Raton: CRC Press.
- Ganz, A. (1969) CMC and Hydroxypropyl cellulose – Versatile Gums For Use. Food Prod. Dev., 3, pp. 65-69.
- Gassin, A.L. (2017) Working together to fight food waste: EU Circular Economy Action Plan, EC: DG Health and Food Safety, Unit 1, pp. 1-20

• Gennadios, A., M. Hanna, L. Kurth. (1997) Application of Edible Coatings on Meats, Poultry and Seafoods: A review, Lebensmittel Wissenschaft und Technology, 30, pp. 337-350.

• Guilbert, S., N. Gontard. (1995) Edible and biodegradable food packaging., In P. Ackermann, M. Jagerstad, T. Ohlsson (Eds.), Foods and packaging materials – Chemical interactions (pp. 159-168). England: The Royal Society of Chemistry.

• Hagenmaier, R., P. Shaw. (1992) Gas Permeability of Fruit Coating Waxes., J. Am. Soc. Hortic. Sci., 117, pp. 105-109.

• Hagenmaier, R., P. Shaw. (1991) Permeability of Shellac Coatings to Gases and Water Vapor., J. Agric. Food Chem., 39, pp. 825-830.

• Hassan, B., et. al. (2018) Recent advances on polysaccharides, lipids and protein based edible films and coatings: A review, Review article, International Journal of Biological Macromolecules, Volume 109, pp. 1095-1107.

• Hassan, Z., Lesmayati, S., Qomariah, R., Hasbianto, A. (2014) Effects of wax coating applications and storage temperatures on the quality of tangerine citrus (Citrus reticulata) var. Siam Banjar. International food research journal, 21(2), pp. 641-648.

• HCWH (2017) Europe position papare: Food waste in Circular Economy Package, pp. 1-6

• Holownia, K., M. Chinnan, M. Erickson, P. Mallikarjunan. (2000) Quality Evaluation of Edible - coated Chicken strips and frying oils. J. Food Sci., 65, pp. 1087-1090.

• Holownia, K., M. Erickson, M. Chinnan, R. Eitenmiller. (2001) Tocopherol Losses in Peanut Oil During Pressure Frying of Marinated Chicken Strips Coated with Edible Films, Food Res. Int., 34, pp. 77-80.

• Jokay, L., G. Nelson, E. Powell. (1967) Development of Edible Amylaceous Coatings for Foods. Food Technol., 21, pp. 12-14.

• Kaplan, H. (1980) Washing and Colour Adding, pp. 379. In W. Wardowdki, S. Nagy, W. Grierson (ed.), Fresh Citrus Fruits. AVI, Westport, Conn.

• Kester, J., O. Fennema. (1986) Edible Films and Coatings: A review, Food Technology, 40, 12, pp. 47-59.

• Khan M., Adrees M., Tariq M., Sohaib M. (2013) Application of edible coating for improving meat quality: A review. Pakistan journal of food sciences, Volume 23, Issue 2, pp. 71-79.

• Krzemiski, A., M. Marudova, J. Moffat, T. Noel, R. Parker, N. Welliner, et al. (2006) Deposition of Pectin/poly-L-lysine Multilayers With Pectins of Varying Degrees of Esterification, Biomacromolecules, 7, pp. 498-506.

• Krochta, J., A. Pavlath, N. Goodman. (1990) Edible Films From Casein-Lipid Emulsions for Lightly Processed Fruits and Vegetables, p. 329. In W. Spiess and H. Schubert (ed.) Engineering and Food. Elsevier, New York.).

• Labuza, T., W. Breene. (1989) Application of Active Packaging for Improvement of Shelf Life and Nutritional Quality of Fresh and Extended Shelf-life Foods. J. Food Process Preservation, 13, pp. 1-69.

• Lerdthanangkul, S., Krochta, J. (1996) Edible Coatings Effects on Postharvest Quality of Green Bell Peppers, Journal of Food Science, 61, pp. 176-179.

• Lopez-Rubio, A., R. Gavara, J. Lagaron. (2006) Bioactive Packaging: Turning Foods Into Healthier Foods Through Biomaterials, Trends in Food Science and Technology, 17, pp. 567-575.

• Miguel Ângelo Parente Ribeiro Cerqueira (2018) Edible Packaging, Encyclopedia, Reference Module in Food Science.

• Maftoonazad, N., F. Badii. (2009) Use of edible films and coatings to extend the shelf life of food products, Recent, patents on food, nutrition & agriculture, Volume 1, Number 2, pp. 162 – 170.

• Maftoonazad N., Ramaswamy H. (2005) Postharvest shelf-life extension of avocados using methyl cellulose-based coating LWT 38 pp. 617 – 624.

• Malmiri, H., Osman, C. Tan, Rahman, R. (2011) Evaluation of effectiveness of three cellulose derivative-based edible coatings on changes of physico-chemical characteristics of ‘Berangan’ banana (Musa sapientum cv. Berangan) during storage at ambient conditions, International Food Research Journal 18(4): pp. 1381-1386.

- Martín-Belloso O., M. Alejandra Rojas-Graü, R. Soliva-Fortuny. (2009) Delivery of Flavor and Active Ingredients Using Edible Films and Coatings, Publisher: Springer, Edible films and coatings for food applications, pp. 295 – 314.
- Marudova, M., S. Lang, G. Brownsey, S. Ring. (2005) Pectin-chitosan Multilayer Formation. Carbohydrate Research, 340, pp. 2144-2149.
- Mate, J., J. Krochta. (1996) Whey Protein Coating Effect on the Oxygen Uptake of Dry Roasted Peanuts, J. Food Sci., 61, pp. 1202-1206, 1210.
- McClements, D., E. Decker, J. Weiss. (2005) University of Massachusetts 05-27: Novel Procedure For Creating Nanolaminated Edible Films And Coatings. U. S. patent application.
- Mei, Y., Y. Zhao, H. Furr. (2002) Using Edible Coating to Enhance Nutritional and Sensory Qualities of Baby Carrots. J. Food Sci., 67, pp. 1964-1968.
- Meritaine da Rocha, Michele M. de Souza, Carlos Prentice (2018) Chapter 9: Biodegradable Films: An Alternative Food Packaging, Book chapter Food Packaging and Preservation, pp. 307-342.
- Mishra, B., B. S. Khatkar, S. Siddiqui. (2006) Edible coatings for postharvest preservation of fresh fruits and vegetables, Advances in postharvest technologies for horticultural crops, pp. 131 – 172.
- Murray, D., L. Luft. (1973) Low D. E. Corn Starch Hydrolysates: Multi-functional Carbohydrates Aid in Food Formulation. Food Technol, 2, pp. 32-34, 36, 38, 40.
- Nussinovitch, A. (2003) Water Soluble Polymer Applications in Foods., Oxford: Blackwell Science.
- Ochoa, E., Saucedo - Pompa S., Rojas - Molina R., Garza H., Charles - Rodríguez A., Noé Aguilar C. (2011) Evaluation of a candelilla wax -based edible coating to prolong the shelf - life quality and safety of apples. American journal of agricultural and biological sciences, 6, (1), pp. 92 – 98.

- Park, H., M. Chinnan, R. Shewfelt. (1994) Edible Corn-zein Coatings Storage Life Tomatoes, Journal of Food Processing and Preservation, 18, pp. 317-333.
- Petra, W. (2015) Food Fraud in the Context of ASIA Event. Tokyo.11 November 2015, GFSI.
- Plotto A., K. Goodner, E. Baldwin, J. Bai, Rattanapanone N. (2004) Effect of polysaccharide coatings on quality of fresh cut mangoes (Mangifera Indica) Proc. Fla. State Hort. Soc. 117: pp. 382-388.
- Potjewijd, R., M. Nisperos, J. Burns, M. Parish, E. Baldwin. (1995) Cellulose-based Coatings as Carriers for Candida guillermondii and Debaryomyces sp. in Reducing Decay of Oranges Hort Science 30(7): pp. 1417–1421.
- Raju, P., A. Bawa. (2006) Food Additives in Fruit Processing. In Y. H. Hui (Ed.), Handbook of Fruits and Fruit Processing (pp. 145-170). Iowa: Blackwell Publishing.
- Santagata, G., et. al. (2018) Pectin-honey coating as novel dehydrating bioactive agent for cut fruit: Enhancement of the functional properties of coated dried fruits. Research article. Food Chemistry, Volume 258, pp. 104-110.
- Shahbaz, Y. (2018) Application of carboxymethyl cellulose and chitosan coatings containing Mentha spicata essential oil in fresh strawberries, International Journal of Biological Macromolecules, Volume 112, pp. 264-272.
- Sinha Ray, S., M. Bousmina. (2005) Biodegradable Polymers and Their Layered Silicate Nanocomposites: In Greening the 21st Century Materials World. Progress in Material Science, 50, pp. 962-1079.
- Stuchell, Y., J. Krochta. (1995) Edible Coatings on Frozen King Salmon: Effect of Whey Protein Isolate and Acetylate Monoglycerides on Moisture Loss and Lipid Oxidation, J. Food Sci., 60, pp. 28-32.
- Swanson, H., J. Miers, T. Schultz, H. Owens. (1953) Pectinate and Pectate Coatings. II. Application to Nut and Fruit Products, Food Technology, 7, pp. 232-236.

• Suppakul P., K. Jutakorn, Y. Bangchokedee. (2010) Efficacy of cellulose-based coating on enhancing the shelf life of fresh eggs Journal of Food Engineering 98 pp. 207–213.

• Tharanathan, R. (2003) Biodegradable films and composite coatings: past, present and future, Trends in food science & technology, Volume 14, Issue 3, pp.71 – 78.

• Trevisani, M., Cecchini, M., Siconolfi, D. mancusi, R., Rosmini R. (2017) Effects of Beeswax Coating on the Oxidative Stability of Long-Ripened Italian Salami. Journal of food quality, pp. 5.

• Vargas, M., C. Pastor, A. Chiralt, D. McClements, C. Gonzalez-Martinez. (2008) Recent Advances in Edible Coatings for Fresh and Minimally Processed Fruits. Critical Reviews in Food Science and Nutrition, 48, pp. 496-511.

• Weiss, J., P. Takhistov, D. McClements. (2006) Functional Materials in Food Nanotechnology. Journal of Food Science, 71, pp. 107-116.

• Wu, Y., C. Weller, F. Hamouz, S. Cuppett, M. Schnepf. (2001) Moisture Loss and Lipid Oxidation for Precooked Ground-beef Patties Packaged in Edible Starch-alginate-based Composite Films. J. Food Sci., 66, pp. 486-493.

• Xie, L., N. Hettiarachchy, Z. Ju, J. Meullenet, H. Wang, M. Slavik, M. Janes. (2002) Edible Films Coating to Minimize Eggshell Breakage Post-wash Bacterial Contamination Measured By Penetration in Eggs. J. Food Sci., 67, pp. 280-284.

ADDITIONAL REFERENCE

• в-к Капитал (2013) Износът спасява хранително вкусовата промишленост, март, достъп 2.4.2018: https://www.regal.bg/novini/bulgaria/2013/03/28/2031076_iznosut_spasiava_hranitelno-vkusovata_promishlenost/

• сп. Инженеринг ревю (2015) Проекти за модернизация в предприятия в ХВП със средства по ОП, бр.5,достъп 2.4.2018: http://www.engineering-review.bg/bg/proekti-za-modernizaciya-v-predpriyatiya-v-hvp-sas-sredstva-po-op-/2/2973/

EIGHT CHAPTER
SUSTAINABILITY OPPORTUNITIES IN BULGARIAN WINE INDUSTRY IN THE LIGHT OF CIRCULAR ECONOMY

1. Winemaking within circular Economy

The climate change, environmental pollution and rising prices of raw materials make manufacturers of agricultural and farming produce pay more and more attention to quality, safety and environmental sustainability. Winemaking is a strategic export-orientated industry, which also possesses sustainable products. Sustainable winemaking can be defined as a global strategy for production of grapes and all related systems for winemaking, which lead to economic sustainability by offering quality produce and setting efficient requirements for reducing the risk to the environment, biodiversity and health of the users in the different regions. One of the successful examples for sustainable winemaking in the world has been developed as concrete policies or strategic partnerships, incl. California Sustainable Winegrowing Alliance (USA), Wine Sustainable Policy (New Zealand), Integrated Production Wine Scheme (South Africa).

For the bigger part of the firms, the introduction of sustainable practices includes the maintaining of environmental standards and programmes: EMS, incl. ISO 14 001 or performance of an Environmental management plan in place. Winemaking is no exception. Some research shows that the environmental culture of the wineries and their financial engagements towards the environment are the key factors for the successful introduction of the EMS (Alonso, 2010). Other surveys include in the evaluation of the wine supply chain environmental indicators, such as carbon emissions. They become key factors for the decision making of the stakeholder to locate their winemaking business in a specific territory/region. In this sense, the level of carbon emissions brings economic consequences for vintners: what are the suitable ways for transport and loading; how to pack the produce; where to export the produce? (Varsei et al., 2017)

Wine sustainability can be estimated via indicators for measuring the harmful emissions of carbon dioxide (CO_2). New Zealand is to become the first in the world to display the carbon footprint of each individual glass serving on its label, reflecting its commitment to preserving a clean, green place. The methodology for assessing the life cycle of a product (LCA) is largely used in the research on sustainable wine-producing (Dodds and al., 2013).

According to a European project (Eco prowine 2018), the overall contribution of the wine industry is equal to 153 kg CO_2/ton for wine-growing activities and 235 kg CO2/ton for winery operations. Taking into account the production of bottles and the transport of the product to the markets, a carbon footprint of about 2 kg of carbon per standard bottle has been estimated, equivalent to 76.3 million tons of CO_2 released into the atmosphere each year. The vinification process produces high quantities of waste water (from 0.5 to 14 liters of water per liter of wine produced) which in some cases has extremely high organic loads (COD 2.500-67.000 mg / L).

Both the voluntary certificates and the carbon footprint assessment are part of the tools used to assess circular economy. The main goal of the circular economy concept is the systematic elimination of waste in accordance with the life cycle of the product (Florez et al., 2018). Circular economy is called upon to render additional value to the business, the communities and society as a whole through successful recovery of water resources, raw materials and energy and through creating local closed loops (VEOLIA, 2019). In this respect, each industrial sector and business example, including winemaking, can enhance the successful implementation of the circular economy principles. In this regard, the European Commission claims that circular economy may be able to provide economic benefits for firms, in addition to environmental benefits, and widely recommends their adoption. (European Commission, 2015).

The subject matter of this survey is Bulgarian winemaking and more specifically the production of wines by small and middle-size regional wineries. The goal is to analyse the current state, opportunities and challenges in the sphere of environmental sustainability for winemakers. The collected data are harmonized with the circular economy concept of the European commission.

2. Bulgarian wine industry – a general outlook review

The sector of viniculture and winemaking is a sustainable sector in Bulgaria and has been developing dynamically over the past decade. A smaller yield of grapes, better quality and price, and hence: forecasts for a more expensive and better wine. These are the trends for restructuring of the sector which started even before Bulgaria became an EU member state in 2007. The sector has not been developing vigorously lately, but rather in slight leaps on the background of the almost ceased export to Russia. The production is not huge: for the past 2017 the profits of the 100 larger wineries amount to 150 mln BGN[25], with about a quarter of the produce being sold abroad. The change in the volume and value of the wine market in Bulgaria for 2015-2017 is given in Table 8.1.

Table 8.1

WINE MARKET IN BULGARIA

Year	Volume (mln.L)	Change	Value (mln.lv)	Change
2017	32	5.40%	150	3.50%
2016	30.5	-10.80%	145	-3.00%
2015	34	16.30%	153	7.30%

Source: National Statistics Institute 2017 and Author' calculation

With this, Bulgaria ranks on eighth place as a producer of grapes and on tenth place as a producer of wines in the EU-28. (Figure 8.1) In short, over the past years the wine market in the country has been seeing a slight rise and the optimistic view is that the exports will turn to some more exotic destinations.

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[25] According to Bulgarian National Bank 1 BGN=0.512 EUR

Figure 8. 1

Total production of wines in EU-28 in 2017-2018

Organisation Commune des Marchés Règl. (CE) 1308/2013

EU-28 Production totale et vinification - CAMPAGNE 2017 – 2018
Situation au 29 Septembre 2017 _en 1.000 HL

PAYS	Campagne 2012-13	Campagne 2013-14	Campagne 2014-15	Campagne 2015-16	Campagne 2016-17	Moyenne 5 ans (AVG5)	Production totale [1)] 2017-2018 1000 HL		Versus 2016/17	Versus AVG5
Bulgaria	1 337	1 755	833	1 367	1 245	1 307	1 355		+9%	+4%
Czech Republic	487	501	536	819	631	595	645		+2%	+8%
Germany	9 012	8 409	9 202	8 819	9 014	8 891	7 950		-12%	-11%
Greece	3 115	3 343	2 800	2 501	2 581	2 868	2 460		-5%	-14%
Spain	34 241	53 233	44 080	42 001	43 360	43 383	**36 800**		-15%	-15%
France	41 365	41 491	47 094	47 857	45 563	44 674	**37 200**		-18%	-17%
Croatia	1 293	1 248	842	992	773	1 030	608		-21%	-41%
Italy	45 616	54 029	44 739	51 496	50 920	49 360	**40 023**		-21%	-19%
Cyprus	112	108	94	79	81	95	99		+22%	+4%
Luxembourg	85	101	125	111	83	101	90		+8%	-11%
Hungary	1 818	2 666	2 773	2 779	2 819	2 571	2 500		-11%	-3%
Austria	2 155	2 392	1 999	2 268	1 952	2 153	2 401		+23%	+12%
Portugal	6 305	6 238	6 202	7 045	6 022	6 362	6 621		+10%	+4%
Romania	3 606	5 242	3 842	3 787	3 323	3 960	5 346		+61%	+35%
Slovenia	684	770		877,132	739	767	586		-21%	-24%
Slovakia	324	371	286	375	315	334	301		-4%	-10%
U.K.	25	33	47	40	38	37	*30*		-21%	-18%
other MS	27	29	31	41	36	33	*36*	4)	=	+9%
Total EUR28	151 608	181 960	165 524	173 255	169 495	168 522	**145 100**		-14,4%	-14%

Source: Member state communication following Art. 6 of Regulation (EU) 2017/1185, elaborated by DG AGRI G2

Russia was the main market for the export of Bulgarian wines up to three years ago but there has been a drastic fall in this export destination. Only about 16 mln litres were exported for Russia last year. The more important partners today are the countries in Western Europe as well as Poland, the USA and China. The Asian markets are facing their dynamic development, too – China, Vietnam, Korea and Japan. The Bulgarian producers are gradually regaining their positions on the wine map of the world. Production is being restructured – rather than large wine producing plants the sector has re-orientated itself towards smaller series of quality wines produced by small and middle-sized companies.

