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HELIX SPIN ECONOMY AND PLASMA WASTE RECOVERY IN CONSTRUCTION AND BUILDING MATERIALS INDUSTRY

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Abstract

The circular economy is a development model that redefines economic growth by decoupling it from the consumption of resources (especially non-renewable) and conveys waste back into productive activities, as raw materials for other production circuits, thus helping the increase of resource efficiency, and reducing the impact of economic activity in the environment. As one of the main aspects addressed by the circular economy concept, waste recycling can limit sometimes the practical and conceptual nature of this system.
Starting from the concept of circular economy we propose a new concept called helix spin economy, in which the plasma processing technologies applied to industrial and municipal waste have a special importance. Plasma gasification of municipal waste leads to the production of valuable and safe outcomes for the environment, such as syngas, metals and glassy rocks. As for assessing the modeling of the complex economic processes that govern the helix spin economy, the research team considers fuzzy mathematics and the theory of uncertainty.

Key words: fuzzy mathematics, helix spin economy, hydrogen plasma gasification, municipal waste

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1. Introduction

Circular economy in construction and building materials industry can open the horizon of new directions in smart specialization at regional level, with conceptual, technical and technological challenges necessary to identify and manage. Often, the theoretical framework is surpassed by the practical one, as dispersed forms and initiatives need to be integrated into comprehensive sustainable mid term development policies, at both conceptual and legislative level. Within the conclusions of the Club of Rome, it was emphasized that the linear economic model is a theoretical and practical one, and the premise that the natural resources are available and inexhaustible proved to be a false one.

In respect with the waste and residues disposal, the trendline continues to highlight an accelerating rise. Stockpiling or sending municipal waste to landfill has adverse environmental impacts and, so they are not the most efficient disposal solution. Therefore, the underlying principle of the circular economy assumes the conversion of the waste streams into value (Zająca and Avdiushchenko, 2020).

As a model of production and consumption, circular economy involves sharing, reusing, repairing, renovating and recycling of existing materials and products as much as possible. In this way, the product

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life cycle is extended. In practice, this involves in fact waste minimization and and valorization as secondary raw materials. The goal is to recover the materials from which an economic good is made when it reaches the end of life. The obtained materials are reintroduced in the economic process. They can be used again and again, thus creating added value (Fig. 1) (Aka, 2019).

Fig. 1. The diagram of the circular economy (Aka, 2019)

The circular economy model transforms the traditional linear economic model based on a 'take-make-consume-throw away' pattern. This new model is based on principles that each field of activity focuses on cheap, easily accessible materials and energy. A comparative analysis of the concepts associated with the circular economy of (Ghisellini et al., 2016) have shown notable differences in their practical application in countries all arround the world. This made possible the appearance of a significant number of new concepts, associated with the circular economy, such as eco-efficiency, eco-design, natural capitalism, industrial ecology etc., which aim to achieve the transformation and use of products and raw materials by a way able to ensure the balance between ecological protection and economic growth.

Research has succedeed in developing a number of directions, by focusing on the relevant principles of technological and innovative sustainability in the field of construction with regard to basic technologies and business innovation models, by enhancing a contribution for the least studied issues of business sustainable development. The application of modern technologies for the reclamation of directly recoverable waste and of plasma energy conversion technologies for non-recoverable waste is an important step in upgrading the concept of circular economy with direct application in the development of sustainable businesses with a low carbon footprint and marginal environmental impact.

Considered to be a new technology, plasma gasification demonstrates a major potential for solving an important environmental problem, namely the reduction of waste that is currently sent to landfills, by converting it. It is important to note that hydrogen plasma gasification process has the potential to convert part of the waste into a clean synthetic gas that can be used to generate electricity in combined heat and power (CHPP) plants (Alecu et al., 2020), gas engines or can even replace natural gas. As for the valorization of the thermal energy obtained from the gaseous products, both literature and practice note that it can be done by classical or modern methods. The easiest way is the production of steam and heat for generation of electricity and thermal energy. The sustainable operation of a hydrogen plasma gasification plant also requires consideration of the cleaning process for the released gases. The design of post-treatment equipment is crucial for the plasma gasification process, since it requires advanced emission control systems to have a product that meets the regulatory standards (Achinas, 2019; Alecu et al., 2020).