After a number of difficult years which followed the economic crisis of 2008-2009, the wine production branch managed to turn around the negative trend in 2015 when a rise of 6% was achieved and in 2016 the rise reached 7.4%. For the first time in years, exports saw a small but significant rise which put an end to the shrinking of the foreign markets. The competition among the leading companies in the sector, which develop much faster than the average market players, is becoming stronger. Yet, in the sector, the strong dominance of the cheap table wines is preserved. Quality wines with protected designation of origin (PDO) have about a 9% share which generates a revenue of a total of 20.4 mln BGN, with the sales of red wines and rosé wines being almost three times larger than these of white wines, but while the sales of red wines and rosé wines have fallen with almost 21%, the sales of white wines have grown with 25%. About 13% of the revenue from quality wines comes from sales on foreign markets.

The total profit of the companies in the sector in 2017 is 250 mln BGN. In 2016, it reached 225.2 mln BGN with that amount being 209 mln in 2015. The rise is more clear on the home market (+4.5% up to 159.1 mln BGN), but finally the export was marked by a small rise of 2.5% to 66 mln BGN. Despite the positive trend, though, the share of the foreign sales from the total sales has dropped with a little over 3.7 % and in 2016 the export formed 29.3% of the total sales, with that being 33% just a year earlier.

Table 8.2

BULGARIAN EXPORT OF WINE

Year	Value (mln.lv)	Volume (mln.L)	Average Price (lv/L)
2007	210	140	1.48
2008	170	100	1.67
2009	130	70	1.83
2010	110	60	1.85
2011	120	70	1.73
2012	120	70	1.70
2013	110	60	1.79
2014	100	50	1.87
2015	90	50	1.83
2016	80	40	2.06

Source: National Statistic Institute, 2017

The data in Tables 8.2 and 8.3 show that the volume and value of the export, as well as the import of wine in Bulgaria have also decreased over a 10-year period, but, accordingly, there is a permanent tendency towards a rise in the price per litre of the average price for both Bulgarian and foreign wines.

Table 8.3

BULGARIAN IMPORT OF WINE

Year	Value (mln.BGN)	Volume (mln.L)	Average Price (BGN/L)
2007	43	16	2.67
2008	25	8	3.16
2009	15	5	3.00
2010	17	8	2.18
2011	22	7	3.05
2012	24	7	3.49
2013	28	7	4.00
2014	26	5	5.09
2015	33	8	4.08
2016	31	7	4.23

Source: National Statistical Institute, 2017

The picture with the top 25 companies is much more dynamic – they form 78% of all the revenue and almost 90% of the export. (Table 8.4) About 23% is the total increase in the turnover of these companies in 2016. This to a large extent is due to the improved results of the wineries in the top 10, which hold more than 55% of the market share.

Table 8.4

TOP 25 OF BULGARIAN WINE PRODUCER COMPANIES (in thousands BGN)

COMPANY	2016			2015			Change 16/15. %	
	Total Sales	Home	Export	Total Sales	Home	Export	of Sales	of Export
Sys Industries OOD	34271	33660	611	11082	9874	1208	209.25	49.42
Vinex Slavyantsi AD	16333	1097	15536	16334	2085	14249	1.83	9.03
Domaine Boyar International EAD	16285	9420	6865	17456	8069	9387	-6.71	-26.87
Villa Yambol EAD	13749	13434	315	7183	6908	275	91.41	14.55
Katarzyna Estate EOOD	9243	9028	215	8368	7285	1083	10.46	-80.15
LVK Vinprom AD	8207	7617	590	10257	9589	688	-19.99	-14.24
Domain Menada EOOD	7831	6551	1280	7429	6470	959	5.41	33.47
Logodaj Winery OOD	7101	2699	4402	7923	3229	4694	-10.37	-6.22
VP Brands International AD	6322	6125	197	2144	1927	217	194.87	-9.22
Black Sea Gold AD	6107	5653	454	7283	6691	592	-16.15	-23.31
Balkantabako EOOD	5650	0	5650	2266	2266	0	149.34	0
ST Ivena Commerce – V. Shotev	5451	818	4633	9116	4320	4796	-40.20	-3.40
Vinal AD	4905	721	4184	5431	676	4755	-9.69	-12.01
Lovico Winery EAD	4458	1294	3164	4512	1558	2954	-1.20	7.11
Vinprom Ruse AD	3511	738	2773	2766	447	2319	26.93	19.58
Edoardo Miroglio EOOD	3498	2021	1477	3874	2747	1127	-9.71	31.06
Bessa Valley Winery EOOD	3414	1276	2138	3128	1207	1921	9.14	11.30
ST Krasimira Kostova	3161	2112	1049	2763	1554	1209	14.40	-13.23
Stambolovo Winery EOOD	2927	2659	268	2276	2276	0	28.60	-

Angel's Estate SA	2696	2594	102	2044	1919	125	31.90	-18.40
Vinzavod AD	2590	2202	388	2895	2601	294	-10.54	31.97
VI Khan Krum AD	2477	2396	81	2839	2743	96	-12.75	-15.63
Terra Tangra OOD	2451	1963	488	2458	1965	493	-0.28	-1.01
Concerto Winery EOOD	2402	2258	144	1712	1363	349	40.30	-58.74
Vinprom Svishtov AD	2296	1864	432	2479	2246	233	-7.38	85.41
TOTAL 25	**177 636**	**120 200**	**57 436**	**146 018**	**91 995**	**54 023**	**21.65**	**6.32**

Source: CAPITAL Magazine , 2017

According to figures from the Executive Agency on Vine and Wine, each year vine plantations in Bulgaria increase with about 10 thousand decares, thanks to European programmes. According to data of the Ministry of Agriculture, there are about 62 thousand hectares of vine plantations in Bulgaria and despite the slight rise in the amount of the planted areas as compared to the preceding two years the retrospect has revealed that this sector faces a stable trend of decrease. For instance, in the period 2008-2009, vineyards were about 100 thousand hectares, or with almost 40% more than today.

According to data of the National Vine and Wine Chamber, if in 2013 the registered vintners were 124, their number rose to 257 by August 2018 with 19 new ones being in the process of creation. Only 80 wineries actively produce wine, of which 60 produce over 1 mln bottles of wine and make between 10% and 20% of the profit in the sector. The investments in the sector come mainly from Bulgarian businessmen, including funds from European programmes and from foreign investors. Of the top 25 producers, only 4 are not Bulgarian property. According to figures from the Executive Agency on Vine and Wine, the viniculture plantations in the country are 59 988.6 hectares. On the global vineyard map, Bulgaria takes the 15th place for hectares/vines in the world.

Bulgaria is divided into five main winemaking regions: The Danube Plane (North-Bulgarian), the Black Sea Region (East-Bulgarian), the

Rose Valley (Sub-Balkan), the Thracian Valley (South-Bulgarian) and the Valley of the Struma River region (South-West Bulgarian).

Burgas Region, part of the Southern Black Sea region, has the largest number of plantations – 8000 hectares, with 14 wineries. The second place is occupied by Plovdiv Region, as far as plantation area is concerned, but the region is leader in the number of wine producers – 40 strong. Haskovo Region ranks third in the number of planted areas and wine producers – with 6888 hectares and 18 wineries. Nine regions have between 2000 and 5000 hectares, among them Pleven Veliko Tarnovo, Varna, Sliven, Stara Zagora and Pazardzhik.

In Varna Region, part of the Northern Black Sea Region, there are 19 registered wine producers, of which only one is in the top 25. This region is characterized mainly by its specialisation in high quality white and rosé wines, produced by middle-sized wineries and meant for the home and foreign markets. 30% of the vine plantations in the country are located in this region and 53% of the white wines are produced there. Some of the main winemakers in the region are Khan Krum, Vinex Preslav, and LVK Targovishte, Domain Boyar – Shumen, Osmar Winery, Dimyat Varna, Vinprom Alvina.

3. Bulgarian winemaking and its environmental initiatives

According to Global Wine Industry, the global wine production in 2017 dropped with 8%. Bulgaria follows the same trends and was in decline for the period 2010-2016 with 2% and occupies the 21st place in winemaking in the world (WWTG, 2017). The country is in 29th place as a wine consumer and has a rise of 0.4% for 2017 as compared to the preceding year. The conclusion of Global Wine Industry is that the development and management of the winemaking sector over the past years is not determined only by the preferences of the users for buying specific wine brands, but also by factors such as the quality of the vines, safety and security of wine production, and the overall impact of the environment on the industry. Apparently, environmental initiatives are becoming part of the policy for sustainable development of wine producers in a global aspect. It is pertinent to say here that according to

Smith &Kemp (1998), Marshall (1998), 70% of the total global pollution and 60% of the carbon emissions in the winemaking industry are produced by the small and middle-size enterprises. In 2003, Silverman & Lanphar arrived at the conclusion that the most significant environmental impact in winemaking is the result of the following factors, in that order of importance: electricity consumption, water consumption, water pollution, use of chemicals, packaging and wrapping. Over the past years, the global vintners have been studying the environmental aspects of winemaking through their participation in different programmes and initiatives for certification, environmental and social responsibility, including ISO 14 001, Bio-Gro organic certification[26], carbon footprint assessment, glass labelling, etc. In Bulgaria, such practice is not very common amongst winemakers, especially the small and middle-size wineries in the country.

In the National Programme for Assistance for the Wine and Vine Sector for the period 2014-2018 of the Ministry of Agriculture, Food and Forestry, an assessment of the environmental impact is provided for, but it only extends to including appeals for environmental sustainability of winemaking in Bulgaria, for increasing the level of user awareness and the adoption of more benign practices by the producers, including the reduction of pesticide use, better soil protection, protection from polluting the landscape and protecting the biodiversity[27]. In addition, the National Strategy for Development of Vine Growing and Winemaking in the Republic of Bulgaria for the period 2005-2025 points out that the vision for the development in the sector includes the production of eco friendly products, which is subject to state funding through the mechanisms for organic farming[28]. The Report on the activity of the Executive Agency on Vine and Wine for 2017 highlights a single project with a profile reflecting environmental issues. The project Vine SoS: *SoS*

[26] The Bio-Gro system is an organic certification of New Zealand for vineyards and wineries due to its strict organic practice requirements.
[27] MAFF (2014) National Programme for Assistance for the Wine and Vine Sector in Bulgaria for 2014-2018, pp. 1-25.
[28] MAF (2004) National Strategy for Development of Vine Growing and Wine Making in the Republic of Bulgaria (2005-2025)

for the Endangered Traditional Vine Sorts is developed as per the Cooperation Programme Interreg Greece-Bulgaria for the period 2014-2020 and has as a priority the protection and recovery of biodiversity, the protection and recovery of soils and encouragement of eco-system services, including participation in the Natura 2000 Programme, and the creation of green infrastructures favouring winemakers.

The overview of the winemaking situation in Bulgaria in respect of its environmental initiatives shows a lagging behind global trends. This can lead to creating hurdles for the introduction and implementation of sustainable environmental practices in the following years. It is necessary to study and promote the ecological and social responsibility of vintners in Bulgaria, especially the small and middle-size ones. For instance, a survey among the small and middle-size vintners in Portugal shows that building green brand equity is of utmost importance in the context of this highly competitive and fragmented marketplace. Even though brand equity creates competitive barriers based on consumer behaviour, it also offers sustainable competitive advantages. (Brochado & Oliveira, 2018)

The preliminary expectations of the authors are that in the sphere of adopting environmental practices, the local winemakers will exhibit the following weaknesses: lack of knowledge, lack of ecological leadership, inadequate skills to implement green practices, lack of managerial attitude to invest in sustainable practices (e.g. water, waste, energy management, employee training). Such behaviour is understandable in view of the lack of pressure from the public, government and investors, as well as the lack of compliance with EU and global ecological regulations in the sector. Our observations are based on certain expert surveys, according to which the assessment of the environmental practices in winemaking depends on the environmental performance of the company and the existing national programmes for enhancement of green practices in the sector (Silverman et al., 2005).

4. Research method

This analysis studies the data from a questionnaire completed by three wine producing companies (white wines, rosé wines and red wines) in the region of Varna. The companies are middle-sized with the capacity to process grapes of up to 300 tons per year. Additionally, in-depth interviews have been made with the representatives of the three companies, aiming at compounding a database concerning their environmental policies studying their opinions on sustainable practices in winemaking. The interviewed also discussed the preliminary expectations of the authors on the readiness of small and middle-size winemakers to adequately meet the European and global green practices in the sector. The survey of the data on winemaking by the three companies covers three stages of the production process with significance for the environmental performance of the company: Wine making process, Cleaning facilities of equipment and installations, Bottling and packaging. The collected data about them cover the following trends: (Table 8. 5)

The goal of the survey is to establish the current state of data collection on environmental practices in each of the companies. Additionally, the reasons for the levels of engagement of vintners in eco-investment and the hurdles set before the development of green policies in the sector are also analysed. The data from the questionnaire and the interviews were compounded in April and May of 2018.

Table 8. 5

Typical environmental impacts in winemaking

Wine making process
Total water used (L or m3) per L of wine produced;
Organic waste generated (kg or volume) per L of wine produced;
% of organic waste reused as fertilizers;
% of organic waste discarded in the land or in water;
Energy use or Thermal energy used – kWh/L of wine produced;
Kg or tons of fertilizers and pesticides used for land preparation;
Cleaning facilities of equipment and installations
Water use;
System to recycle water
Use of chemicals (caustic soda, detergents etc);
Energy used or Thermal energy used
Bottling and packaging
Water use
Use of material (type of packaging)
Packaging waste
% Packaging recovered

Source: the authors

5. Results

Before presenting the results from the survey, we shall draw a small picture of the steps through which winemaking goes. The technology of wine making includes:

Qualification and acceptance – the process is carried out only for healthy grapes (usually between 10-15 kg), which are checked for their sugar content, titration acids and pass organoleptic evaluation;

Sorting and crushing the grapes – the purpose is to remove all the rotting or unripe clusters. The inspected grapes are transferred to the destemmer and then to the crusher. The stems are collected in a container and are preserved until the moment they are taken to fertilise the vine plantations (as marc). All the bins are washed to be reused.

Cooling and setting – the grape pulp goes through a peristalsis pump with a basket to a pneumatic press and whenever necessary cools further through a heat exchanger of the *pipe-in-pipe* type to 10-12ºC for white/rosé wines and to 14-16º for red wine.

Drainage, pressing and fining – white and rosé grapes pulp is drained in a tub. The separated pressed must is transferred to fining bins via a pump. As per Ordinance 52/06.04.2000 of the permitted environmental practices, sulphating is carried out.

Heating the grapes pulp – for red grapes for fermentation the pulp is heated to 22-24º, and for white to 18-20º.

Heating the must – for fining sweet must, it has to be heated to 16-18º so as alcoholic fermentation can take place.

Fining and decanting of must – a process in which the drained and pressed sweet grapes must is fined in a tub by cooling. The clear must is decanted using a pump. The must sediment is analysed for sulphur dioxide and if needed – sulphated further and passed to a vacuum filter for filtration.

Strong alcoholic fermentation – alcoholic fermentation is a process during which the grapes sugars are decomposed to ethanol and carbon dioxide. The clarified must is seeded with dry wine yeast (up too 20-30 gr/hectolitre). The alcoholic fermentation takes place in vats filled with must up to 90% of their volume. It is usually perceived that within one grape picking campaign (30 days) one fermentation cycle takes place.

Silent alcoholic fermentation – this is a natural continuation of the strong alcoholic fermentation and is characteristic of young wines. It takes place between 20 and 30 days after the first fermentation, the wine is further sulphated.

Blending batches – young wines are blended in batches in order to achieve certain physical-chemical and organoleptic characteristics.

Processing with fining agents – this is done in order to save time from self-fining and stabilisation. The additional processing includes lab tests for stabilisation against different types of dregginess. After thickening the sediments, the wine is decanted and filtered.

Stabilisation and filtering – protein stable wines undergo thermal processing (cooling up to -5ºC) in thermally insulated tanks.

Bottling of wines – sterile filtered wine is bottled using a manual bottling line, comprising: a) rinsing bottle machine; b) filling machine; c) corking machine; d) capping machine; e) capsulating machine; f) labelling machine.

The studied companies from Varna Region apply all the basic stages in the winemaking cycle. Their cellars produce white, rosé and red wines. On the basis of the proposed technological cycle, as well as for the needs of the present analysis, three main stages have been appointed to evaluate the environmental possibilities of the vintners within the context of circular economy, namely: 1) winemaking; 2) cleaning the used equipment; 3) bottling and packaging. The first stage is the one creating the largest waste output. This is the most expensive for technological maintenance stage, and the most labour-consuming one with about 30% consumption of the total electrical power and 50% of the water consumption in all the three stages. Because of the specifics of winemaking, as well as the absence in the wineries of a team directly engaged with the issues of waste in the context of circular economy, it is difficult to assess the amount of the consumed litres of water and kilowatts of energy separately for each of the three stages.

In the winemaking process (stage one) about 14% of the organic waste per litre produced wine are formed. Organic waste comes mainly in the form of marc, seeds, stems, skins and sediment. Marc is a source for preparing alcoholic distillates. As a rule, it has low pH content. The European Directives require that marc is composted, but in reality, this practice has not been implemented in Bulgaria. To achieve trouble-free usage of marc, vintners sell to farmers marc useful for their cattle and domestic animals, mostly red marc for fodder. The grapes stem is a biological waste which does not pollute the environment and is used in agriculture by the wine producers themselves. Fertilising the soils for planting, as a rule, is done after a profound evaluation of the need for additional fertilisation of the vine plantations. Nitrogen, phosphorus and potassium are the most frequently used, but they have different levels of decomposition in the soil.

Some waste products from winemaking are rich in tartaric acid and tannin, incl. skins and sediment. In Bulgaria the practice of using tannin in agrifood industry is not popular, while tartaric acid is. It is recommendable that the latter be derived directly by the vintners, as in this way costs are saved from transport and additional equipment. Marc and sediments in winemaking pass through a vacuum filter which extracts the valuable resource for production of wine brandy, whose local name is *rakia.* This product is passed via direct sale from producer to producers of high-alcohol content beverages. Irrespective of the fact that investing in a vacuum filter is a serious expense for a small or middle-sized winery, its implementation and use ensures the firms against fines by the Regional Inspectorates of Environment and Water /RIEW/ (organisations carrying out prevention and follow-up control of harming the environment pollution and the condition of the water systems), whether they tend to throw away the waste in the sewer. Vintners in Bulgaria are obliged to declare to the RIEW how they use their marc and sediments. In this connection, it must be noted that small and middle-sized wineries personally invest in the building of water treatment stations. The state stays uninvolved but the RIEW controls the water quality by taking samples. Generally, the water treatment stations of the small and middle-sized firms in the winemaking sector are located nearby the winery and the treatment station recycles the water. Its secondary use is for watering the vine plantations and the farming land.

A serious advancement in the process, from an environmental and waste-free point of view, is the collection of grapes seeds and their sale for further use. E.g., in the village of General Kantardzhievo in Varna Region, there is a firm with a closed production cycle which extracts, filters, refines and bottles grape seed oil. Grape seed oil is rich in Omega 3 fatty acids and also has a number of applications in cosmetics. The produce is almost entirely meant for export.

Wine production is a seasonal activity and over 30% of the used electricity is consumed in the months of August and September. The needed amount of electrical power is bought from the electrical distribution companies on the territories of the wineries by the winemakers themselves. Thermal energy and other renewable energy sources are not used. The reason is that such projects are expensive and exceed the investment possibilities of the small and middle-sized companies in the sphere of winemaking.

The bottling and packaging of the wine (stage three) leads to the release of different wastes, mostly paper, glass and plastic. Glass is sent for recycling and about 80% of the remaining wastes are re-used. This, as a general rule, is not something that vintners do, but is done by companies engaged in waste recycling and located in the vicinity. In Varna Region, there is one plant for recycling hard household wastes (mechanical and biological treatment, composting) in the village of Ezerovo, which has been in operation since 2011. The company running the plant is licensed by the Ministry of Environment and Water and works in accordance with the effective Bulgarian Law on Waste Management. The basic difficulties which winemakers face is that practically they have to organize their waste management themselves: they incur expenses for pressing the bales, transporting the wastes on their own to the waste treatment plant and finance their own separate waste collection. At the same time, wine producers are obliged to pay fees to the waste treatment company. The only serious reduction of the cost comes from Varna Municipality which deduces these expenses from the company's municipal fees for waste collection and management.

6. Some observations concerning the implementation of circular economy by the small and middle-sized winemakers in Varna Region

The realisation that natural resources are limited and each industrial sector needs efficient approaches for environmental sustainability lies in the basis of the successful implementation of circular economy models in winemaking.

Winemaking in Varna region requires serious economic and technological investments and for that reason the maintaining of certain environmental standards (in the context of circular economy) is only recognised as a regular business aiming at environmental and biological protection. Vintners of this study are acquainted to a certain extent with the principles of circular economy because of the specifics of their activities, namely – the separation of certain useful components of grapes which can turn into a basic resource for other productions. In this respect, winemakers have an interest in possible programmes and projects financed by the EC, the national governments and/or local authorities for financing the "zero waste" concept.

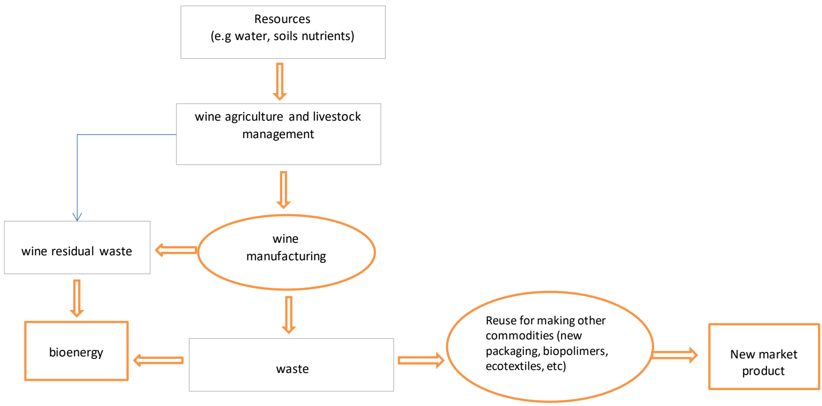
Wastes in winemaking, as a part of circular economy, can be categorised mainly in two separate features: a) biological – they are used by the winemaker or other agricultural companies and b) non-biological – potentially damaging to the environment, whose hazard level depends on the implementation of the legal requirements and directives and the implemented environmental certification. Winemakers have difficulties in sorting and collecting waste from the production process (mainly not the biological ones), as they invest in this activity on their own and the state and its waste treatment companies only have a control function. The different types of waste in wineries come mainly from Stage 1 (winemaking) and Stage 3 (bottling and packaging). Stage 2 (cleaning the used equipment) does not create waste but means a serious use of water resources (about 50%). Wineries use large quantities of water for irrigation and cleaning and sanitation of barrels, vats and equipment. In the long term, the lack of more efficient approaches for waste recycling may lead to problems with water resource management.

The adoption of environmental certification can favour a circular economy approach. In other words, the commitments enhancement towards a higher environmental sustainability can maximize the recovery phase and recycling, and at the same time the reduction of landfill use. The awareness of environmental risks along the value chain, together with the reduction of materials and resource use (that can allow for the development of different plans for improving environmental performance) creates a new product from residual waste, while efficiently incrementing management processes. The main constraint is that the small and middle-sized vintners in Varna Region do not have ISO 14001 or other environmental assessments, such as the life cycle assessment (LCA) or carbon footprint analysis. Safety and security standards are perceived as a synonym of environmental certificates, as they include the main requirements for chemical and technical preparation in winemaking. The only way to make small and middle-sized wineries introduce the ISO 14001 is through legislation. The ISO 14001 is introduced only by the big winemakers who export their produce.

Sustainable winemaking requires that small and middle-sized winemakers carry out professional consultations aiming at implementing best practices, training for learning best practices and acquaintance with the advantages of using environmental labels for wine. It would be useful if the Executive Agency on Vine and Wine could offer to the line ministry a methodology for recognising an image as *clean and green* for winemaking in the different regions in Bulgaria, as well as activating the need for financial support for the introduction of environmental certification in the sector. More attention needs to be paid to integrated farming systems that reduce external inputs, such as fertilizers, energy and plant protection products. New technology can be used to create a circular economy model with more efficient resource use. Responsible use of water, including water recycling, as well as efficient use of manure and by-products on farms should be further promoted. Another example of this is the use of rapeseed cake for animal feed. The use of synergies outside the farm through collaboration between animal and plant producers to optimize the use of organic fertilizers or to significantly diversify production contributes to the reduction of the environmental impact and at the same time to the reduction of production costs. Circular economy is concerned not only with waste reduction, but also with the optimization of production and consumption systems. Figure 8.1 shows an approach to circular economy in which recycling waste for producing new commodities has become a priority: global demand for food, feed, fuels and fibers is increasing, while natural resources are becoming increasingly scarce. It is necessary to preserve the productive lands in order to achieve more sustainable production and consumption, it is also essential to encourage a circular economy approach.

Figure 8. 1

Scheme of wine manufacturing according to circular economy.



Source: The Authors

The goal is to create new business models by optimizing the use of resources and enhancing waste recycling. The use of residuals deriving from the first harvesting activities and the use of by-products coming from the transformation of raw materials for other commercial activities is promising and should be promoted. The circular economy approach must become attractive to small and medium-sized enterprises, in order to make the most of their innovation potential to find outlets for by-products and secondary products. It allows them to be more competitive, to maintain employment and to generate jobs and growth in rural areas. It is possible to cite an interesting experience of the European project named Wineleather (2018). This project has studied the opportunity to reuse the grape marc for producing eco-leather. On about 26 billion liters of wine produced all over the world every year, it is possible to obtain almost 7 billion kilos of grape marc to be used in the production of about 3 billion square meters of Wineleather.

Another opportunity, together with food production, is the reducing of fossil fuels producing bioenergy and bio-products from residual waste. In line with this orientation, farmers and agricultural cooperatives can share the production and use of alternative energy sources, in particular biogas, solar and wind energy.

In conclusion the viticulture and winemaking sector in Bulgaria is not among the priorities of Measure 4.2 *Aid for Processing Agricultural Products* from the Rural Development Programme 2014-2020. Measure 4.2 concerns bioproduction in other sectors of the agrifood industries posed by the European Agricultural Fund for Rural Development. Finding it impossible to participate in this Measure, winemakers are deprived of the possibility to use funds for collection, sorting, processing and reuse of wastes, energy efficiency funds etc., which could enhance significantly the turning of the winemaking sector in Bulgaria into a truly sustainable industry.

There are examples of such successful methodologies. The Italian VIVA is the first methodology in the country for creating a trademark for sustainable winegrowing. It started as a project in 2011 and in 2015, and was promoted by the very Italian government. The American SWA is a methodology on wine developed in California. As in the Italian case, the American initiative uses as a main instrument the carbon and water footprints assessment.

The presented survey is the first of its kind and it is difficult to find a comparative background for the received results with other vintners in Bulgaria. That is why the authors' discussion correlates the achievements in the sector with some European and global achievements within the framework of circular economy as a basis for successful development and application of the policy for environmental sustainability.

BIBLIOGRAPHICAL REFERENCE

- Alonso, A.D. (2010) "How "green" are small wineries? Western Australia's case", British Food Journal, vol. 112, No2, pp. 155-170.
- Brochado, A. and Oliveira, F. (2018) "Brand equity in the Portuguese vinho verde "green wine" market", International Journal of Wine Business Research, vol. 30, No 1, pp. 2-18.

- Dodds, R., Graci, S., Ko, S. and Walker, L. (2013) "What drives environmental sustainability in the New Zealand wine industry? An examination of driving factors and practices", International Journal of Wine Business Research, vol. 25, No 3, pp. 164-184.
- European Commission (2015), "Moving towards a circular economy", available at: http://ec.europa.eu/environment/circular-economy/index_en.htm
- Ecoprowine (2018) available at: https://ec.europa.eu/environment/eco-nnovation/projects/en/projects/eco-prowine
- Flores, C.C., Bressers, H., Gutierrez, C. and de Boer, C. (2018) "Towards circular economy- a wastewater treatment perspective, the Presa Guadalupe case", Management Research review, vol. 41, issue 5, pp. 554-571.
- Marshall, L. (1998), Economic Instruments and the Business Use of Energy, Stationery Office, London.
- Silverman, M. and Lanphar, T. (2003), "Benziger family winery", paper presented at Greening of Industry Network Conference October, San Francisco, CA.
- Silverman, M., Marshall, R.S. and Cordano, M. (2005), "The greening of the California wine industry: implications for regulators and industry associations", Journal of Wine Research, Vol. 16 No. 2, pp. 151-169.
- Smith, M.A. and Kemp, R. (1998), Small Firms and the Environment 1998: A Grounded Report, Groundwork, Birmingham.
- Varsei, M., Christ, K. and Burritt, R. (2017) "Distributing wine globally: financial and environmental trade-off", International Journal of Physical Distribution and Logistics Management, vol. 47, No 5, pp. 410-428.
- VEOLIA (2015), "Water at the heart of the circular economy", available at: www.veolia.com/gulfcountries/sites/g/files/dvc171/f/assets/documents/2014/10/Veolia_brochure_www_STOCKHOLM_2014.pdf
- Wineleather (2018), available at: https://cordis.europa.eu/project/rcn/215862/factsheet/en
- WWTG (2017) Wine industry Overview, November, pp. 1-24.

NINTH CHAPTER
COMPARATIVE STUDY OF THE CURRENT STATE AND ATTITUDES TOWARDS CIRCULAR ECONOMY IN SOME EUROPEAN COUNTRIES

1. The Importance of Circular Economy for Entrepreneurship in the European Union

Circular economy is the latest in a number of concepts, such as zero waste concept. Over the past years, a number of existing key studies explore the opportunities for actions to enhance circularity in various resource areas and product sectors from different perspectives which enhance the implementation o circular economy in different spheres and sectors of industry. For example, the EllenMacArthur Foundation in its 2013 report analyses the consumer goods sector to identify priority goods where the most substantial and underexploited opportunities for circularity lie, highlighting products as priorities within this sector, such as furniture and washing machines. (Ellen Macarthur Foundation, 2015) In contrast, a study by Green Alliance takes the priority materials of metals, water and phosphorus as a starting point due to their role as key inputs to the economy and the large quantities of these currently lost in the production process (Green Alliance, 2011).

Over the last decade, there has been a range of policies and measures already in place at EU, national, regional and local levels, and a range of initiatives under way by private actors and other stakeholders that address part of the transition to a circular economy (Table 9.1).

Table 9.1

Key EU Policies and Measures toward Circular Economy

EU policy/measure	Notes
The Circular Economy Package	Published in July 2014 which includes an overarching communication (COM(2014) 398), a proposal to amend aspects of six EU waste Directives (COM(2014) 397), and related communications on sustainable buildings (COM(2014) 445), green employment (COM(2014) 446) and green action for SMEs (COM(2014) 440)
The Roadmap to a Resource Efficient Europe	COM(2011) 571
The 7th Environmental Action Programme	Decision No 1386/2013/EU
The Bioeconomy Strategy	COM(2012) 60
The Europe 2020 Strategy	

Source: Results systematised by the authors on the grounds of the specified secondary information sources

The commitments and initiatives in Table 9.1 are closely related to parallel policy discussions and offer a good base on which to build and which will generate interesting insights to encourage further action.Various EU programmes which include the Thematic Strategy on the Sustainable Use of Natural Resources, Sustainable Consumption and Production, Integrated Product Policy, and the resource-efficient Europe flagship initiative Roadmap to a Resource Efficient Europe deal with the principles and tools of circular economy[29]. Largely through the Leadership of the Ellen MacArthur Foundation, the EU is now advancing many of these initiatives in policy proposals framed as circular economy and is expected to introduce changes to existing EU

[29] The cited documents are accessible at: http://ec.europa.eu/environment/archives/natres/index.htm; http://ec.europa.eu/environment/eussd/escp_en.htm; http://ec.europa.eu/environment/ipp/index_en.htm;http://ec.europa.eu/environment/resource_efficiency/about/roadmap/index_en.htm

legislation, including more ambitious recycling targets. The European Commission has also produced *Closing the Loop* – an EU action plan for circular economy, which sets out some innovative proposals for the manufacturing of household products. The associated on-going European semester process (including the adoption of country-specific recommendations) provides a solid background for widespread dissemination of the circular economy concept. The ambitions for advancing the green economy within and beyond the EU reflect on the post-2015 Development Framework: and the drafting of the Global Sustainable Development Goals.

The main concepts and definitions connected with circular economy which are used throughout the study are presented in Table 9.2.

Table 9.2

Circular Economy: Key Concepts and Definitions

Concept	Definition
Circular Economy[30]	Circular economy is an industrial economy that is restorative and regenerative by design (promotes greater resource productivity aiming to reduce waste and avoid pollution), and which aims to keep products, components and materials at their highest utility and value at all times, distinguishing between technical and biological cycles.
Green Entrepreneurship	Green entrepreneurship is the activity of consciously addressing an environmental/social problem/need through the realization of entrepreneurial ideas with a high level of risk, which has a net positive effect on the natural environment and at the same time is financially sustainable.
Servitization of Products	The servitization of products describes the strategy of creating value by adding services to products or even replacing a product with a service.
Closed-loop Recycling	Closed-loop recycling is a production system in which the waste or byproduct of one process or product is used in making another product. For example, recycling waste newspapers to make paper-board or other types of paper.
Open-loop Recycling	Open-loop recycling includes the conversion of material from one or more products into a new product, involving a

[30] The *circular economy* concept is presented in item 4 of Chapter Two.

	change in the inherent properties of the material itself (often a degradation in quality). For example, recycling plastic bottles into plastic drainage pipes. Often called downcycling or reprocessing.

Source: Adapted from: European Commission. Green growth and Circular Economy - Environment - European Commission. available: http: //ec.europa.eu/environment/ eussd/escp_en.htm. [Accessed: 20-Feb-2017]; European Commission. Resource Efficiency - Environment - European Commission. [Online]. Available: http:/ec.europa.eu/environment/resource_efficiency/about/roadmap/ index_en.htm. [Accessed: 20-Feb-2017]; European Commission. Sustainable natural resources - environment – European Commission, sustainable use of natural resources. [Online]. Available: http://ec.europa.eu/environment/archives/natres/index.htm. [Accessed: 20-Feb-2017]; European Commission. Integrated product policy - environment - European Commission. [Online]. Available: http://ec.europa.eu/ environment/ipp/index_en.htm. [Accessed: 20-Feb-2017].

The EU countries have implemented the above policies and measures to different extents and with different levels of intensity. This Chapter reviews the activities for promoting and implementing the circular economy concept and certain good practices in Malta, Romania, Bulgaria, Greece, Spain, and the UK (Scotland).

Malta's[31] Green Economy Strategy and Action Plan adopted in December 2015 aims at enhancing the areas of eco-innovation and circular economy. The areas being tackled include six basic areas as follows: Malta's green economy (mainly jobs in the water supply industry, solid waste management sector and renewable energy-related sectors) is estimated to grow by 19% over the next three years. To further stimulate green economy in the coming years, the strategy proposes the development of stronger links between industry and academia and the incorporation of sustainable development in all vocational training; waste management including updating of waste infrastructure and the setting up of waste separation and recycling systems and education programmes. A new Waste Management Plan

[31] Greening our economy – Achieving a sustainable future by the Ministry for Sustainable Development, the Environment and Climate Change; Programme of the Maltese Presidency of the Council of the European Union (1 January 2017 - 30 June 2017)

was also issued in January 2014, which sets the following national targets, in line with EU legislation:

- Target for the recycling of 50% of paper, plastics, metal and glass waste from households by 2020;
- Limit of 35% of biodegradable municipal waste allowed to landfill by 2020;
- A 70% recovery target for Construction and Demolition Waste by 2020;
- The oligation to collect 65% of the average weight of electrical and electronic equipment placed on the national market by 2021;
- Target for recycling 75% of packaging waste by 2030;
- Target for recycling 65% of municipal waste by 2035;
- A binding landfill target to reduce the landfilling of municipal solid waste (MSW) to a maximum of 10% of the total MSW generated by 2035;
- Ban on the landfilling of separately collected waste and the promotion of economic instruments to discourage landfilling.

Regarding the greening of the energy sector, an electricity interconnection between Malta and Italy was activated in 2015 and other projects are underway to update the energy infrastructure and energy generation. Although progress has been made in improving energy efficiency, additional efforts are needed to reach the country's 2020 target. Malta's share of renewable energy sources in total consumption has increased, reaching 4.7% in 2014. The use of cooperation mechanisms with other member states (such as importing green electricity through the interconnector) could be considered to help the country to achieve its targets. A new photovoltaic panel scheme was introduced in 2015, whereby residents installing such systems in their home are eligible for a grant covering up to 50% of the capital cost capped to 2300 Euros, or 757 Euros per KWp, and a feed in tariff of 16c for 6 years and marginal cost for the remaining lifetime of the system. The transport system is still largely dependent on imported fossil fuels; the share of renewable energy in transport was 4.7% in 2014. A National Electro-mobility Action Plan was adopted in 2013. The government is also providing individuals who purchase electric vehicles with a grant of up to 4000 EUR.