Reaserch shows that plasma gasification of urban waste leads to the production of more valuable and safe results for the environment, such as syngas (mixture of carbon monoxide and hydrogen), metals and glassy rocks. Syngas can be used directly as a clean burning fuel to produce green electricity (Welt, 2019), or as a chemical feedstock (Welt, 2019) used within the production of biofuels, plastics and hydrocarbons.

Temperatures of the hydrogen plasma gasification process are very high and allow the melting of all conceivable materials, including minerals, metals and inert materials (Welt, 2019). By classical processes, these materials can be recovered in the classical form of ingots and the minerals in the form of vitrified glass rock. Since metals and bulk glass, such as cans, jars and bottles, are easy to recover, by enjoying uccessful and sustainable recycling markets, it is advisable that this means of recycling remain independent. It is important to stress out that waste recycling processes have to precede the plasma gasification process. Municipal waste (MSW) contains many other commodity metals in diferent percents (Welt, 2019) such as aluminum, steel, copper, zinc and brass. If adding electronics, then, there may be precious and rare earth metals that could be indentified and exploited. The process stands for all these materials to melt at the bottom of the plasma gasifier and then, gradually, an vortex molten sink (Welt, 2019) will be collected.

The recovery of heat energy from the molten vortex sink with improved heat transfer (Welt, 2019) represent a andvantage of the hydrogen plasma gasification process. As excess material accumulates, by clasical methods, it is poured off to create metal ingots and vitrified (Welt, 2019) rocky slag.

All materials are recoverable in environmentally safe (Welt, 2019) and useful forms by the plasma gasification process. Nowadays, the 3Rs (Reduce, Reuse, and Recycle), at the global level, have an important role (https://www.epa.gov/recycle) in terms of material use efficiency and raw materials stewardship (Welt, 2019). As compared to other options such as composting and incineration are partial solution, the hydrogen plasma gasification process represents a new and versatile technology through which it can achieve at a higher level the sustainability of the circular economy, offsetting the use of fossil fuels by the clean and cheap energy produced (Welt, 2019).

2. Materials and method

2.1. Modern technologies for energy recovery of municipal waste as a renewable energy source

We aim to contribute to the development of the theoretical and industrial framework, to the structuring of a link with sustainable and relevant macro and micro policies, and to the improvement of sustainable building practices. The analysis integrates a variety of sustainability principles and practice, the way they relate with the main directions of the smart specialization of the region but also to the macro and micro perspectives of the sustainability concept within economy and society, establishing a pattern as how it can be identified as a comprehensive framework model (Jakšić et al., 2018).

Therefore, we pursue a set of correlation matrices that help identify the relevant roles and relationships between principles in achieving sustainable objectives related to the dimensions of the circular economy in construction and smart regional specialization, how they can contribute to the development of national strategies and regional ones. Finally, we will present some current global trends in research and circular economy and intelligence specialization in the field of building waste recycling (Cucos, 2014).

Reflections on the specificities of circular economy that show embedded sustianable results emphasize that the proposed framework of correlated matrices fulfills the main objective as it has been underlined within the initial stages of the current research, by covering a vast area of relevant both theoretical and practical relevance. As for a first theoretical contribution, the proposed framework is able to fulfill tehnical requirements for determining a comprehensive model able to satisfy an enhanced understanding of macro and micro sustainability insights, and provide a specific field for embedded relations.

Considering the concept of circular economy presented in the diagram in Fig. 2 as a starting point (after Ellen MacArthur Foundation, 2012), our team developed a new concept called helix spin economy (as presented in Fig. 3, it is designed and 3D modeled in Blender software by the team) by stating that the plasma processing technologies of industrial and municipal waste have a special importance (cite the sources).

The two interconnected branches refer to the economic circuit of industrial and respectively agricultural products, plasma processing technologies having the role of providing electric and heat energy and raw materials obtained from waste conversion.