Water stress is a long-standing issue in Malta, with an annual natural renewable freshwater availability well below the UN threshold of absolute water scarcity. Malta is therefore heavily dependent on the desalination of water for its drinking water supply, which consumes 3% of the total electricity generated. An updated Water Catchment Management Plan for the period 2015-2021 was adopted in 2015, which sets out a programme of measures to optimise the management and use of water resources in Malta and Gozo. Innovative approaches to improve water availability are being explored and tested through projects such as MARSOL – Demonstrating Managed Aquifer Recharge as a Solution to Water Scarcity and Drought, an FP7 project investigating managed aquifer technologies, and Alter Aqua, a public-private initiative aimed at mobilising Non-Conventional Water Resources (rainwater harvesting, storm water management and greywater reuse systems). Proposed actions related to water management include:

- Introduction of voluntary water audits in companies.
- A grant scheme to support investments targeting water efficiency.
- The Second Water Catchment Management Plan adopted in 2015, which foresees a number of innovative measures aimed at promoting efficient use of water resources, increasing water availability and developing new technologies for water treatment and management.

The most important document for structural changes concerning circular economy in **Romania** is the Partnership Agreement Romania (2014RO16M8PA001.1.1). It stipulates that the extension and modernization of the water and wastewater infrastructure continue to be one of the most important priorities in improving Romanian living standards, especially in rural areas. Waste management is still far short of European standards with low levels of re-use, recycling and energy recovery. Romania has as transition period until 2017 to phase out non-compliant landfills. Romania is well endowed with natural assets, which, if sustainably managed, can offer important development potential, but environmental quality and biodiversity remain under pressure from both natural process and economic activity. There is a need to enhance environmental protection and to shift to more sustainable practices in areas where agriculture production is intensifying and in the construction sector, in extractive industries and in business generally.

There are still a few actions aimed at circular economy at a national level. The most important event is "CIRCULAR", the largest conference on the topic of circular economy, which took place 1st September 2015, in Bucharest as a Green Report conference, organized by the Green Revolution Association. But still there are measures taken at the level of environmental protection such as:

- Environment Fund Administration, which manages the schemes for water infrastructure, renewable energy investments;
- National Agency for environmental protection;
- National Rural Development Programme. The "greening" payments provide an additional support per hectare provided that the CAP "greening" criteria are met. The agri-environment payment (EAFRD) supports farmers who voluntarily commit to meeting additional conditions (exceeding the basic requirements) of environmental protection;
- ESI funding.

Measures for environment protection, resource efficiency and climate change will be provided through ERDF and CF, including measures promoting good environmental practices in business. The EAFRD will complement activities in this area by measures to protect and maintain biodiversity on agricultural and forest land, and by integrating climate change mitigation and adaptation actions to reduce the GHG emissions in agriculture and forestry. However the new European legislative package is not transposed into the Romanian legislation. The basic regulatory framework is limited to one Law - 211/2011 transposing the Waste Framework Directive. In it, the concept of circular economy is not set, but the steps appear to be prosecuted alongside with appropriate measures. Practical measures are not implemented yet.

An intensive agenda of conferences and debate on the future of waste management in **Spain** has been organised across the State by local administrations, public bodies, business people´s associations, stakeholders and educators, to showcase the circular economy[32] and emphasize the need for zero waste. The Circular Economy Foundation (Fundación para la Economía Circular - FEC[33]) is the most active entity in promoting circular economy. FEC is a private, supranational foundation comprising a board of members that brings together former senior regional administrations. The Foundation works with world experts, governments, private entities and social agents in areas related to circular economy, sustainability, resource use and environment. It is currently the undisputed leader in the knowledge of these sectors in Spain and Portugal. FEC also works closely with economic, social and citizen entities such as CEOE[34], CEPYME[35], Chambers of Commerce, professional associations, syndicates such as UGT and CC.OO, Consumer or Neighbourhood Associations, and Ecologist Groups among others, the Industrial Engineers of Madrid, Barcelona and Seville professional schools, addressing their concerns and opinions. It is important to note that the Spanish state is a decentralized administrative political structure with 17 autonomous regions whose parliaments have broad powers, established by the Constitution of 1978. The State is responsible for drawing up basic legislation and attention to international obligations in environmental matters. Autonomous regions can adapt and develop basic regulations, as well as establish additional measures of protection. In addition, they have competences in education and management concerning environmental protection. In Spain, the most relevant milestone was the drafting of the White Paper on Environmental Education in 1999, which will be maintained and renewed with other international reference points such as the European Union's Sustainable Development Strategy 2001 or the 7th Action by the European Community on the Environment until 2020 "Living well, within the limits of our planet". The White Paper aims to give new impetus to

[32] Estrategias para la Gestión Sostenible de los Residuos en el Horizonte 2020. Fundación para la Economía Plan Estatal Marco de Gestión de Residuos (PEMAR) 2016-2022. BOE núm. 297, 12 de diciembre de 2015.

[33] For more detail: http://economiacircular.org/

[34] Confederation of Employers and Industries of Spain (https://www.ceoe.es/en/)

[35] Confederación Española de la Pequeña y Mediana Empresa (http://www.cepyme.es/)

environmental education, paying more attention to social aspects, deepening a change of values, integrating it into all sectors of citizenship and encouraging the full participation of all citizens in environmental policy. The objective was to guarantee the presence of environmental education in the Educational System. In schools, colleges and institutes, environmental education was introduced as a transversal theme.The White Paper addressed environmental education in the business world. It promoted environmental education through business organizations by encouraging programmes and courses of continuous training in environmental matters, as well as participation in internal processes, involving all the employees in the environmental balance of the company.The trade unions were entrusted with encouraging the involvement of workers in the environmental management of companies by keeping them informed, motivating them and providing them with environmental knowledge and values.

Data revealed at the International Symposium RE-Greece 2016: *Circular Economy and Sustainable Use of REnewable REsources in the context of Climate Change and Social Upheavals*[36] show that the general public in **Greece** is very well aware of recycling various forms of materials (18% of material is recycled in Greece) and specific disposal boxes can be located in all municipalities (paper, glass, food residue, technical equipment/parts, lamps, batteries etc.). There are many different schemes and informational sessions ongoing and programmed by municipalities and prefectures to primarily inform local and regional actors on the principles and concepts of circular economy (examples: Municipality of Nisiros, University of Patras[37], etc). The general public is subsequently informed by the respective local and regional actors. The main topics of presentations are the following:

- Recycling and re-use;
- New ways of using material;
- Behaviour and global role;
- Influence in the economy;

[36] For more detail: http: //re-greecesymposium.wix.com/nisyros
[37] For more detail: http: //green.upatras.gr/sites/green.upatras.gr/files/program.pdf

- Role of local and regional authorities;
- Business models of circular economy;
- Support structures and information;
- Definitions and concepts, good examples and case studies from across Europe;
- Implementation areas in Greece and example sectors (i.e. raw materials, technology and parts, bio distilleries, fishing, recycling, etc);
- Value added on various production sectors.

The government, in cooperation with the Hellenic Recycling Agency (HRA), has started an information training campaign in primary and secondary schools in Greece approved by the Ministry of Education. The programme is aimed at students in the last grades of elementary school to the final classes of secondary schools in Attica and Thessaloniki. The programme aims to raise awareness on environmental benefits, recycling methods and the results of the recycling of electrical and electronic appliances, as well as motivating themselves, their parents and teachers to participate actively in recycling electric appliances. The specific training programme includes audiovisual materials, Q&A sessions and presentations[38]. The initial Directive 94/62/EC on Packaging and Packaging Waste was issued on 20/12/1994. The actual implementation date in Greece was 07/11/2008. The Greek legislation on Circular Economy includes[39] four Greek laws passed (with updates), six Ministerial Ordinances and two Presidential decrees. The aim is to reach the EC goals and boost European and Greek competitiveness. This will help to foster sustainable economic growth, generate new jobs for Greece and the EU while taking advantage of the funding available: €5.5 billion from structural funds and €650 million from Horizon 2020. The new update on Law N.2939/2001 was presented on 13th October 2016 by Deputy Minister Mr. Tsironis related to Packaging and Alternative Management of Packaging and Other Products. A new organization was

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[38] For more detail: http: //www.eoan.gr/el/content/468/ekpaideutiko-programma-tou-sed-anakuklosi-suskeuon-a-e

[39] Kaminaris, V., de Graaf, D. Platis, E., Konti, K., SEV (Hellenic Federation of Enterprises) and EY.EY (2016) Study on the Circular Economy in Greece, May

set up called the Hellenic Recycling Agency (HRA) and will be the competent authority of the Ministry of the Environment & Energy for the design and implementation of the recycling policy in Greece. It is responsible for approving national alternative management systems for each product and for controlling the progress of recycling within the Hellenic territory[40]. However, according to the above resource, the implementation period in Greece is 7 months to 2 years.

In 2013, **Bulgaria** was ranked last under the Eco-Innovation Scoreboard. This indicates low performance of the country in terms of circular economy and eco-innovation activities. Despite this, Bulgaria has made efforts to improve in these domains through the implementation of several Operational Programmes since 2013. In 2014 and 2015, eco-innovation policy measures and funding schemes included:

- The Innovative Strategy for Smart Specialization of the Republic of Bulgaria 2014 – 2020;
- National Waste Management Plan 2014-2020;
- The Ordinance on construction and demolition waste management and use of recycled construction materials;
- The Regions in Growth Operational Programme 2014 –2020;
- The Operational Programme for the Environment 2014 – 2020;
- The Operational Programme for Innovations and Competitiveness 2014 – 2020;
- The Operational Programme for Transport and Transport infrastructure 2014 – 2020;
- The Operational programme for Science and Education for Smart Growth 2014 –2020;
- National programme for energy effectiveness of buildings;
- National Trust Ecofund.

A search in Google with the key words “circular economy” (in Bulgarian language) generates 25,000 results which are mainly news about new European and national initiatives and projects in the field of

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[40] For more detail: www.eoan.gr

circular economy as well as links to companies providing different services connected with circular economy, e.g. waste management, renewable energy sources, etc.

On 23 February 2016, a conference was held on “Circular Economy and the Possibilities for Bulgarian Business”. Many representatives of the businesses took part and were active during the discussion. Minister Vasileva presented long-term framework of actions initiated by her office. The framework is related to resource efficiency, sustainability of production and consumption in the country. The Minister guaranteed an active government policy to build circular economy in Bulgaria which will cover all parts of government and attract all stockholders. The government encourages the use of renewable energy in the transport sector through several different initiatives:

- National Action Plan for Renewable Energy;
- National Action Plan for the Promotion of Production and Adoption of Environmentally Friendly Vehicles Including Electric Mobility in Bulgaria for 2012 – 2014, and
- National Long-term Programme for the Promotion of Biofuels in the Transport Sector 2008 – 2020.

Currently, no special legislation in the area of education on circular economy exists. There are some subjects connected to the topic of circular economy such as: The Human Being and Nature, The Human Being and Society, Chemistry and Environment Protection.

Much of the **UK**’s environment and waste policy, which also applies in **Scotland**, is devolved upon the Scottish Government and its parliament. As a result, Scotland has been developing progressive waste and resource policies for the past 15 years. A major development was the Zero Waste Plan (ZWP), Scotland’s response to Article 28 of the Waste Framework Directive (2008/98/EC) on national waste strategies. The plan’s mission is to achieve a zero waste Scotland, where we make the most efficient use of resources by minimizing Scotland’s demand on primary resources, and maximizing the reuse, recycling and recovery of resources, instead of treating them as waste. This clearly has resonance with the principles of CE. This ZWP led to the Scottish Government introducing innovative legislation that required municipalities to provide food waste collection services to households, for restaurants to segregate their food waste, and for all businesses to have a segregate system for recyclates.

In 2016 the Scottish Government went further and produced its Circular Economy Strategy – *Making Things Last*. In addition to policies that related to the waste management sector, such as extending producer responsibility to tyres, furniture and mattresses, the Strategy looks to establish CE innovation funds, a remanufacturing centre supporting industry and academics. The Scottish Government also runs a Resource Efficient Scotland programme, which has a wider interest in resource use, including energy efficiency. The programme offers online webinars and a free online training course (Green Champions Training) which is written for SMEs in modules which include question and answer interactions. The course has no formal qualification status.

2. Methodology for Studying the Public Opinion and Attitudes towards Circular Economy and Innovative Green Entrepreneurship

This study of the public opinions and attitudes towards circular economy and green entrepreneurship is carried out in two stages. During the first one, secondary source data is collected and analysed (desk research) and in-depth interviews with experts are conducted (quality research method). On the basis of the results from the first stage, a questionnaire is compiled and an online survey with representatives of SMEs in the analysed countries is carried out. The study covers six EU countries – Malta, Romania, Bulgaria, Greece, Spain, and UK (Scotland). The countries are selected for their participation in the *Circular Economy Digital Training Toolbox to Foster Innovative Green Entrepreneurship – Eng@ge"* Project.

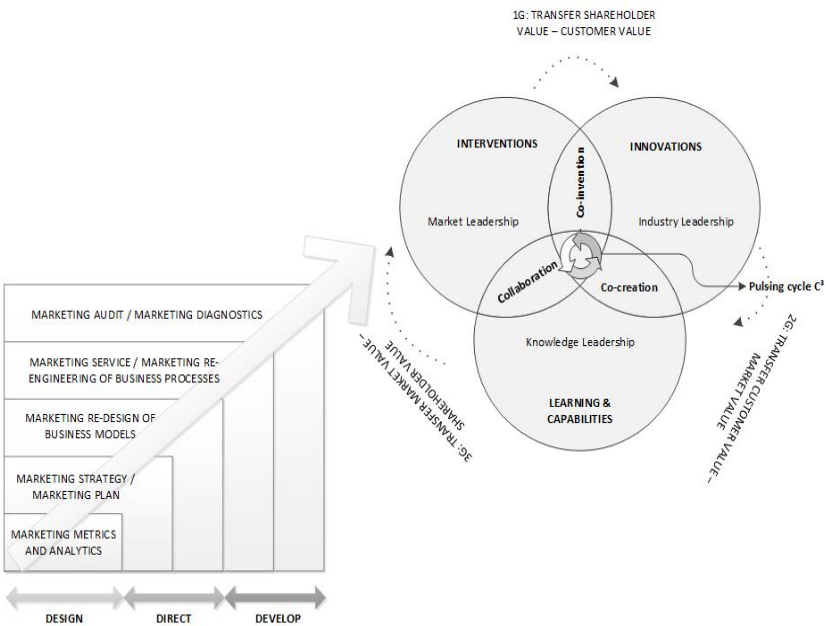
The questionnaire consists of three sections (Appendix 9.1). The first section focuses on the attitudes toward innovative green entrepreneurship. The second section deals with the conditions for developing circular economy and the current state of circular economy implementation in the respondents' countries. The third section is devoted to the attitudes toward circular economy implementation. The questionnaire is translated into the following languages: Bulgarian, Spanish, Romanian, and Greek.

The LimeSurvey platform was used to configure the questionnaires. The survey was administered online between April and May 2017. A total number of 152 respondents participated in this survey. The results are processed with the SPSS 23.0 software package.

The concept of the „3G" business model (Figure 9.1) is used to present the implications derived from the survey (Vassileva and Ivanov, 2017).

Figure 9.1.

The Concept of the "3G" Business Model



Source: Vassileva and Ivanov, 2017

The "3G" business model reflects the notion of marketing management in Marketing 4.0 as a self-generating and self-renewing process of activating, adapting and anticipating the challenges of the extremely dynamic environment.

The left corner in Figure 6.1 shows the marketing membrane defined as a diagnostic-expert system for designing, targeting and development of busniness models with marketing activities for target interventions within the transfer: *shareholder value – customer value – market value* (see upper right-hand corner in Figure 9.1), realized through the pulsing cycle *collaboration – co-invention – co-creation*. Genome G1 – Market Leadership – requires companies to strive for market leadership through corporate interventions. The purpose of these interventions is to build and maintain marketing security for a proactive response to market risks, during market entry and market exit. Genome G2 – Industry Leadership – requires innovation in brand markets through integrated outbound-inbound strategies. Strategic interventions provide synchronization between changes in business model design and business process reengineering, on the one hand, and brand marketing decisions on markets, on the other hand. Genome G3 – Knowledge Leadership – requires companies to invest in building creative marketing engineering competencies to reach digital maturity level, which creates potential for putting the four major digital technologies (social media and networks, mobile technologies, analytics and cloud technologies) on equal footing, integrated into all intervention areas.

The content of the stages of the marketing management process in Marketing 4.0 (the left corner of Figure 9.1) are delineated in Table 9.3.

Table 9.3.

The *design – direct – develop* stages of marketing management in the 3G business model

Stage	**Focus**	**Main Issues**	**Range of Study**	**Author**
Design	Processes	Marketing metrics and analysis	Information filtering system Efficiency of the search engines Level of intercompany price competition (digital and analogue product attributes) Internet user behavior	Ansari et al. (2000) Lal and Sarvary (1999) Moe and Fader (2000)

Direct	Work flows	Marketing strategy/ Marketing planning Marketing predesign of the business models	Direct versus traditional channels for retail trade; Optimal form of supply of digital information; The internet as an efficient seamless market; Acquisitions of the internet users; Price sensitivity; Offline/online price sensitivity; User experience "flow"; Pricing strategies for online and offline offers; Unification as an operating model; Online/offline strategies for pricing and communication.	Balasubramaniian (1998) Bakos and Brynjolfsson (1999, 2000) Brynjolfsson and Smith (2000) Hoffman and Novak (2000) Lynch and Ariely (2000) Shankar et al. (1999) Novak et al. (2000) Venkatesh and Chatterjee (2000) Werbach (2000) Zettelmeyer (2000)
Develop	Talent management	Marketing services/Marketing re-engineering of the business process Marketing audit/Marketing diagnostics	User choice behavior; Online versus offline; Information filtering system of preliminary and advanced screening; Type of user knowledge; Type of digital information directed at various customers.	Degeratu et al. (2000) Haubl and Trifts (2000) Mittal and Sawhney (2001) Shapiro and Varian (1998)

Source: The table is elaborated by the authors using the conceptual model in Figure 6.1 and systematizes the authors in the table as per the #G business model components.

Following the logic of the Marketing 4.0 principles (Jara et al., 2012), the organizations have to implement the 3G business model based on the type of customer, market and digital kills which will be directing the key businesses over the next five ot ten years. This requires the acqusition of new talent so that the management could operate the three genomes of the model (G1, G2 and G3) described above.

This model is expedient when companies introduce the principles of circular economy, as it reflects the conceptualization of Amit & Zott (2001) and Zott & Amit (2003) of the business model as a potential for creating value through designing transactions between the company and its main external stakeholders (partners, suppliers and users). In replete and dynamic markets the following three categories of business models can be differentiated: operators, solution suppliers and hybrids. Operators mainly achieve market growth through geographic expansion, market consolidation and expanding their product portfolios through mergers and acquisitions and/or targeted “Greenfield” investments. Solution suppliers have the potential to offer added value services or to attempt an entirely new business by continuing to increase the value for the users. Hybrid companies usually seek differentiated growth in different aspects of the product-market relations. A key moment for them is their restructuring according to the technological and industry specific advantages, as well as concentrating on their basic competences. When assessing the possibility for implementing circular economy, companies need to also assess the business model which reflects the specifics of their activities and the relationship with their stakeholders, as well as prioritise accordingly their processes, work flows and talent management.

3. Comparative Analysis of the Readiness to Implement circular Economy in the Studied Countries

The results from the study on circular economy and green entrepreneurship show that the highest level of awareness is observed for UK respondents. The least aware about circular economy and green entrepreneurship are Malteese and Spanish respondents (Table 9.4).

Table 9.4

Level of awareness of the terms 'Circular Economy' and 'Green Entrepreneurship', %

Statement	MT	RO	BG	UK	EL	ES
I was aware of ‘circular economy’ only	11.11	11.76	5.26	36.84	-	9.09
I was aware of ‘green entrepreneurship’ only	-	17.65	21.05	5.26	-	24.24
I was aware of both terms	22.22	35.29	31.58	42.11	81.82	12.12
I was not aware of any of them	66.67	35.29	26.32	10.53	-	54.55

Source: Personal elaboration of the authors.

‘Innovative Green Entrepreneurship’ is associated mainly with the following terms and concepts: 1/ sustainability (sustainable thinking, sustainable use of resources, sustainable environment); 2/ eco friendly processes, eco business, environment friendly businesses; 3/ recycling; 4/ reuse of waste; 5/ ecology (environmental protection, ecological products); 6/ renewable energy. Details about the answers of the respondents by countries are presented in Table 9.5.

Table 9.5

Associations about ‘Innovative Green Entrepreneurship’ by Countries

Malta	**Bulgaria**
4) Coming up with original ways of doing business while minimizing environmental harm; 5) A company that while offering a service or producing some goods, they consider their environmental responsibilities while minimising their carbon footprint and operate in a sustainable manner; 6) Product development that gives priority to environmental issues; 7) Exploit the environment to make profit by offering services or developing eco products.	8) Eco oriented entrepreneurship; 9) Activities aimed at preserving environment and natural resources; 10) Development and implementation of alternative energy resources; 11) New and innovative methods to exploit natural resources and to protect the environment; 12) Eco friendly profitable entrepreneurship; 13) Reuse of waste.

<table>
<tr><th>The UK</th><th>Greece</th></tr>
<tr><td rowspan="3">• An entrepreneur who brings innovative thinking to sustainability;
• Developing business from items considered to be waste;
• This term describes for me, what the nature of future business must be like in order to protect the environment and ensure sustainable use of natural resources, i.e. that business operations will need to do much more (be flexible - entrepreneurial) with a lot less in terms of resources (be innovative) in a way which benefits the environment (green);
• New environmentally friendly methods and technologies or new ways to effectively implement existing technologies;
• Sustainable, low carbon methods;
• Hipsters;
• Some kind of "new" commercial/business deal environmentally correct or with the correct attitude towards the environment. Something that will make it "different" from what has been done that is degrading our environment;
• Sustainable ideas that protect and enhance our environment;
• Environmental Management Systems;
• Innovative green technologies related to waste management and recycling;
• A new approach to environmental management;
• Saving the planet earth from potential problems like greenhouse gas emissions or plastics disposed in the sea ending up in the food chain through consumption of fish;
• Organization/individual who are interested in innovative green lifestyle, and who are concerned;
• It sound as a small company with a great and interesting goal which needs our help for its expansion.</td><td>• Recycling and renewable sources of energy;
• Minimalism;
• Sustainable solutions with the aim to enhance environmental outcome and its protection. (renewable sources of energy, innovative use for waste management etc)
• Recycling, green energy;
• New entrepreneurial ideas based on the environmental aspect or seriously considering the environmental perspective;
• Sustainable environment;
• Use of waste and manufacture symbiosis together with ICT.</td></tr>
<tr><td>Romania</td></tr>
<tr><td>• A new business, innovative which aims to develop solutions / technologies / sustainable services from the viewpoint of the environment;
• Resources protection;
• Which provides a business that does not affect the environment/can protect the environment;
• Good ideas for the benefit of everyone;
• Using the services that the environment gives us for free;
• Something that has to do with nature, related to nature/to the environment;
• An entrepreneurship friendly towards the environment;
• Initiative in the environmental field;
• Companies which carry out activities on environmental protection;
• Companies that focus their activities to protect the environment;
• The development of businesses through which to use bioenergy;
• Ambience and colour for a healthy living environment.</td></tr>
</table>

Spain	
• Any sustainable action, even if it recovers traditional activities or uses, is innovative; • I do not like the term green nor entrepreneurship, although they are very commercial and have become popular. In many cases, I think they are just hot air. • Creation of new companies that respect the environment; • Does not harm the environment; Care of the environment; • A new approach to make industry more sustainable; • An advertisement for Green Giant; • Activity aimed at preserving and conserving the environment; • Investment in less polluting industrial processes; • Sustainable development companies; • Environmental and sustainability awareness for businesses;	• A company that is based on respect for the environment; • To improve the conservation of the planet; • Create companies that work ecologically with new technologies; • New strategies for reducing contamination; • Innovation concerning the environment and recycling; • Creation of initiatives that respect the environment; • Entrepreneurship that respects the environment; • A business that respects the environment in a sustainable way; • An initiative that does not harm the environment; • New ways to care for our planet; Modern use of recycling with state-of-the-art techniques.

Source: Personal elaboration of the authors.

The most important characteristics which should be possessed by an innovative green entrepreneur company differ slightly by countries. Environmental stability is ranked on the first place by the respondents from Malta, UK, and Greece but on third place by Romanian respondents (Table 9.6 and Table 9.7). Clear organization strategy, vision, mission, goals, culture are considered as the most important characteristics according to Romanian and Bulgarian respondents.

Table 9.6

Importance of the Characteristics of an Innovative Green Entrepreneur by Countries, Ranking

	MT	RO	BG	UK	EL	ES
Successful, motivated, contented employees	-	-	-	-	-	-
Financial strength	2	-	-	-	-	-

Clear organization strategy, vision, mission, goals, culture	-	1	1	4	-	3
Good public relations (customers, partners, shareholders)	-	-	4	-	-	-
Strong reputation	-	-	-	-	5	-
Quality products	5	4	3	3	3	4
Ecological and social awareness	4	2	2	2	2	1
Environmental sustainability	1	3	-	1	1	5
Adaptability, flexibility	3	5	-	5	-	-

Note: The respondents ranked the five most important characteristics with 1 = the least important; 5 = the most important.
Source: Personal elaboration of the authors.

Ecological and social awareness is ranked second by its importance according to the respondents (except those from Malta and Spain). Quality products are considered important as well (ranked third).

Table 9.7

Importance of the Characteristics of an Innovative Green Entrepreneur by Countries, %

Malta	1	2	3	4	5
Successful, motivated, contented employees	12.50	12.50	-	12.50	12.50
Financial strength	-	25.00	-	12.50	12.50
Clear organization strategy, vision, mission, goals, culture	12.50	12.50	12.50	12.50	-
Good public relations (customers, partners, shareholders)	-	-	-	-	12.50
Strong reputation	-	-	-	12.50	-
Quality products	12.50	12.50	12.50	12.50	37.50
Ecological and social awareness	25.00	-	12.50	25.00	12.50
Environmental sustainability	37.50	25.00	12.50	12.50	12.50
Adaptability, flexibility	-	12.50	50.00	-	-

Romania	1	2	3	4	5
Successful, motivated, contented employees	-	-	11.76	5.88	18.75
Financial strength	11.76	5.88	11.76	5.88	12.50
Clear organization strategy, vision, mission, goals, culture	47.06	5.88	17.65	-	6.25
Good public relations (customers, partners, shareholders)	-	-	5.88	11.76	18.75
Strong reputation	11.76	-	-	5.88	-
Quality products	-	11.76	-	29.41	6.25
Ecological and social awareness	17.65	47.06	11.76	-	12.50
Environmental sustainability	11.76	17.65	23.53	29.41	-
Adaptability, flexibility	-	11.76	17.65	5.88	25.00
Bulgaria	**1**	**2**	**3**	**4**	**5**
Successful, motivated, contented employees	13.33	-	13.33	13.33	13.33
Financial strength	-	20.00	13.33	13.33	13.33
Clear organization strategy, vision, mission, goals, culture	60.00	-	6.67	13.33	13.33
Good public relations (customers, partners, shareholders)	-	-	-	20.00	13.33
Strong reputation	-	-	-	-	13.33
Quality products	6.67	20.00	26.67	13.33	6.67
Ecological and social awareness	20.00	46.67	6.67	13.33	13.33
Environmental sustainability	-	6.67	13.33	6.67	6.67
Adaptability, flexibility	-	6.67	20.00	6.67	6.67
UK	**1**	**2**	**3**	**4**	**5**
Successful, motivated, contented employees	15.79	-	-	10.53	15.79
Financial strength	5.26	15.79	10.53	5.26	5.26
Clear organization strategy, vision, mission, goals, culture	21.05	5.26	-	21.05	15.79
Good public relations (customers,	-	5.26	5.26	15.79	10.53

partners, shareholders)					
Strong reputation	-	10.53	5.26	10.53	10.53
Quality products	10.53	15.79	15.79	10.53	10.53
Ecological and social awareness	10.53	31.58	31.58	5.26	-
Environmental sustainability	36.84	5.26	21.05	15.79	5.26
Adaptability, flexibility	-	10.53	10.53	5.26	15.79
Greece	1	2	3	4	5
Successful, motivated, contented employees	-	-	-	25.00	28.57
Financial strength	-	-	-	-	-
Clear organization strategy, vision, mission, goals, culture	25.00	25.00	12.50	25.00	-
Good public relations (customers, partners, shareholders)	-	-	-	-	14.29
Strong reputation	-	-	12.50	-	42.86
Quality products	-	12.50	50.00	-	14.29
Ecological and social awareness	25.00	37.50	12.50	25.00	-
Environmental sustainability	37.50	25.00	12.50	-	-
Adaptability, flexibility	12.50	-	-	25.00	-
Spain	1	2	3	4	5
Successful, motivated, contented employees	15.15	15.62	6.25	15.62	19.35
Financial strength	12.12	15.62	3.12	6.25	3.23
Clear organization strategy, vision, mission, goals, culture	15.15	18.75	25.00	9.38	6.45
Good public relations (customers, partners, shareholders)	-	-	9.38	6.25	6.45
Strong reputation	-	-	9.38	3.12	6.45
Quality products	6.06	9.38	21.88	25.00	12.90
Ecological and social awareness	33.33	18.75	3.12	9.38	9.68
Environmental sustainability	18.18	18.75	6.25	18.75	22.58
Adaptability, flexibility	-	3.12	15.62	6.25	12.90

Source: Personal elaboration of the authors.

Respondents provided other characteristics except those listed in the questionnaire which they consider important to be possessed by an innovative green entrepreneur such as: must have value other than financial – beneficial to the environment and society; innovation; adequate life and work balance; strong leadership; successful and motivated employees; good communication; a proven track record of delivery from key individuals in the company; confident, independent, accessible; take into account the demands and concerns of the society on which it is based; own capacity in research and innovation; high visibility for entrepreneurial awareness; knowledge; involvement in public awareness activities; motivational strategies; transdisciplinarity; strategy and innovation management.

The main benefits of applying innovative green entrepreneurship are as follows: contribution to societal issues, customer satisfaction, product/brand support, and influence on organization values, culture, mission, goals (Table 9.8).

Table 9.8

Main Benefits of applying Innovative Green Entrepreneurship by Countries, Mode, %

	MT	RO	BG	UK	EL	ES
Recognition by the public and stakeholders	4 (75.0)	3/4 (43.75)	4 (27.27)	5 (47.06)	4 (75.00)	3 (40.00)
Image and reputation enhancement	4 (87.5)	4 (35.29)	4 (31.82)	5 (50.00)	4 (71.43)	3 (40.00)
Contribution to societal issues	5 (50.0)	4 (35.29)	5 (66.67)	5 (66.67)	5 (50.00)	5 (46.67)
Staff motivation and loyalty	3 (50.0)	4 (43.75)	5 (28.57)	4 (47.06)	4 (85.71)	4 (43.33)
Financial efficiency	3/4 37.5)	4 (40.00)	5 (40.91)	3 (37.50)	3/4 37.5)	3 (35.48)
Influence on organization values, culture, mission, goals	4 (62.5)	5 (50.00)	5 (33.33)	4 (47.06)	4 (42.86)	4 (46.67)

Product / brand support	4 (50.0)	5 (43.75)	5 (28.57)	4 (50.00)	4 (71.43)	4 (54.84)
Market position support	4/5 (37.5)	4 (33.33)	4/5 (28.57)	4 (46.67)	4 (57.14)	3 (50.00)
Customer satisfaction	4 (50.0)	5 (53.33)	5 (52.38)	4 (50.00)	4 (62.50)	4 (48.28)
Staff recruitment and retention	3 (37.5)	3 (33.33)	5 (33.33)	4 (37.50)	4 (57.14)	4 (28.57)
Trust-building among stakeholders	4 (50.0)	4 (46.67)	5 (33.33)	3 (50.00)	4 (62.50)	4 (48.39)

Note: 1 = no benefit at all; 3 = relative benefit; 5 = strong benefit,
Results are presented by Mode. Corresponding percentages are given in brackets
Source: Personal elaboration of the authors.

Respondents provide other benefits except those listed in the questionnaire which they consider important for the implementation of innovative green entrepreneurship. Some of them are given in Appendix 9.2.

Besides the benefits recognised by the respondents, several barriers to the transition to circular economy are mentioned. These barriers could be arranged into the following groups. The first group of barriers includes those related to different types of investment, such as insufficient investment in recycling and recovery infrastructure, innovation and technologies; insufficient skills and investment in circular product design and production which could facilitate greater re-use, remanufacture, repair and recycling; challenges in obtaining suitable finance for investment. The second group of barriers encompass the imbalance within the relationships between the market players and the power distribution, such as non-alignment of power and incentives between actors within and across value chains (e.g. between producers and recyclers) to improve cross-cycle and cross-sector performance; still limited consumer and business acceptance of potentially more efficient service-oriented business models. Information-related barriers include shortfalls in consumer awareness, weaknesses in policy coherence at different levels, limited information, know-how and economic incentives for key elements in the supply and maintenance chain, etc. Many of the barriers are specific to particular materials, products and sectors, such as widespread planned obsolescence in products, insufficient waste separation at source, current levels of resource pricing which create economic signals that do not encourage efficient resource use, pollution mitigation or innovation.

The opinion of the respondents regarding the importance of different aspects of circular economy is quite diverse by countries. The most frequent answers (measured by mode) include the following:

- principles of circular economy,
- green entrepreneurs,
- recycling (closed loop recycling),
- recycling (open),
- recovery,
- eco-design (Table 9.9).

Table 9.9

Importance of the Topics Related to Circular Economy Education by Countries, Mode, %

Topics	MT	RO	BG	UK	EL	ES
Principles of CE	4/5 (44.44)	4/5 (41.18)	4 (41.18)	5 (52.63)	5 (45.45)	4 (42.42)
New business models	5 (66.67)	5 (64.71)	4 (35.29)	5 (42.11)	5 (45.45)	4 (39.39)
Green entrepreneurs	5 (55.56)	5 (64.71)	4 (41.18)	5 (52.63)	5 (36.36)	4/5 (39.39)
Servitization	4/5 (33.33)	5 (35.29)	4 (47.06)	4 (36.84)	4 (27.27)	4 (30.30)
Reuse	5 (44.44)	5 (64.71)	5 (52.94)	5 (63.16)	5 (45.45)	5 (45.45)
Recycling (closed loop recycling)	5 (77.78)	5 (82.35)	5 (76.47)	5 (63.16)	5 (36.36)	5 (57.58)
Recycling (open)	5 (66.67)	5 (64.71)	5 (70.59)	5 (47.37)	5 (45.45)	5 (57.58)
Recovery	4/5 (44.44)	5 (64.71)	5 (47.06)	5 (42.11)	5 (36.36)	5 (39.39)
Design for circular economy	5 (55.56)	5 (64.71)	4/5 (29.41)	5 (57.89)	4/5 (27.27)	4 (33.33)
Eco-design	5 (88.89)	5 (41.18)	4/5 (17.65)	5 (47.37)	4/5 (27.27)	5 (27.27)

Note: 1 = unimportant to 5 = very important

Results are presented by Mode. Corresponding percentages are given in brackets

Source: Personal elaboration of the authors.

The findings are calculated as weighted mean as well (Table 9.10). According to the results, several specific patterns could be identified. Recycling is considered very important by all participating countries except Greece. New business models and green entrepreneurship are important for Malta, Romania and Greece. Re-use and design for circular economy are important for UK while eco-design – for Malta.

Table 9.10

Importance of Different Aspects of Circular Economy by Countries, Weighted Mean

Aspects of circular economy	MT	RO	BG	UK	EL	ES
Principles of circular economy	4.00	3.71	3.29	3.89	4.18	3.45
New business models	4.22	4.18	3.00	3.63	4.00	3.67
Green entrepreneurs	4.11	4.18	3.41	3.79	4.09	3.73
Servitization	3.67	3.29	3.12	2.84	2.09	3.42
Reuse	3.89	4.18	3.76	4.37	3.00	3.79
Recycling (closed loop recycling)	4.33	4.35	4.00	4.26	2.45	3.97
Recycling (open)	4.22	4.18	3.88	3.68	2.91	3.85
Recovery	4.00	4.18	3.65	3.63	2.82	3.64
Design for circular economy	4.11	4.18	3.06	4.16	2.73	3.27
Eco-design	4.44	3.47	2.06	3.79	2.73	2.61

Note: 1 = unimportant to 5 = very important. Results are presented by weighted mean.
Source: Personal elaboration of the authors.

From a policy standpoint, addressing these aspects of circular economy means:

- Encouraging economic actors to take into account the economic value of their environmental effects and value chain inputs.
- Developing skills, awareness and investment in circular product design and production.
- Stimulating the improvement of cross-cycle and cross-sector performance.

- Encouraging a change in consumption patterns.
- Investment and innovation in recycling and recovery infrastructure and technologies.
- Based on study results three opportunity zones with corresponding implications for circular economy in digital environment are idenified (Table 9.11).

Table 9.11

Opportunity Zones for Implication of the "3G" Business Model for Circular Economy

Stage	Focus	Opportunity zone	Implications for circular economy
Design	Processes	Business model and key actors (challengers)	The culture and operating style should be adjusted to the company's digital strategy; Human-centered experiences including green products/ services; Digital dashboard (incl. carbon footprint) (it provides important markers beyond traditional financial metrics); Key operational KPIs; Adoption of agile principles; Understand how digital technologies can upend business models.
Direct	Work flows	Value creation	Reinvention (a zero-based redesign of the customer experience of a given task); Implementation of sprint-based processes (to maintain pace and a focus on creating value quickly); Regular check-ins; Test-and-learn sessions; Agile product development (it emphasizes a test-and-learn approach).
Develop	Talent management	Providing knowledge/ Developing skills, attitudes, and habits	Providing knowledge (digital and environmentally-friendly); Creating agile habits; Ability to commit time; Cross-functional teams.