In Fig. 3 the spheres represent complex economic processes as follows:

- industrial product manufacture is composed of the following processes: Mining and materials manufacturing, materials and parts manufacturing, product manufacturing, retails and services providers and maintain. The collection block includes reuse and redistribute, refurbish and remanufacture and recycle activities, in case the industrial waste can no longer be optimally capitalized from an economic point of view and is transferred to the hydrogen plasma installations that convert this waste into syngas (Alecu et al., 2020), electricity and heat and nodules. Polymetallics that are reused in the industrial production process thus replacing part of the raw material extracted from the environment in this way the industrial production cycle is resumed;

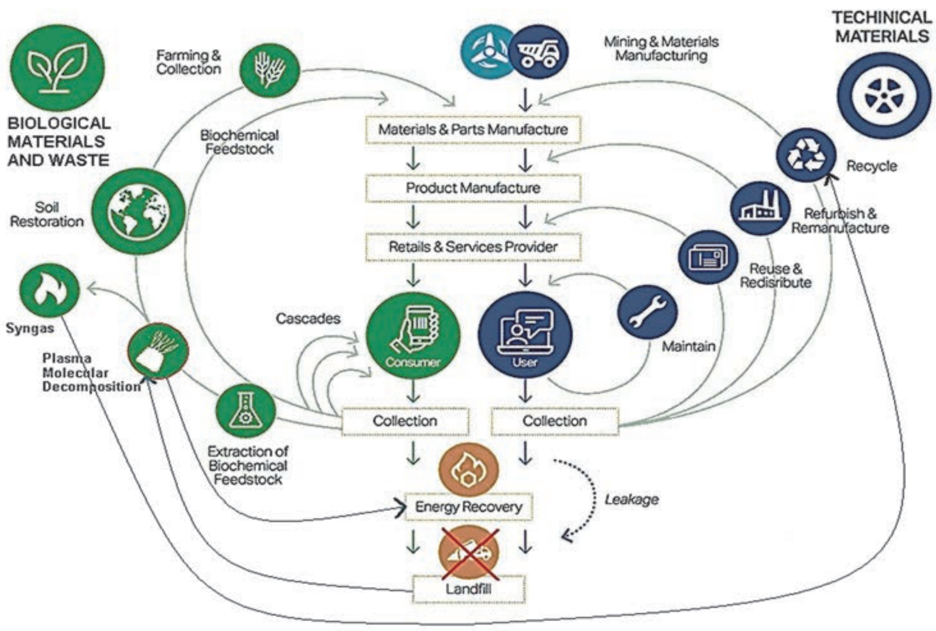

Fig. 2. Outline of the circular economy using plasma technologies (upon Ellen MacArthur Foundation, 2012)

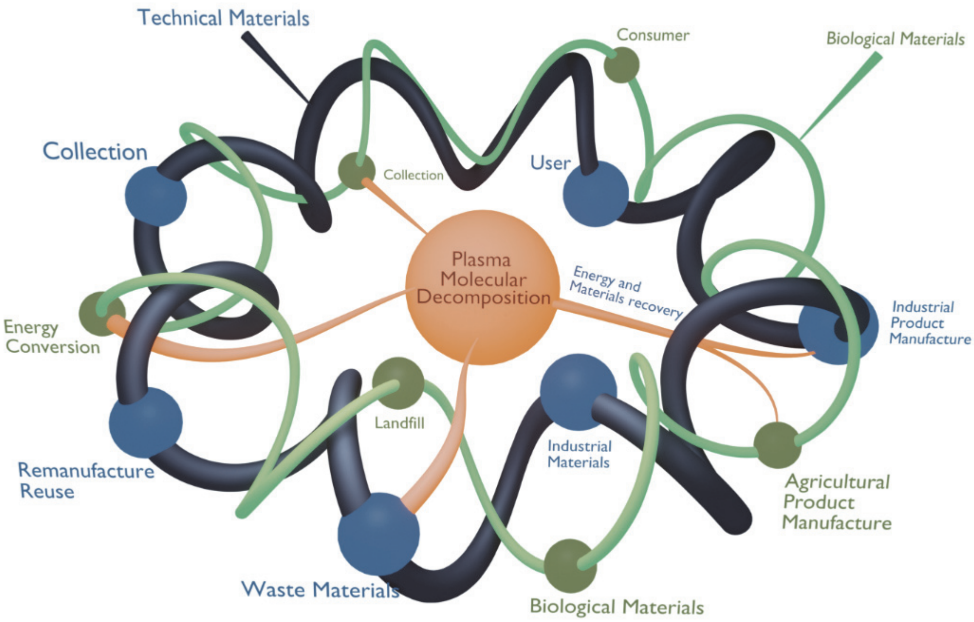

Fig. 3. Helix spin economy using plasma technologies (3D modeled in Blender software by authors)

- the manufacture agricultural sector presumes the use of spare parts and used end products, along with specific services, while the resulting waste could be used for the biogas production as a traditional method, but it could also presume the use of plasma installations. For this case, the waste recycling through hydrogen plasma gasification is subjected for achieving electric energy and/or heat energy that could be used both within industrial and civil building processes (Alecu et al., 2020).