Source: Personal elaboration of the authors.

In order to exploit the abovementioned opportunities top management needs better knowledge about the technology environment, its potential impact on different parts of the company and its value chain, and thus about how digital technologies can undermine existing strategies and stimulate the need for new ones. Management boards should invest in experimental initiatives (including circular economy) that could reshape markets. Additionally, today's strategic discussions need to match the speed of disruption and respond to real-time market signals about digital and eco-oriented shifts. Designing customer-centered solutions should be the core of the Design stage (Table 9.11). This requires reimagining the entire journey and identifying the most important proccesses to reimagine according to the principles of circular economy. New talents are needed to accomplish these activities such as user-experience designers, data storytellers, customer experience officers, qualified analysts.

Presented results and conclusions correspond to the findings of the EU study aimed at identification of the potential circular economy actions, priority sectors, material flows and value chains (Vanner et al., 2014). EU policies and actions by themselves are insufficient to secure progress towards circular economy in the EU, as they address only certain parts of the transition, focusing on individual sectors, products or policy 'silos'. The transition to a circular economy requires systemic change and a more holistic, integrated approach which takes into account the myriad of inter-linkages within and between sectors, within and across value chains and between actors. Such an approach would help to take into account the different incentives in play, the distribution of economic rewards and impacts of specific measures along a value chain, across different sectors and policy areas. Opportunities for increased circularity vary considerably across different firms, sectors, products and value chains. Moreover, the need for policy intervention beyond private initiatives (if any) and the type of intervention needed will vary according to the issue at hand. In some areas, the transition to a circular economy might materialise without intervention (particularly where products have high embedded material values, where incentives within the private sector allow moves towards more circular and/or service-based models independently); while in other areas support, including funding, and targeted public intervention is needed to encourage the transition. It is, therefore, important that the value chain structure and the business circularity for the different actors is understood in detail and taken into account in the policy development process.

BIBLIOGRAPHIC REFERENCE

- Amit, R. & Zott, C. (2001), Value creation in e-business. *Strategic Management Journal*, 22, pp.493-520.
- Ansari, A., Essegaier, S. & Kohli, R. (2000), Internet recommendation systems. *Journal of Marketing Research*, August 2000, 37 (3), pp.363-375.
- Bakos, Y. & Brynjolfsson, E. (1999), Bundling information goods: Pricing, profits and efficiency. *Management Science*, 45 (12), pp.1613–1630.
- Bakos, Y. & Brynjolfsson, E., (2000), Bundling and competition on the Internet. *Marketing Science*, 19 (1), pp. 63–82.
- Balasubramanian, S. (1998), Mail vs. mall: A strategic analysis of competition between direct marketers and conventional retailers. *Marketing Science*, 17 (3), pp.181–195.
- Brynjolfsson, E. & Smith, M.D. (2000), Frictionless commerce? A comparison of Internet and conventional retailers. *Management Science*, 46 (4), pp. 563–585.
- Degeratu, A.M., Rangaswamy, A. & Wu, J. (2000), Consumer choice behavior in online and traditional supermarkets: The effects of brand name, price, and other search attributes. *International Journal of Research in Marketing*, 17 (1), pp. 55–78.
- Ellen Macarthur Foundation (2015), Growth within: A circular economy vision for a competitive Europe [Онлайн]. Наличен на: https://www.ellenmacarthurfoundation.org/assets/downloads/publications/EllenMacArthurFoundation_Growth-Within_July15.pdf [Достъп на: 08-04-2018].
- European Commission. Sustainable natural resources - environment – European Commission, sustainable use of natural

resources. [Онлайн]. Наличен на: http://ec.europa.eu/environment/ archives/natres/index.htm. [Достъп на: 20-Feb-2017].

- European Commission. Green growth and circular economy - environment - European Commission. [Онлайн]. Наличен на: http://ec.europa.eu/environment/eussd/escp_en.htm. [Достъп на: 20-Feb-2017].
- European Commission. Integrated product policy - environment - European Commission. [Онлайн]. Наличен на: http://ec.europa.eu/ environment/ipp/index_en.htm. [Достъп на: 20-Feb-2017].
- European Commission. Resource efficiency - environment - European Commission. [Онлайн].Наличен на: http://ec.europa.eu/ environment/resource_efficiency/about/roadmap/index_en.htm. [Достъп на: 20-Feb-2017].
- Haubl, G. & Trifts, V. (2000), Consumer decision making in online shopping environments: The effects of interactive decision aids. *Marketing Science*, 19 (1), pp.4–21.
- Hislop, H. & Hill, J. (2011), Reinventing the wheel - a circular economy for resource security, Green Alliance, 5 October, 2011.
- Hoffman, D.L. & Novak, T.P. (2000), How to acquire customers on the Web. *Harvard Business Review*, 78 (3), pp. 179–188.
- Jara, A. J., Parra, M. C. & Skarmeta, A. F. (2012), Marketing 4.0. A new value added to the marketing through the internet of things. *2012 Sixth International Conference on Innovative Mobile and Internet Services in Ubiquitous Computing (IMIS)*, Palermo, pp. 852-857.
- Kaminaris, V., DE Graaf, D. Platis, E., Konti, K., SEV (Hellenic Federation of Enterprises) and EY. EY (2016) Study on the Circular Economy in Greece, May
- Lal, R. & Sarvary, M. (1999), When and how is the Internet likely to decrease price competition? *Marketing Science*, 18 (4), pp. 485– 503.
- Lynch JR., J.G. & Ariely, D. (2000), Wine online: Search costs affect competition on price, quality, and distribution. *Marketing Science*, 19 (1), pp. 83–103.
- MOE, W.M. & FADER, P.S.(2000), Capturing evolving visit behavior in clickstream data. *Working Paper*, The Wharton School.

- Mittal, V. & Sawhney, M.S. (2001), Learning and using electronic information products and services: A field study. *Journal of Interactive Marketing*, 15(1), pp. 2-12.
- Novak, T.P., Hoffman, S.L. & Yung, Y.-F., (2000), Measuring the customer experience in online environments: A structural modeling approach. *Marketing Science*, 19 (1), pp. 22–42.
- Shankar, V., Rangaswamy, A. & Pusateri, M. (1999), The online medium and customer price sensitivity. *Working Paper*, University of Maryland at College Park, MD.
- Shapiro, C. & Varian, H.R. (1998), Versioning: the smart way to sell information. *Harvard Business Review*, 76 (6), pp. 106–114.
- Vanner, R., Bicket, M., Withana, S., Brink, P., Razzini, P., Van Dijl, E., Watkins, E., Hestin, M., Tan, A., Guilcher, S. & Hudson, C. (2014), Scoping study to identify potential circular economy actions, priority sectors, material flows and value chains. Funded under DG Environment's Framework contract for economic analysis ENV.F.1/FRA/2010/0044, August 2014.
- Vassileva, B. & Ivanov, Y. (2017), "3G" Business Model for Marketing 4.0: Implications for Circular Economy. *Journal of Emerging Trends in Marketing and Management*. [http://www.etimm.ase.ro/?p=162].
- Venkatesh, R. & Chatterjee, R. (2000), Electronic publishing of print magazines: Optimal form and pricing. *Working Paper*, University of Pittsburgh.
- Werbach, K. (2000), Syndication: The emerging model for business in the Internet era. *Harvard Business Review*, 78 (3), pp. 85–93.
- Zettelmeyer, F. (2000), Expanding to the Internet: Pricing and communications strategies when firms compete on multiple channels. *Journal of Marketing Research*, August, pp. 292-308.
- Zott, C. & Amit, R. (2003), Business model design and the performance of entrepreneurial firms. *INSEAD Working Paper* 2003/94/ENT/SM/ACGRD 4.

ADDITIONAL REFERENCE

- Greening our economy – Achieving a sustainable future by the Ministry for Sustainable Development, the Environment and Climate change
- Programme of the Maltese Presidency of the Council of the European Union (1 January 2017 - 30 June 2017)
- Estrategias para la Gestión Sostenible de los Residuos en el Horizonte 2020. Fundación para la Economía Plan Estatal Marco de Gestión de Residuos (PEMAR) 2016-2022. BOE núm. 297, 12 de diciembre de 2015.

CONCLUSION

The interrelation between economics and the environment has been studied for over 50 years now in the hope of finding new approaches for overcoming and enhancing sustainable development in business. There has been a large number of international meetings and discussions, different documents have been released, such as strategies, plans and regulations. Circular economy as a concept is gaining greater popularity in the European member-states by the minute. This is to an extent due to the fact that over time concepts similar to the essence of circular economy are being enhanced – such as green economy (focusing on the way natural resources are used), bio-economy (focusing on eco-innovation, renewable energy sources, etc.), industrial economy (focusing on possible strategies for using natural resources such as water, energy, etc., wastes incl.). Circular economy is the new environmental trend in the development of businesses today. It is a clean and cost-efficient economy where each output waste from a production process can be used as an input product in another production process.

In the course of studying circular economy on a large scale in this monograph, we can draw the following conclusions:

Circular economy is a modern dynamic concept which allows for the use of innovative research and implementation approaches in different sectors of the economy;

- Circular economy and the implementation of its tools in Bulgaria are still not well known to both companies and users of services and goods;
- Circular economy opens new opportunities to businesses by requiring high environmental awareness of the managers, stimulation of the existing positive tendencies for sustainable development of the business and even greater motivation for the creation and implementation of eco-innovations;
- The pressure from the regulatory plane and environmental regulations are an important factor of institutional and investment support for the implementation of the principles of circular economy. The latter is of extreme importance for Bulgaria, as per the released in

2015 by the European Commission package of measures for circular economy;

- The implementation of circular economy tools is a prerequisite for environmental leadership in such strategic industries as the hospitality and wine, food and beverage production, and energy production industries.

The implementation of eco-innovations, eco-certifications and LCA can drastically improve a company's performance and as a result lead to greatly increased financial revenues.

- Entrepreneurs in the different European countries are differently aware of circular economy – some lack basic effective legislation (Bulgaria), others offer environmental education and projects (Malta, Greece) and yet third-ones form working structures (Spain) or implement concrete circular economy strategies (Scotland, UK). The raising of the awareness of the European entrepreneurs (in Bulgaria in particular) about the usefulness of implementing tools for evaluation of circular economy is a key factor for their marketing positioning and receiving profits from environmental activities.

Taking into consideration the complexity and dynamics of the development of the hospitality industry and food and beverage production in Bulgaria, this research is a first modest contribution to the study of circular economy by advancing concrete innovative approaches. The identifying of marketing tools for green entrepreneurship in the study of circular economy also serves for the establishment of the principles of circular economy in the European Union.

The future efforts of the authors are directed at doing research that will allow the testing of other conceptual models in different industries and/or countries, in accordance with the level to which the circular economy concept has evolved.

Appendix 4.1.

QUESTIONNAIRE CARD

LIFE CYCLE ASSESSMENT AT HOTEL CHECK-INS AND CARBON FOOTPRINT ESTIMATION

Dear Sir/Madam,

This study is part of Project 3 in Professional Trend 3.8, Economics, for a scientific research on "Innovative models for Circular Economy: Challenges and Possibilities for the Bulgarian Small and Medium-size Enterprises". Project 3 is developed as per Ordinance No.3 of the Ministry of Education of Bulgaria of 27/11/2015, approved with Report No.1 of 02/06/2016 by decision of the Competition Committee of the Scientific and Research Institute of Varna University of Economics 9founded with Ordinance No.285 of 21 october 2015 of the Ministerial council of the Republic of Bulgaria).

Goal of the Questionnaire: Evaluation of the environmental specifics through presentation of the life cycle in hotels – identifying possible problems and offering solutions.

Preliminary Information:
Please, define the type of hotel you are:
.... all-year-round hotel
.... seasonal hotel

If you ar an all-year-round hotel, please fill in the table for the whole year.
If you are a seasonal hotel, please fill in the table only for the specific season.

Please specify the number of permanent employees at the hotel for the period 2015-2016?
....

Please specify the annual number of guests at your hotel for the period 2015-2016?
....

Have you got an ISO 14001 Certificate? YES NO
If not, do you intend to acquire one? YES NO

Do you know what *carbon footprint* is? YES NO
If yes, do you wish to know how to estimate it? YES NO
Are you the manager at your hotel? YES NO

Please, fill in the Table for the 2015-2016 season?

Types of transport used by staff and km to reach the hotel (per day)	
Types of transport used by the hotel customers and km to reach the hotel (per day)	
Consumed electric power (kw/h) Consumed electric power (kw/h), related to air condition use (*if applicable*)	
Consumed water (litres)	
Deposited waste kg/t	
Typology of waste	Plastics kg/t Glass kg/t Paper kg/t Cardboard kg/t Tin kg/t Other kg/t
Transport to the waste dump site (km), per day (*if available*)	
Food waste (kg/t) per day (*if available*)	
Percentage recycled waste (*if available*)	
Cleaning detergents and solvents, (l/kg)	
If you have a pool Pool cleaning chemicals (kg/t)	
Laundry (*if you have one*) and quantity of used water (l)	
Used washing detergents (*if applicable*) (l/kg)	
Laundry used (*if no laundry at hotel*) km and type of transport used to and from the laundry	
Where and how do you get the food at the hotel (km and origin)	

THANK YOU FOR YOUR KIND COOPERATION!

Appendix 7.1

Ordinances Related to Food Industry

No.	TITLE	SUBJECT
Ordinances governing the requirements for finished products and the packaging materials		
1.	Ordinance No. 1 of 26 January 2016 on food hygiene[41].	1. Hygiene requirements for manufacturers and retailers of food, including operators of primary food production and related activities; 2. Hygiene requirements for primary food production; 3. Hygiene requirements for food production and trade facilities; 4. Conditions for production and trade of foods.
2.	Ordinance No. 6 of 05/05/2011 on the specific requirements for the official control on the use of protected geographical indications and traditional specialties guaranteed.[42]	The ordinance regulates the terms and procedures for carrying out official controls on the use of geographical indications and traditional specialties guaranteed on agricultural products. Control is exercised during the production, labelling and placing on the market of agricultural products and foodstuffs with protected geographical indications and of traditional specialties guaranteed.
3.	Ordinance No. 1 of 07/02/2013 on the application of the rules for organic production of plants, animals and aquaculture, plant and animal products, aquaculture products and foods, their labelling and the control on production and labelling[43].	Prescribes the terms and procedures for application of the rules for organic production of plants, animals and aquaculture, plant and animal products, aquaculture products and foods, their labelling and the control on their production and labelling in accordance with Council Regulation (EC) No. 834/2007 of 28/06/2007 on organic production and labelling of organic products and repealing Regulation (EEC) No. 2092/91 (OJ No. L 189 of 20/07/2007, p. 1) and Commission Regulation (EC) No. 889/2008 of 5

[41] Prom. SG 10 of 5 February 2016.
[42] Prom. SG 39 of 20 May 2011, am. and suppl. SG 69 of 19 August 2014.
[43] Prom. SG 16 of 19.02.2013, in force as of 19.02.2013, am. and suppl., SG 63 of 01.08.2014.

		September 2008 laying down detailed rules for the implementation of Council Regulation (EC) 834/2007 on organic production and labelling of organic products with regard to organic production, labelling and control (OJ No. L 250 of 18/09/2008, p. 1).
4.	Ordinance No. 1 of 09/01/2008 on the requirements for eggs trade[44].	Regulates the requirements for the supply, storage, transportation, grading, marking and packing of eggs from hens of the *Gallus gallus* species and the procedures for inspections of their placing on the market, with a view to ensure compliance with EC Regulations.
5.	Ordinance No. 2 of 23/01/2008 on plastic materials and objects intended to come into contact with foodstuffs[45].	Defines the materials and objects, including active and intelligent materials and articles of plastics intended to come into contact with foodstuffs, the purity of the substances and the specific conditions of their use; the permissible levels of migration of low-molecular substances from materials and objects in or on the foodstuffs they come into contact with; rules for controls on materials and objects and on the substances of which they are made; the manner of labelling and marking of materials and objects and the information that must accompany them in their placing on the market; the procedure for carrying out official controls on materials and articles.
6.	Ordinance No. 2 of 23.01.2015 on the maximum residue levels	The ordinance regulates the maximum residue levels (MRLs) of pesticides in or on foods; conditions and procedures for

[44] Prom. SG 7 of 22.01.2008, in force as of 22.01.2008, am. and suppl., SG 9 of 31.01.2012, SG94 of 29.10.2013, amended by Decision No. 8770 of 16.07.2015 of the Supreme Administrative Court – SG 100 of 18.12.2015.

[45] Prom. SG 13 of 08.02.2008, in force as of 08.02.2008, am. and suppl., SG. 86 of 03.10.2008, in force as of 01.01.2010, SG 62 of 10.08.2010, in force as of 10.08.2010, SG 44 of 10.06.2011, in force as of 10.06.2011, SG 2 of 06.01.2012, in force as of 06.01.2012, suppl., SG 25 of 27.03.2012, in force as of 27.03.2012, am. and suppl., SG 72 of 16.08.2013, in force as of 16.08.2013.

	of pesticides in or on foods[46].	sampling in the conduct of official controls on pesticide residues in or on foodstuffs of plant and animal origin. This ordinance applies to products intended for human consumption as listed in Annex I to Regulation (EC) 396/2005 of the European Parliament and of the Council of 23 February 2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin and amending Council Directive 91/414/EEC (special edition in Bulgarian, 2007, Chapter 03, Volume 63).
7.	Ordinance No. 2 of 23/02/2017 on the specific requirements for production, collection, transportation and processing of raw cow's milk, the placing on the market of milk and milk products and their official control[47].	Lays down the terms and procedures for: 1. The conduct of official controls and evaluation of farms for production of raw cow's milk in accordance with the general requirements set out in Annex III, Section IX, Chapter I of Regulation (EC) 853/2004 of the European Parliament and of the Council of 29 April 2004 laying down specific hygiene rules for food of animal origin (OJ, L 226, 25/07/2004) The (Regulation (EC) No. 853/2004), including sampling of raw milk in relation to the specific requirements of Annex III, Section IX, Chapter I, Art. III, paragraphs 1 and 2 of Regulation (EC) No. 853/2004; 2. The monthly sampling of raw cow's milk for the purpose of self-control in accordance with the provisions set out in Annex III, Section IX, Chapter I, Art. III, paragraph 1, paragraph 2, items "a – c", paragraph 3, item "a", item "i" and paragraph 4 of Regulation (EC) 853/2004; 3. Control of laboratories, test methods and system for electronic processing of the results of the analysis of raw cow's milk; 4. Remedial action upon receipt of unsatisfactory results from the official control and evaluation of the farms and/or results of the analysis of raw cow's milk in accordance with paragraphs 1 and 2;

[46] Prom. SG 9 of 03.02.2015, in force as of 03.02.2014.
[47] Prom. SG 20 of 07.03.2017, in force as of 07.03.2017.

		5. Processing and marketing of raw milk and dairy products made from milk that does not meet the requirements of Regulation (EC) 853/2004 as regards total number of microorganisms (TNM), total number of somatic cells (TNSC) and the structure and hygiene of farms; 6. Tracking of raw cow's milk and identification marking of milk and dairy products intended for the EU market or exclusively for the Bulgarian market; 7. Frequency of inspections based on risk analysis for food business operators throughout the food chain in the dairy sector; 8. Carrying out own checks and fulfilment of self-control obligations of interested parties throughout the raw milk and dairy products production chain.
8.	Ordinance No. 3 of 04/06/2007 on the specific requirements for materials and articles other than plastics intended to come into contact with food[48].	Sets forth the specific requirements for materials and articles, including active and intelligent materials and articles other than plastics, intended to come into contact with food. Materials and articles which do not meet the requirements of the Community legislation and of this Ordinance are not allowed for preparation, packaging, transportation, storage, sale or serving of foodstuffs. When batches of materials or articles are marketed, except for the retail stage, they must be accompanied by a statement from the manufacturer in accordance with Regulation No. 1935/2004 on materials and articles intended to come into contact with food.
9.	Ordinance 9 of 16/03/2001 on the quality of water intended for drinking and other domestic purposes[49].	Lays down the requirements for the quality of water intended for drinking and other domestic purposes. The ordinance aims to protect human health from the adverse effects of contaminated drinking water, by

[48] Prom. SG. 51 of 26.06.2007, suppl. SG 13 of 8.02.2008, in force as of 8.02.2008, am. and suppl. SG. 83 of 23.09.2008, in force as of 23.09.2008.

[49] Prom. SG 30 of 28.03.2001, am. SG 87 of 30.10.2007, in force from 30.10.2007, am. and suppl. SG 1 of 4.01.2011, am. SG 15 of 21.02.2012, in force from 21.02.2012, am. and suppl. SG 102 of 12.12.2014.

		setting requirements for its quality and safety.
10.	Ordinance on the labelling and presentation of food[50].	The ordinance defines the requirements for: 1. the labelling, presentation and advertising of foodstuffs in order to ensure the consumers' right to information; 2. nutrition labelling, including when a nutrition or health claim is made. Food is labelled in accordance with Regulation (EC) No. 1169/2011 of the European Parliament and of the Council of 25 October 2011 on the provision of food information to consumers, amending Regulations (EC) No. 1924/2006 and (E) No. 1925/2006 of the European Parliament and the Council.
11.	Ordinance No. 16 of 28/05/2010 on the quality requirements and compliance control of fresh fruit and vegetables[51].	Regulates the quality requirements and the terms and procedures for carrying out compliance controls on fresh fruit and vegetables and maintaining a database on traders of fresh fruit and vegetables.
12.	Ordinance No. 9 of 22/06/2005 on the terms and procedures for approval and registration of beeswax processors and comb foundation producers, as well as of producers and traders of honey and bee products[52].	Lays down the terms and procedures for approval and registration of beeswax processors and comb foundation producers, as well as of honey and bee products producers and traders; The activities related to beeswax processing, comb foundations production, and honey and bee products production and trade must comply with certain animal health and hygiene requirements for: 1. extraction, primary processing and marketing of natural and heat-treated honey and other bee products; 2. construction and operation of facilities for storage, processing and packaging of honey and beeswax, production of comb foundations, bee feed and other bee products in retail packaging.

[50] Prom. SG 102 of 12.12.2014, in force from 13.12.2014.
[51] Prom. SG 43 of 08.06.2010, am. SG 71 of 13.09.2011.
[52] Prom. SG 54 of 1.07.2005.

13.	Ordinance No. 15 of 28/06/2002 on the requirements for the use of food flavourings[53].	This ordinance contains: 1. A list of flavourings and source materials for their production listed in the Annex to Commission Implementing Regulation (EU) No. 872/2012 of 1 October 2012 adopting the list of flavouring substances provided for by Regulation (EC) No 2232/96 of the European Parliament and of the Council, introducing it in Annex I to Regulation (EC) No 1334/2008 of the European Parliament and of the Council and repealing Commission Regulation (EC) No 1565/2000 and Commission Decision 1999/217/EC(OJ, L 267, 02.10.2012); 2. A list of authorised smoke flavouring primary products for use as such in or on foods and/or for the production of derived smoke flavourings, as specified in the Annex to Commission Implementing Regulation (EU) 1321/2013 of 10 December 2013 establishing the Union list of authorised smoke flavouring primary products for use as such in or on foods and/or for the production of derived smoke flavourings.
14.	Ordinance No. 17 of 16/06/2008 on animal health requirements for aquaculture animals and products thereof and on the prevention and control of diseases in aquaculture animals[54].	The ordinance defines: 1. animal health conditions to be met in the placing on the market, the importation and transit of aquaculture animals and products thereof; 2. precautions taken by the Bulgarian Food Safety Agency regarding the control of diseases in aquaculture animals, as well as measures taken by regulators of aquaculture business and of other associated sectors.
15.	Ordinance No. 22 of 13/10/2003 on the terms and procedure for sampling of foodstuffs[55].	The ordinance prescribes the terms and procedure for sampling of domestically produced or imported foodstuffs, for carrying out laboratory analysis for the purposes of

[53] Prom. SG 70 of 19.07.2002, in force from 20.01.2003, am. and suppl.SG. 62 of 01.08.2006, in force from 01.08.2006, SG 39 of 25.05.2010, in force from 25.05.2010, am. SG 68 of 02.08.2013, in force from 02.08.2013, am. and suppl., SG 39 of 09.05.2014, in force from09.05.2014.

[54] Prom. SG64 of 18.07.2008, in force as of 01.08.2008, am. and suppl., SG 24 of12.03.2013, in force as of 12.03.2013, SG58 of 15.07.2014, in force as of 16.11.2014.

[55] Prom. SG. 93 of 21.10.2003

		the official control of foodstuffs. Official regulators can take food samples as part of controls carried out in production and trading facilities. Food samples are taken also in the following cases: 1. notifications of the presence of dangerous and substandard foods on the market; 2. in the investigation of nutritional diseases; 3. in case of suspected contamination of food due to natural disasters, industrial accidents and other incidents; 4. in the course of forensic examinations; 5. at the request of individuals and legal entities.
16.	Ordinance No. 26 of 14/10/2010 on the specific requirements for direct supply of small quantities of raw materials and foodstuffs of animal origin[56].	The ordinance governs the terms and procedures for: 1. Direct supply from the producer to the final consumer or to local retail establishments directly supplying the final consumer, in small quantities: a) primary products - raw milk, honey and bee products, eggs from hens and quail and fresh and refrigerated sea and freshwater fish; b) fresh meat of poultry and rabbits slaughtered at the farm; c) big and small wild game or meat from big or small wild game; 2. Supply of food of animal origin, processed and/or reprocessed in a retail establishment, to other retail establishment as a marginal, localized and restricted activity; 3. The registration of persons carrying out direct supply under item 1, and registration of retail establishments carrying out supply of food under item 2.
17.	Ordinance No. 47 of 28/12/2004 on the	Lays down the requirements for dietary supplements. Dietary supplements are

[56] Prom SG 84 of 26.10.2010, in force as of 26.10.2010; amended by Decision 16678 of 16.12.2011 of the Supreme Administrative Court – SG 46 of 19.06.2012; am. and suppl., SG 46 of 3.06.2014, in force as of 3.06.2014, SG 87 of 10.11.2015, in force as of 10.11.2015.

	requirements for dietary supplements[57].	marketed as foodstuffs, presented as such and reach the final consumer pre-packaged.
18.	Ordinance No. 48 of 11/11/2003 on the terms and procedure of sampling and on the methods used for analysis of honey[58].	The ordinance prescribes the procedure and manner of sampling and the methods of analysis of honey. The analysis of honey is performed to determine: the organoleptic properties; sugars content; water content; water-insoluble impurities; electrical conductivity; free acidity; diastatic activity; the amount of hydroxymethylfurfural; pollen characteristics.
19.	Ordinance No. 119 of 21/12/006 on measures to control certain substances and their residues in live animals, raw materials and foodstuffs of animal origin intended for human consumption[59].	Contains the control measures applied by the National Veterinary Service (NVS) to monitor the substances and groups of residues listed in Annex 1; requirements for self-control of owners of animals, raw materials and foodstuffs of animal origin intended for human consumption; measures taken by the NVS in case of suspicion or evidence of violations.
20.	Ordinance on the requirements for quick-frozen foods[60].	Sets forth the requirements for manufacturers and retailers in respect of: 1. the characteristics and the name of quick-frozen foodstuffs intended for human consumption; 2. the maximum temperatures during transport and storage of quick-frozen foodstuffs; 3. methods for labelling and marking of quick-frozen foodstuffs; 4. the sampling procedure and the method measuring the temperature of quick-frozen foodstuffs.
21.	Ordinance on the requirements for cereal-based food and food for	The ordinance defines the requirements for the composition, characteristics and labelling of cereal-based foods intended to meet the

[57] Prom. SG 5 of 14.01.2005, in force as of 1.08.2005, am. and suppl., SG90 of 11.11.2005, SG 44 of 5.06.2007, amended SG 90 of 16.11.2010, in force as of 16.11.2010.

[58] Prom. SG 103 of 25.11.2003.

[59] Prom. SG 6 of 19.01.2007, in force as of 19.01.2007.

[60] Prom. SG 114 of 6.12.2002, in force as of 07.12.2003, amended SG 20 of 7.03.2006, in force as of 31.03.2006, am. and suppl., SG 39 of 15.05.2007, in force as of 15.05.2007, SG 84 of 27.09.2013, in force as of 1.07.2013.

	infants and young children[61].	specific nutritional needs of infants and young children in good health.
22.	Ordinance on special purpose food[62].	The ordinance defines the requirements to producers and retailers regarding the composition, characteristics and names of special purpose foodstuffs. Special purpose foodstuffs are those whose special composition or production process separate them clearly from foodstuffs for ordinary consumption, and which comply with the stated specific nutritional purposes and are sold in a way indicating their use. Special purpose foodstuffs must correspond to the specific nutritional needs of one of the following categories of people: 1. people with disturbed digestive or metabolic processes; 2. people who due to specific physiological conditions can benefit from controlled consumption of certain substances contained in the foodstuffs; 3. infants and young children in good health.
23.	Ordinance on the cocoa and chocolate products[63].	The ordinance defines the requirements to producers and retailers regarding the name, composition and characteristics of cocoa and chocolate products.
24.	Ordinance on the requirements for certain partly or wholly dehydrated milks for human consumption[64].	The ordinance defines the requirements to the names, composition, characteristics, labelling, sampling and analysis methods for certain partly or wholly dehydrated milks for human consumption.

[61] Prom. SG 27 of 25.03.2003, in force as of 1.01.2004, am. and suppl., SG55 of 25.06.2004.

[62] Prom. SG 107 of 15.11.2002, in force as of 1.04.2004, am. and suppl., SG 69 of 23.08.2005, SG 15 of 16.02.2007, SG 75 of 18.09.2007, in force as of 18.09.2007, SG 47 of 22.06.2010, in force as of 1.01.2012, SG 86 of 11.02.2010, in force as of 02.11.2010.

[63] Prom. SG 107 of 15.11.2002, in force as of 1.08.2003.

[64] Prom. SG 8 of 30.01.2004, in force as of 1.07.2004, am. and suppl., SG 89 of 6.11.2007, in force as of 6.11.2007, SG 54 of 13.06.2008, in force as of 31.08.2008.

25.	Ordinance on honey intended for human consumption[65].	The ordinance defines the requirements for the composition, characteristics and names of honey intended for human consumption.
26.	Ordinance on fruit jams, jellies, marmalades, jelly-marmalades and sweetened chestnut purée[66].	The ordinance defines the requirements for the names, composition, characteristics, labelling and production of fruit jams, jellies, marmalades, jelly-marmalades and sweetened chestnut purée intended for human consumption.
27.	Ordinance on the composition, characteristics and names of infant formulas and follow-on formulas[67].	The ordinance defines the requirements to producers and retailers regarding the names, composition, characteristics, labelling, presentation and advertising of infant formulas and follow-on formulas.
28.	Ordinance on the composition and characteristics of salt for food[68].	The ordinance defines the requirements for the composition and characteristics of salt for food, which is made available to consumers, used in the catering industry and in the production of food products.
29.	Ordinance on sugar intended for human consumption[69].	The ordinance defines the requirements for the names, characteristics, composition, labelling and methods of analysis of sugars intended for human consumption.

Source: Personal elaboration of the authors.

[65] Prom. SG 85 of 5.09.2002, in force as of 1.08.2003, am. and suppl., SG 39 of 05.29.2015, in force as of 06.24.2015.

[66] Prom. SG 19 of 28.02.2003, in force as of 12.07.2003.

[67] Prom. SG 110 of 21.12.2007, in force as of 1.01.2008, suppl., SG 37 19.05.2009, am. and suppl., SG 84 of 27.09.2013, in force as of 1.07.2013, SG 28 of 28.03.2014, in force as of 03.28.2014.

[68] Prom. SG 11 of 6.02.2001, amend. SG 96 of 9.11.2001. amended SG No.58 of30.07, 2010.

[69] Prom. SG 89 of 20.09.2002, in force as of 12.07.2003, amended SG 114 of 30.12.2003, in force as of 30.12.2003, SG 1 of 6.01.2004.

Appendix 7.2

Directives and Regulations Relating to the Food Industry

No.	NAME	EU LEGISLATION
Directives relating to the food industry[70]		
1.	Foodstuffs	Council Directive 97/78/EC of 18 December 1997 laying down the principles governing the organization of veterinary checks on products entering the Community from third countries. Directive 2000/13/EC of the European Parliament and of the Council of 20 March 2000 on the approximation of the laws of the Member States relating to the labelling, presentation and advertising of foodstuffs. Council Directive 2001/110/EC of 20 December 2001 relating to honey. Council Directive 2002/99/EC of 16 December 2002 laying down the animal health rules governing the production, processing, distribution and introduction of products of animal origin for human consumption. Commission Directive 2008/5/EC of 30 January 2008 concerning the compulsory indication on the labelling of certain foodstuffs of particulars other than those provided for in Directive 2000/13/EC of the European Parliament and of the Council.
Regulations relating to the food industry[71]		
1.	Foodstuffs	Regulation (EC) No. 1924/2006 of the European Parliament and of the Council of 20 December 2006 on nutrition and health claims made on foods Council Regulation (EC) No. 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No. 2092/91 Commission Regulation (EC) No. 889/2008 of 5 September 2008 laying down detailed rules for the implementation of Regulation (EC) No. 834/2007 on organic production and labelling of organic

[70] BFSA, Documents, European legislation, Directives http: //www.babh.government.bg/bg/Page/102/index/102/Директиви [Site accessed 27.08.2017]

[71] BFSA, Documents, European legislation, Regulations. http: //www.babh.government.bg/bg/Page/118/index/118/Регламенти [Site accessed 27.08.2017]

		products with regard to organic production, labelling and control. Regulation (EC) No. 1760/2000 of the European Parliament and of the Council of 17 July 2000 establishing a system for the identification and registration of bovine animals and regarding the labelling of beef and beef products and repealing Council Regulation (EC) No. 820/97. Commission Regulation (EU) No. 10/2011 of 14 January 2011 on plastic materials and articles intended to come into contact with food. Council Regulation (EC) No. 1/2005 of 22 December 2004 on the protection of animals during transport and related operations and amending Directives 64/432/EEC and 93/119/EC and Regulation (EC) No. 1255/97 Commission Regulation (EC) No. 466/2001 of 8 March 2001 setting maximum levels for certain contaminants in foodstuffs. Regulation (EU) No. 1308/2013 of the European Parliament and of the Council of 17 December 2013 establishing a common organization of the markets in agricultural products and repealing Council Regulations (EEC) No. 922/72, (EEC) No. 234/79, (EC) No. 1037/2001 and (EC) No. 1234/2007. Council Regulation (EC) No. 509/2006 of 20 March 2006 on agricultural products and foodstuffs as traditional specialties guaranteed. Commission Delegated Regulation (EU) No. 664/2014 of 18 December 2013 supplementing Regulation (EU) No. 1151/2012 of the European Parliament and of the Council with regard to the establishment of the Union symbols for protected designations of origin, protected geographical indications and traditional specialities guaranteed, and with regard to certain rules on sourcing, certain procedural rules and certain additional transitional rules. Regulation (EC) No. 1829/2003 of the European Parliament and of the Council of 22 September 2003 on genetically modified food and feed. Regulation (EC) No. 1830/2003 of the European Parliament and of the Council of 22 September 2003 concerning the traceability and labelling of genetically modified organisms and the traceability of food and feed products produced from

		genetically modified organisms and amending Directive 2001/18/EC. Commission Regulation (EU) No. 16/2011 of 10 January 2011 laying down implementing measures for the Rapid Alert System for food and feed. Regulation (EU) No. 609/2013 of the European Parliament and of the Council of 12 June 2013 on food intended for infants and young children, food for special medical purposes, and total diet replacement for weight control and repealing Council Directive 92/52/EEC, Commission Directives 96/8/EC, 1999/21/EC, 2006/125/EC and 2006/141/EC, Directive 2009/39/EC of the European Parliament and of the Council and Commission Regulations (EC) No 41/2009 and (EC) No 953/2009**.** Commission Regulation (EC) No. 41/2009 of 20 January 2009 on the composition and labelling of foodstuffs suitable for people intolerant to gluten Commission Regulation (EC) No. 1170/2009 of 30 November 2009 amending Directive 2002/46/EC of the European Parliament and of the Council and Regulation (EC) No. 1925/2006 of the European Parliament and of the Council as regards lists with vitamins and minerals, and their forms that can be added to foods, including food supplements. Commission Implementing Regulation (EU) No. 29/2012 of 13 January 2012 on marketing standards for olive oil. Commission Regulation (EC) No. 1825/2000 of 25 August 2000 laying down detailed rules for the application of Regulation (EC) No. 1760/2000 of the European Parliament and of the Council as regards the labelling of beef and beef products. Regulation (EC) No. 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety. Regulation (EC) No. 2065/2003 of the European Parliament and of the Council of 10 November 2003 on smoke flavourings used or intended for use in or on foods. Regulation (EC) No. 2160/2003 of the European Parliament and of the Council of 17 November

		2003 on the control of Salmonella and other specified food-borne zoonotic agents.
2.	Food Hygiene	Regulation (EC) No. 852/2004 of the European Parliament and of the Council of 29 April 2004 on the hygiene of foodstuffs. Regulation (EC) No. 853/2004 of the European Parliament and of the Council of 29 April 2004 laying down specific hygiene rules for food of animal origin. Regulation (EC) No. 854/2004 of the European Parliament and of the Council of 29 April 2004 laying down specific rules for the organization of official controls on products of animal origin intended for human consumption.
3.	Materials in Contact with Food	Regulation (EC) No. 1935/2004 of the European Parliament and of the Council of 27 October 2004 on materials and articles intended to come into contact with food and repealing Directives 80/590/EEC and 89/109/EEC. Regulation (EC) No. 396/2005 of the European Parliament and of the Council of 23 February 2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin and amending Council Directive 91/414/ EEC. Commission Regulation (EC) No. 2023/2006 of 22 December 2006 on good manufacturing practice for materials and articles intended to come into contact with food. Commission Regulation (EC) No. 450/2009 of 29 May 2009 on active and intelligent materials and articles intended to come into contact with food.
4.	Food Control	Commission Regulation (EC) No. 2073/2005 of 15 November 2005 on microbiological criteria for foodstuffs. Commission Regulation (EC) No. 2075/2005 of 5 December 2005 laying down specific rules on official controls for Trichinella in meat. Commission Regulation (EC) No. 401/2006 of 23 February 2006 laying down methods of sampling and analysis for the official control of the levels of mycotoxins in foodstuffs. Commission Regulation (EC) No. 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs.