Inert waste from the industrial and agricultural process, that can no longer be reused is finally stored in the landfill, with minimal impact on the environment and in small quantities thus reducing the carbon footprint. A design method using fuzzy numbers was adopted for an ecological and innovative technology for waste processing with hydrogen to recover recyclable materials. This way the waste can be turned into a renewable source of energy and materials.

2.2. Methodological aspects regarding the use of triangular fuzzy numbers with variable associated indicators in the substantiation of decisions specific to helix spin economy

Our team proposes the modeling of the complex economic processes that govern the helix spin economy with the help of fuzzy mathematics and the theory of uncertainty. In the following paragraphs we will present a way to solve this problem.

Within the economic processes, uncertainty is no longer given exclusivity when considering the probability concepts. The advantages of this theoretical construction were proven when making predictions based on the analysis of previous experiences; it also has certain limitations in identifying possible courses of action. When considering the technical and technological peculiarities specific to the helix spin economy, theoretical and applied challenges related to approaching decision-making situations in conditions of second or third degree of uncertainty need to be attained, since these methods have increased in importance within the current economic and social context (Antonescu, 2015)

Several instruments have beed underlied within the process of persistent uncertainty (III degree) as absorbtion, by helping managers to adopt a logically structured attitude specific for extreme situations (Alecu and Jaba, 2009; Giariniand and Stahel, 1996). Gradually, several categories of methods and techniques for managing uncertainty in innovation processes were conceptualized: technocratic, political, structural or cultural. Based on crisp (real) numbers, the development of such a concept as the helix spin economy cannot be structured and anticipated by classical instruments.

Therefore, the analysis of the directions of development of the helix spin economy is a decision-making process in conditions of uncertainty, a process that causes the identification and development of new ways to reduce or absorb it. A very useful tool in current practice is the fuzzy mathematics approach (Bojadziev and Bojadziev, 1996; Georgescu, 1995; Lafuente, 1994; Maturo, 2009; Schjaer-Jacobsen, 2004; Wang and Zhang, 2009). In this context, in order to capture the directions of action within the helix spin economy, we propose (analyzing the different technical, economic and social particularities of the fields of activity) the use of fuzzy numbers with associated variable center of gravity (Alecu, 2011; Gherasim, 2005; Madhuri et al., 2017).

The gravity center has a variable size and is being expressed within an associated α coefficient (Alecu, 2012, 2019); in regard with the α coefficient, is is worthy to mention that it can achieve strictly positive and subunit values (zero to one). The evaluations will be subject to bias when the case of α will have values close to 0, therefore the triangular fuzzy numbers within the decision making processes will only express simultaneously total ambiguity and III rd degree uncertainty. On the opposite side, if α has values close to 1 (an optimistic view) a large part of the issues cand be subject to the uncertainty management mechanisms.

Considering the fist definition given by Zadeh (Zadeh, 1975) and analyzing the many others theoretical developments (Bojadziev and Bojadziev, 1996; Tofan, 2011; Maturo, 2017), some with high practical applicability (Gherasim, 2004; Wang and Zhang, 2009), a triangular fuzzy number (TFN), can be represented in various forms used in recent decades, but not all are useful for our construction.

Opening the objective pursued, we consider that a triangular fuzzy number can be simply represented starting from an ordered triplet of the form (Gherasim, 2005; Tofan, 2007; Alecu, 2019) $(X) = (X_L, X_M, X_R) \in TFN \quad X_L < X_M < X_R$, having the membership function $\mu_X : R \rightarrow [0,1]$ defined as given by Eq. (1):

$$\mu_X(x) = \begin{cases} \dfrac{x - X_L}{X_M - X_L}, & X_L \le x < X_M \\ 1, & x = X_M \\ \dfrac{X_R - x}{X_R - X_M}, & X_M < x \le X_R \\ 0, & x \notin (X_L, X_R) \end{cases} \tag{1}$$

For the easy use of these triangular fuzzy numbers and defined operations, it is necessary to mention some of the most important simple or synthetic indicators developed over time (Gherasim, 2005; Maturo, 2009; Alecu, 2019; Alecu et al., 2020), such as those below (Eq. 2):