		Commission Regulation (EC) No. 1882/2006 of 19 December 2006 laying down methods of sampling and analysis for the official control of the levels of nitrates in certain foodstuffs. Commission Regulation (EC) No. 333/2007 of 28 March 2007 laying down the methods of sampling and analysis for the official control of the levels of lead, cadmium, mercury, inorganic tin, 3-MCPD and benzo(a)pyrene in foodstuffs. Regulation (EC) No. 1331/2008 of the European Parliament and of the Council of 16 December 2008 establishing a common authorization procedure for food additives, food enzymes and food flavourings. Regulation (EU) No. 1151/2012 of the European Parliament and of the Council of 21 November 2012 on quality schemes for agricultural products and foodstuffs. Commission Regulation (EU) No. 252/2012 of 21 March 2012 laying down methods of sampling and analysis for the official control of the levels of dioxins, dioxin-like PCBs and non-dioxin-like PCBs in certain foodstuffs and repealing Regulation (EC) No. 1883/2006. Commission Implementing Regulation (EU) No. 543/2011 of 7 June 2011 laying down detailed rules for the application of Council Regulation (EC) No. 1234/2007 in respect of the fruit and vegetables and processed fruit and vegetables sectors. Commission Implementing Regulation (EU) No. 1333/2011 of 19 December 2011 laying down marketing standards for bananas, rules on the verification of compliance with those marketing standards and requirements for notifications in the banana sector.

Source: Personal elaboration of the authors.

Appendix 7.3.

QUESTIONNAIRE CARD
SURVEY ON THE PERCEPTION OF USERS ABOUT FOODSTUFFS WITH EDIBLE COATINGS AND FILMS

This survey aims at studying the perception of users to choose, buy and consume foods with edible coatings and films. The questionnaire is concise and requires a minimum amount of time to fill in and its online availability guarantees your complete anonymity. Even so, we do guarantee that all data from the survey will be used explicitly for the purposes of our survey only – Project 3 in Professional Trend 3.8, Economics, for a scientific research on "Innovative models for Circular Economy: Challenges and Possibilites for the Bulgarian Small and Medium-size Enterprises". The results will be given only as a summary report.

The summary report is available to any interested party at their request. Thank you for your time!

The questionnaire comprises 22 questions.

I. <u>GENERAL PERCEPTION TOWARDS PROCESSED AND CANNED FOODS</u>

[1.] Please indicate how frequently you buy the following products?
Please select an answer for each element

[2.]Please give your opinion on the following statements:
Please select an answer for each element

	Strongly agree	Somewhat agree	Somewhat disagree	Strongly disagree	Neither agree nor disagree
In our household we prefer processed and canned foods.	○	○	○	○	○
I believe frozen foods retain better the nutrients and vitamins.	○	○	○	○	○
I believe unprocessed foods are really healthy.	○	○	○	○	○

[3.] Which of the following do you consume the most frequently?

Please classify with 1 to 3 in accordance with your preferences
- Processed and canned foods
- Frozen foods
- Unprocessed foods

Please classify 1-3: from 1= the most frequently to 3 = rarely and 0 – if never

[4.] Please indicate the significance of each of the factors listed below which influence your decisions to buy processed food. Please select the best answer for each element.

	Not important	Of little importance	Somewhat important	Important	Very important
Price					
Packaging					
Trademark					
Type of product (fruit, vegetables, meat, milk, etc.)					
Consumer appeal					
Quality					
Producer					
Quantity					
Other					

[5.] What other factors influence your choice to buy processed foods?
Please write your answer here.

....

[6.] Please indicate the significance of each of the factors listed below which influence your decisions to buy unprocessed food.
Please select the best answer for each element

	Not important	Of little importance	Somewhat important	Important	Very important
Price	○	○	○	○	○
Packaging	○	○	○	○	○
Trademark	○	○	○	○	○
Type of product (fruit, vegetables, meat, milk, etc.)	○	○	○	○	○
Consumer appeal	○	○	○	○	○
Quality	○	○	○	○	○
Producer	○	○	○	○	○
Quantity	○	○	○	○	○
Other	○	○	○	○	○

[7.] What other factors influence your choice to buy unprocessed foods?
Please write your answer here.

....

II. <u>CONSUMER PERCEPTION TOWARDS FOODS WITH EDIBLE COATINGS OR FILMS</u>

[1.] Are aware what edible coatings and films are?
Please select one of the following answers:
- Yes
- Rather yes
- Rather no
- No
- Neither yes, nor no

Edible coatings are an unbroken, thin layer of protein, polysacharides, lipids and antibacterial components or a combination of those. Applied on the foods, they improve the quality, slow down the changes in their composition and properties, prolong their shelf-life, and improve their consumer appeal (e.g. apples with layer of paraffin), and in some cases provide foods with desired qualities (colour, aroma, flavour).

[2.] In your opinion, which are the main advantages of edible coatings and films applied on foods?
Please indicate for each element.

	1	2	3	4	5
They guarantee food safety	○	○	○	○	○
They improve the quality and the self-life of foods	○	○	○	○	○
They give foods a better appearance	○	○	○	○	○
The improve the nutritional qualities of foods	○	○	○	○	○
Other advantages	○	○	○	○	○

Please classify from 1 to 5, with 1 = the most important quality and 5 = the least important quality.

[3.]What other advantages of edible coatings and films can you point out?
Please write your answer here.

....

[4.]Please indicate to what extent you agree with the following statements:
Please indicate for each element.

	Strongly agree	Somewhat agree	Somewhat disagree	Strongly disagree	Neither agree nor disagree
I would like to consume foods with edible coatings/films	○	○	○	○	○
I would replace the processed foods I consume with foods with edible coatings	○	○	○	○	○
I would buy foods with edible coatings/films with their price is not different from the price of the foods I buy now.	○	○	○	○	○

	Strongly agree	Somewhat agree	Somewhat disagree	Strongly disagree	Neither agree nor disagree
I would buy foods with edible coatings/films irrespective of the price.	○	○	○	○	○

Edible coatings/films applied on foods give foods an attractive consumer appeal and a longer shelf-life but do not influence the composition or taste of the foods.

[5.] For each of the prices for a kilo of tomatoes with an edible film, please indicate from 1 to 3: 1 = Too cheap; 2=Too expensive; 3=Acceptable price. Please indicate for each element.

	1 = Too cheap	2 = Too expensive	3 = Acceptable price
1.80 BGN	○	○	○
2 BGN	○	○	○
2.20 BGN	○	○	○
2.40 BGN	○	○	○
2.60 BGN	○	○	○
2.80 BGN	○	○	○
3 BGN	○	○	○
3.20 BGN	○	○	○
3.40 BGN	○	○	○
3.60 BGN	○	○	○
3.80 BGN	○	○	○
4 BGN	○	○	○

Too cheap means – so cheap that it makes you doubt the quality of the product.
Acceptable price means – the best quality for the money.

[6.] For each of the prices for a kilo of apples with an edible film, please indicate from 1 to 3: 1 = Too cheap; 2=Too expensive; 3=Acceptable price. Please indicate for each element.

	1 = Too cheap	2 = Too expensive	3 = Acceptable price
1 BGN	○	○	○
1.20 BGN	○	○	○
1.40 BGN	○	○	○
1.60 BGN	○	○	○
1.80 BGN	○	○	○
2 BGN	○	○	○
2.20 BGN	○	○	○
2.40 BGN	○	○	○
2.60 BGN	○	○	○
2.80 BGN	○	○	○
3 BGN	○	○	○
3.20 BGN	○	○	○

Too cheap means – so cheap that it makes you doubt the quality of the product.
Acceptable price means – the best quality for the money.

[7.] Please indicate your level of consent to pay a higher price for foods with edible coatings or films.

Please indicate in each box your preference from 1 to 5.
- Strongly agree;
- Somewhat agree;
- Somewhat disagree;
- Disagree;
- Neither agree nor disagree.

Please specify with 1 to 5, where 1= I agree to pay a high price and 5 means I do not agree to pay a high price.

An eco-innovation is every innovation leading to a significant advancement towards achieving the goal of sustainable development by decreasing the industrial footprint on the environment, increasing nature's resilience towards ecological pressures or achieving a more efficient and responsible use of natural resources. Eco-innovations enhance the advent of new processes, technologies and services, etc. Eco-innovations are also an opportunity for the enterprises –

they lead to cost reduction, enhance the implementation of new growth opportunities and strengthen the image of the enterprise to its customers. Eco-innovations encourage the enterprises to replace end-of-the-pipe decisions with closed loop approaches which reduce greatly the material and energy flows by changing products and methods of manufacture, which, in this way, bring competitive advantage into many enterprises and sectors.

[8.] Please share your opinion about the following:
Please indicate for each element.

	Yes	Rather yes	Rather no	No	Can't say
Are you aware of the eco-innovations which the manufacturers of foods with edible films and coatings have to introduce in order to guarantee the reduction of generated wastes?	○	○	○	○	○
If the manufacturer of foods with edible films and coatings has already introduced an eco-innovation or is in possession of EMAS, ISO 14001 or another certificate, will this fact influence your choice?	○	○	○	○	○
If the manufacturer of foods with edible films and coatings generates a negligible amount of waste or collects their production waste separately, will this fact influence your choice?	○	○	○	○	○
Are the markings in the labels of foods with edible coatings or films understandable to you and will this influence your choice?	○	○	○	○	○

[9.] What additional information in the markings of the labelling of foods with edible coatings or films would be of interest to you?
Please write your answer here.

....

III. DEMOGRAPHIC BLOC

[1.] Gender:
Please select one of the following:
- Female
- Male
- No answer

[2.] Please state your age?
Please select one of the following:
- Under 18
- 18-25
- 26-35
- 36-45
- 46-55
- 56-65
- Over 65

Select one answer only.

[3.] Please state level of education.
Please select one of the following:
- Secondary education student
- School graduate
- University student
- Professional Bachelor's Degree holder
- Bachelor's or Master's Degree holder
- PhD Degree holder.

Select one answer only.

[4.] What is the average monthly income of your household?
Please select one of the following:
- Under 500 BGN
- 500 – 999 BGN
- 1 000 – 1 999 BGN
- 2 000 – 2 999 BGN
- 3 000– 3 999 BGN
- 4 000– 4 999 BGN
- Over 5000 BGN

Select one answer only.

[5.] Which one of the following fully describes your employment status?
Please select one of the following:
- Full-time job
- Part-time job
- Unemployed
- Housewife/househusband
- University student
- Pensioner

Select one answer only.

[6.] Which of the following options fully describes your household?
Please select one of the following:
- Single adult
- Single parent with 1 or more children
- Family without children
- Family with children
- Pensioner

Select one answer only.

THANK YOU FOR PARTICIPATING!

Appendix 9.1.

QUESTIONNAIRE CARD

SURVEY ON THE PERCEPTION TOWARDS ENTREPRENEURSHIP WITHIN CIRCULAR ECONOMY

Dear Sir/Madam,

This survey is carried out as part of a scientific project on circular economy. It will serve as a basis for developing innovative models for supporting entrepreneurs in the development and implementation of innovative environmental practices.
The survey is anonymous. The information will be used only by the research workers. Thank you in advance for your time and attention!
All the answers need to reflect the situation in your country.
Circular economy *and* green entrepreneurship *are defined as follows:*
Circular economy: Circular economy is an industrial practice which has a recovering and regenerating function (it encourages greater resource efficiency aiming at reducing waste and avoiding pollution) and which aims to preserve products, components and their greatest usefulness and value at all times, distinguishing technical and biological cycles.
"Green entrepreneurship is the activity of consciously addressing an environmental/social problem/need through the realization of entrepreneurial ideas with a high level of risk, which has a net positive effect on the natural environment and at the same time is financially sustainable." (greentproject.eu)

A. Perceptions towards green entrepreneurship

A1. Did you know about *circular economy* and *green entrepreneurship* before taking part in this survey?

I only knew about circular economy	1
I only knew about green entrepreneurship	2
I knew both terms	3
I did not know any of the two	4

A2. When you hear the term *innovative green entrepreneurship,* what is your first association?

....

A3. According to you, which entrepreneurs in your country are the best example of innovative green entrepreneurship?

....

A4. Which are the most important characteristics a company working in green entrepreneurship would have?
Please arrange the FIVE most important characteristics as 1=least important; 5=most important

Successful, motivated, content employees	
Financial stability	
Clear-cut organizational strategy, vision, mission and goals	
Good public relations (customers, partners, stakeholders)	
CStrong reputation	
Quality products	
Environmental and social consciousness	
Environmental sustainability	
Adaptability, flexibility	
Other (please specify)	

A5. Which is the main usefulness from implementing innovative green entrepreneurship?
1 = not useful; 3 = relatively useful; 5 = very useful

Recognisability by the public and stakeholders	1	2	3	4	5
Improvement of image and reputation	1	2	3	4	5
Contributing to solving social problems	1	2	3	4	5
Staff motivation and loyalty	1	2	3	4	5
Financial efficiency	1	2	3	4	5
Influence on the organizational values, culture, mission, goals	1	2	3	4	5
Maintaining the product/brand	1	2	3	4	5
Maintaining market positions	1	2	3	4	5
Consumer satisfaction	1	2	3	4	5
Attracting and retaining employees	1	2	3	4	5

Building trust among the stakeholders	1	2	3	4	5
Other (please specify)	1	2	3	4	5

B. Conditions for developing circular economy and current condition of circular economy in your country

B1. For your region, please evaluate the significance for circular economy of each of the participants in the educational process.

Participant	Unimportant	Somewhat unimportant	Neither important nor unimportant	Somewhat important	Very important
Ministry of Education	1	2	3	4	5
Ministry of Economy	1	2	3	4	5
Ministry of the Environment	1	2	3	4	5
Ministry of Health Care	1	2	3	4	5
Teacher Training Institutions	1	2	3	4	5
Local Educational Authorities	1	2	3	4	5
Other (please specify)	1	2	3	4	5

B2. For your region, please evaluate the significance for circular economy of each of the participants in the unofficial educational process:

Participant	Unimportant	Somewhat unimportant	Neither important nor unimportant	Somewhat important	Very important
Consumer NGOs	1	2	3	4	5
Environmental NGOs	1	2	3	4	5

Commercial groups	1	2	3	4	5
Mass media	1	2	3	4	5
Chambers and Professional Associations	1	2	3	4	5
Social Media	1	2	3	4	5
Public Groups	1	2	3	4	5
Other (please specify)	1	2	3	4	5

B3. Which of the circular economy disciplines are taught in your country (grades 4-7)?

Disciplines	Compulsory	Eligible	Extra-curricular Activities	Not Taught
Entrepreneurship	1	2	3	4
Waste Management	1	2	3	4
Sustainable Development Management	1	2	3	4
Green Innovations	1	2	3	4
Environmental Design	1	2	3	4
Energy Efficiency	1	2	3	4
Innovative Entrepreneurship	1	2	3	4
Green Entrepreneurship	1	2	3	4
Other (please specify)	1	2	3	4

B4. Do schools in your country organise extra-curricular activities related to circular economy topics?
No, they don’t (reference to Question B6)
Yes, they do.
If *yes:*
Please indicate the educational stage.

B5. Which of the following extra-curricular activities related to circular economy are organised in the school in your country?

Eco-schools	1
Start-up clubs	2
Summer schools	3
Other (please specify)	4

B6. Please evaluate each of the following topics as per their significance when teaching circular economy principles:

Topic	Unimportant	Somewhat unimportant	Neither important nor unimportant	Somewhat important	Very important
Introduction into CE	1	2	3	4	5
CE Principles	1	2	3	4	5
New Business Models	1	2	3	4	5
Green Entrepreneurship	1	2	3	4	5
Product-service	1	2	3	4	5
Re-use	1	2	3	4	5
Recycling (closed loop)	1	2	3	4	5
Recycling (open loop)	1	2	3	4	5
Product Recovery	1	2	3	4	5
CE Design	1	2	3	4	5
Eco-design Principles	1	2	3	4	5

Product-service *describes the strategy for creating added value by adding services to products or even exchanging products with services.*
Closed loop recycling *is a manufacturing system in which the waste or waste products from a process are used for the manufacturing of another product, e.g.*

the recycling of old newspapers for the manufacturing of cardboard or other types of paper.

Open loop recycling *includes the turning of a material from one or more products into a new product including a change in the intrinsic properties of the material itself – e.g. the recycling of plastic bottles into plastic drainage pipes. It is often called reprocessing of materials.*

C. Perceptions towards the implementation of circular economy principles

C1. Please indicate the extent to which you agree with the following statements:

Statement	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Circular economy must be taught as a separate discipline.	1	2	3	4	5
Introducing certification will contribute significantly for the implementation of circular economy.	1	2	3	4	5
Circular economy must be introduced into all school subjects.	1	2	3	4	5
School administrations must be proactive in the introduction of the principles of circular economy in their schools.	1	2	3	4	5

C2. According to you, which are the most crucial points for the development of a school curriculum dedicated to circular economy?

....

....

C3. For you region/country, according to you, which are the most suitable areas for developing a school curriculum dedicated to circular economy?

....

THANK YOU FOR YOUR PARTICIPATION!

Appendix 9.2.

Main Benefits from Introducing Innovative Environmental Entrepreneurship

- Efficiency
- Environment protection
- Improving business efficiency
- Environmental benefits
- Personal satisfaction from a acting correctly
- Introducing other, more established business practices and highlighting the role it plays for the improvement of these practices
- Extrenal audit from a reliable independent legislative authority
- Clean environment
- It helps society to reduce the effect of global warming
- Staff training
- Improving the enviroment
- Healthy lifestyle
- Innovation in the sphere
- Providing benefits for the future generations
- Conserving the environment for the future generation
- Sustainable development
- Multiplication of positive effects
- Personal development
- Care for natural resources
- Support of local production and popularising products traditional for the region
- Better access to funding
- Environment protection

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THEORY AND PRACTICE OF CIRCULAR ECONOMY

Reviewer: Prof. Dr. Zoya Mladenova
English proofreading: Tzveta Georgieva

ISBN 978-619-7171-76-1