The core $N(X) = X_M$
The support $SP(X) = (X_L, X_R)$
The length of the support (LSP≥0) $LSP(X) = X_R - X_L$
The middle of the core
$MN(X) = N(X) = X_M$
The middle of the support
$$MSP(X) = \frac{X_L + X_R}{2}$$
The length of the support (LSP≥0) $LSP(X) = X_R - X_L$
The middle of the core
$MN(X) = N(X) = X_M$
The middle of the support $MSP(X) = \dfrac{X_L + X_R}{2}$
Area to the left $S^L(X) = \int_{X_L}^{MN(X)} \mu_X(x)dx$
Area to the right $S^R(X) = \int_{MN(X)}^{X_R} \mu_X(x)dx$
Total area $S(X) = S^L(X) + S^R(X)$
The sign $\delta(X) = \begin{cases} sign(N(X)), & N(X) \ne 0 \\ sign(X_M), & N(X) = 0 \end{cases}$

(2)

Along time, a multitude of qualitative research techniques were used for the development of the IIIrd degree management uncertainty. Objectives as sustainability, efficiency, artificial balancing of uncertainty; uncertainty sharing; reaching of critical mass etc. can only be arisen/approached with the help of indisciplinary resource fields as political, economic and/or social, resulting in the development of the helix spin economy. As current litterature states, only a limited case number of decision making could be associated with fuzzy numbers(Bojadziev and Bojadziev, 1996;Umano et al. 1998; Herrera et al., 2000). The current research proposal consists of the usage of a variable synthetic indicator as an uncertainty absorbtion strategy management instrument that is based of an fuzzy number estimation. For the case of the triangular fuzzy numbers as defined within Alecu (2019) research reveals a practical method for defining the associated variable gravity center (Alecu, 2011) . For this case (Alecu, 2019), the equation will be as follows (Eq. 3):

$$G_\alpha(X) = N(X) + (\alpha - 1) \cdot S^L(X) + \alpha \cdot S^L(X) \tag{3}$$

where: α ∈ [0, 1] - explaining the absorbtion/ management of the uncertainty.

As Fig. 4 shows, the triangular fuzzy number with variable associated indicators transcribes the link between the center of gravity (Gherasim, 2005), and the management uncertainty (Alecu, 2019). The problem solving within economical and technological decisional making process, by using the triangular fuzzy numbers with associated variable centers of gravity implies the development of a basic mathematical operations.

A triangular fuzzy number (Xα) with associated variable center of gravity as a fuzzy number $(X_\alpha) = (X_L, X_M, X_R)_\alpha \in TFN$ could be defined as a fuzzy set on R, while having the membership function μ_X:R→[0,1] as given by Eq. (4) (Gherasim, 2005; Alecu, 2011):

$$\mu_{(X_\alpha)}(x) = \begin{cases} \dfrac{x - X_L}{X_M - X_L}, & X_L \le x < X_M \\ 1, & x = X_M \\ \dfrac{X_R - x}{X_R - X_M}, & X_M < x \le X_R \end{cases}, where \tag{4}$$

where $\alpha \in [0.1]$ is an associated subunitar indicator expressing the way of absorbing uncertainty; $G((X_\alpha)) \in \mathbf{R}$ is the associated variable center of gravity (Alecu , 2019) to a trianghular fuzzy number (X), which can be obtained by Eq. (5):

$$G(X_\alpha) = \langle X \rangle_\alpha = N(X) + (\alpha - 1) \cdot S^L(X) + \alpha \cdot S^L(X) \tag{5}$$

As Alecu (2019) discussed, α value is not subject for changing the values of the abovementioned fuzzy number membership function. Within a decision making process, α value stands for the managers behavioural tendency for uncertainty.

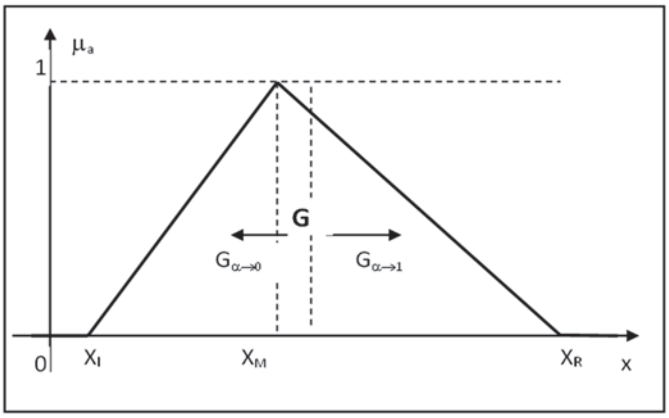

Fig. 4.Triangular fuzzy number with associated variable center of gravity (Alecu, 2019)

In order to describe the basic mathematical operations, a number of three triangular fuzzy numbers with associated variable center of gravity (X_α), (Y_β), (Z_γ) will be considered (Eq. 6):

$$(X_\alpha) = (X_L, X_M, X_R)_\alpha,\ (Y_\beta) = (Y_L, Y_M, Y_R)_\beta \tag{6}$$
$$(Z_\gamma) = (Z_L, Z_M, Z_R)_\gamma \in [0, 1]$$

where value α, β, γ ∈ [0,1] will be used for the assumed levels of absorbtion of uncertainty for the case of each fuzzy number. Then the specific gravity centers will be $G(X_\alpha)$, $G(Y_\beta)$, $G(Z_\gamma)$.

As Alecu (2019) describes, the next fuzzy numbers with associated variable center of gravity math operations will follow:

a. ***The addition*** of (X_α), $(Y_\beta) \in$TFN and $\alpha, \beta \in [0,1]$ is a triangular fuzzy numbers. As Alecu (2019) state, the a law of composition $\oplus : TFN \times TFN \rightarrow TFN$, underlies as (Eq. 7):

$$(Z_\gamma) = (X_\alpha) \oplus (Y_\beta) =$$
$$= \begin{cases} (X_L + Y_L; X_M + Y_M, X_R + Y_R)_\gamma \\ \gamma = (\alpha(X_L + Y_L) + \beta(X_R + Y_R))/(X_L + Y_L + X_R + Y_R) \end{cases} \tag{7}$$

It is easy to observe that the composition law has the next three properties: stable, associative and commutative.

b. As a triangular fuzzy number with associated center of gravity variable is being ***multiplied with a scalar*** $t \in \mathbf{R}$, results will show a triangular fuzzy number $(Z_\gamma) = (Z_L, Z_M, Z_R)_\gamma \in TFN$ displayed as follows (Eq. 8):

$$(Z_\gamma) = t * (X_\alpha) =$$
$$= \begin{cases} (t * X_L; t * X_M, t * X_R)_\gamma, \gamma = \alpha, & t \geq 0 \\ (t * X_R; t * X_M, t * X_L)_\gamma, \gamma = 1 - \alpha, & t < 0 \end{cases} \tag{8}$$

c. In case of ***substracting*** the two triangular fuzzy numbers (X_α), $(Y_\beta) \in$TFN, the law of composition $(-): TFN \times TFN \rightarrow TFN$ will be given by Eq. (9):

$$(Z_\gamma) = (X_\alpha)(-)(Y_\beta) =$$
$$= \begin{cases} (X_L - Y_L; X_M - Y_M, X_R - Y_R)_\gamma \\ \gamma = (\alpha(X_L + Y_L) + (1 - \beta)(X_R + Y_R))/(X_L + Y_L + X_R + Y_R) \end{cases} \tag{9}$$

d. When ***multiplying*** two triangular fuzzy numbers with associated variable gravity centers (X_α), $(Y_\beta) \in$TFN (Gherasim, 2005; Alecu, 2019), results will show a triunghiular fuzzy number, while the multiplication composition law $\otimes : TFN \times TFN \rightarrow TFN$ will be expressed by Eq. (10):

$$(Z_\gamma) = (X_\alpha) \otimes (Y_\beta) = \begin{cases} \dfrac{(X_\alpha) * G(Y_\beta) + (Y_\beta) G(X_\alpha)}{2} = \\ \gamma = (\alpha * \beta) / (\dfrac{\alpha + \beta)}{2}) \end{cases}$$
$$= \begin{cases} (\dfrac{X_L * G(Y_\beta) + Y_L * G(X_\alpha)}{2}, \dfrac{X_M * G(Y_\beta) + Y_M * G(X_\alpha)}{2}, \dfrac{X_R * G(Y_\beta) + Y_R * G(X_\alpha)}{2} \\ \gamma = (\alpha * \beta) / (\dfrac{\alpha + \beta)}{2}) \end{cases} \tag{10}$$

e. When dividing two triangular fuzzy numbers with associated variable centers of gravity (X_α), $(Y_\beta) \in$ TFN (Alecu, 2019; Gherasim, 2005), results will show a triangular fuzzy number, while the division operation will lie undeneath the next law of composition (/): TFN x TFN → TFN (Eq. 11):

$$(Z_\gamma) = (X_\alpha)(/)(Y_\beta) = \begin{cases} \dfrac{(X_\alpha) * G(Y_\beta) + (Y_\beta) G(X_\alpha)}{2 * G(Y_\beta)^2} \\ \gamma = (\alpha * (1 - \beta)) / (\dfrac{\alpha + (1 - \beta)}{2}) \end{cases} \tag{11}$$

To obtain the ranking of the triangular fuzzy numbers (Gherasim, 2005) with variable centers of gravity (Alecu, 2019), we must apply several successive criteria (Alecu et al., 2020) (Eqs. 12-14):

- First criteria, ordering by the gravity center (Eq. 12) :

$$\begin{cases} G(X_\alpha) > G(Y_\beta) \Rightarrow (X_\alpha) > (Y_\beta) \\ G(X_\alpha) < G(Y_\beta) \Rightarrow (X_\alpha) < (Y_\beta) \end{cases} \quad (12)$$

- If ranking the decisional options, a hierarchical triangular fuzzy numbers system must be conceived. Whithin the given example, a number of criteria (Gherasim, 2005; Alecu, 2019) is considered (Eqs. 12-14):

$$\begin{cases} N(X) > N(Y) \Rightarrow (X_\alpha) > (Y_\beta) \\ N(X) < N(Y) \Rightarrow (X_\alpha) < (Y_\beta) \end{cases} \quad (13)$$

- If the case when the aforesaid criteria does not assign the two triangular fuzzy numbers as required, the middle of the core criterion will be applied (Eq. 13):

$$\begin{cases} \delta(X) * LSP(X_\alpha) > \delta(Y) * LSP(Y_\beta) \Rightarrow (X_\alpha) > (Y_\beta) \\ \delta(X) * LSP(X_\alpha) < \delta(Y) * LSP(Y_\beta) \Rightarrow (X_\alpha) < (Y_\beta) \end{cases} \quad (14)$$

3. Results and discussion

3.1. Analysis of reusable raw material sources from waste recycling in the context of the Helix Spin economy

The need for better comprehenssibility of the different macro and micro categories of sustainability, energy conversion, energy and material recovery etc. indicating mutual relations and influences within the helix spin economy in the building sector, is increasing, while the future regional development directions with impact on the central and local public administration policies within the field will be severely influenced by the idea. When micro and macro sustainability view categories are to be used from a practical angle, change management within innovative and goal oriented companies will be encouraged and sustained.

We are considering the development of a novel research topic, with deep interdisciplinary character focusing on originality and innovation and of high international relevance, presenting the management relations exhibited in the integrated systems for the energy management of constructions having the following dimensions:

- analysis of the current level of the energy management methods and techniques, with emphasis on positive aspects and directions of development, identification and mapping of economic connections between the subsystems of the energy management process, using novel methods;
- quantitative and qualitative risk analysis of economic and social processes implying the use of renewable energies;
- establishing the environmental impact of energy recovery from renewable sources and proposing innovative technical solutions to minimize this impact.

Therefore, by performing a comparative analysis of the municipal waste generation in Romania, as for the period of 2010-2020, a sinusoidal evolution of the results show a decrease trendline of the waste volume per capita. While in 2015, the volume reaches from 313 kg to 247 kg per capita, in 2020, the waste volume reaches 272 kg per capita. A similar pattern is to be reached across EU28. Per capita, in Romania there is a lower volume, of about 44%, than that in the EU (488 kg per capita) and much smaller than that in Poland and Bulgaria, as sown in Table 1(Eurostat, 2020).

In the region, for both Poland and Bulgaria, we can talk about similar evolutions. We may consider that closely related to the evolution of the income of the population in the respective countries (Fig. 5, Eurostat, 2020).

Analyzing similar indicators (NALAS, 2019) such as waste generation, except major mineral waste per unit (kg per thousand euros, chain-linked volumes), respectively waste generation, except major mineral waste on consumption of domestic materials (%) , in Table 2 trends following the same pattern(Eurostat, 2020).

An extended importance for the analysis of the helix spin economy is the study of waste recycling management. Thus, in Table 2 it can be easily noticed that in the case of Romania, in the period 2010-2016(Eurostat, 2020), the recycling rate of all waste, excluding major mineral waste, increased constantly from 26% to 30% respectively. In comparison, at EU28 level, the trend is still growing, but at a slower pace. In the region, Romania is the only country that registers such an evolution, over the same period Poland as a whole having shown a declining trend, and Bulgaria making efforts to keep it at same level.

When considering the biomass waste, results show that Romania manifests a decreasing trendline. Thus, at the level of 2018, we registered a volume of 9 kg per capita, although in 2010 we managed to recycle 32 kg per capita. In comparison, in 2018 at the EU28 level, 83 kg per capita were recycled, 9 times more than Romania (Table 3, Eurostat, 2020).

Table 1. Municipal waste generation (kg per capita) (Eurostat, 2020)

Time	***2010***	***2011***	***2012***	***2013***	***2014***	***2015***	***2016***	***2017***	***2018***
European Union - 28 countries	496	498	486	479	478	480	487	487	488
Bulgaria	554	508	460	432	442	419	404	435	423
Poland	316	319	317	297	272	286	307	315	329
Romania	313	259	251	254	249	247	261	272	272

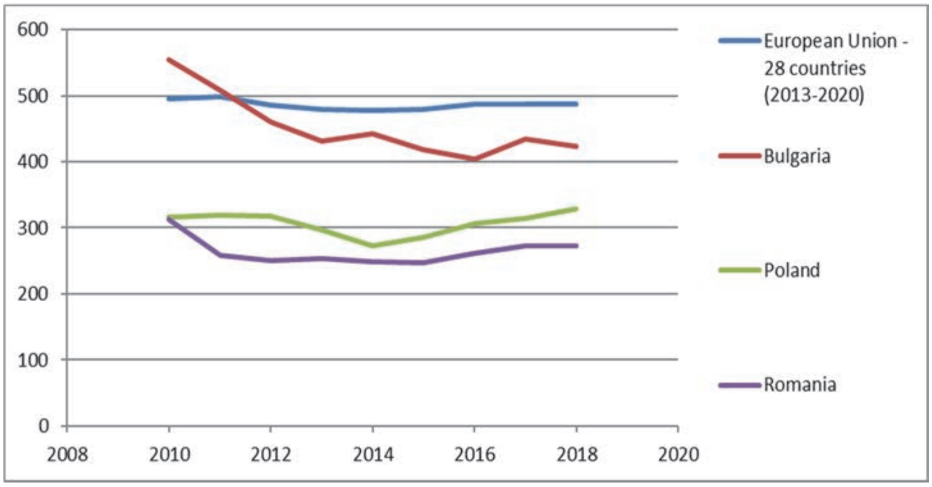

Fig. 5. Variation in the volume of waste in the EU (2010-2018) (Eurostat, 2020)

Table 2. Recycling rate of all wastes, excluding major mineral wastes (%) (Eurostat, 2020)

Time	*2010*	*2012*	*2014*	*2016*
European Union - 28 countries (2013-2020)	55	55	56	57
Bulgaria	27	14	17	27
Poland	58	55	60	56
Romania	26	28	27	30

At the level of 2018, both Bulgaria (34 kg per capita) and Poland (27 kg per capita) registered an increasing trend regarding the recycling of biomass waste, much more visible than that of Romania.

Discussing the large field of waste and demolition in construction industry, in Table 4 it is noticed that in Romania the recovery rate in 2010 was very low, 47%, but reached 85% in 2016. It is a remarkable improvement, but progress is still below to the European average, of 89%, and that of its neighbors Bulgaria, of 90%, and Poland, of 91%, respectively (Eurostat, 2020). These lead us to the need for identifying new methods and tools demanded by management of the helix spin economy. Therefore, the importance of recovering construction and demolition waste using technologies based on the plasma conversion into new materials and energy for house supplying becomes a priority.

We cannot discuss the helix spin economy without analyzing the utilization rate of the circular material from the total of materials.

In Table 5 (Eurostat, 2020) we notice the fact that this indicator registers a decreasing trend for Romania in the period 2010-2017. Thus, the utilization rate of circular material decreases from 3.5 % in 2010 to 1.8 % in 2017. In comparison, in the EU28, this indicator as a whole registers a slightly upward trend, reaching a level of 11.7 % in 2017.

In the region, the standards of the circular economy (NALAS, 2019) are much better implemented, the waste management is much more rigorous, the utilization rate of the circular material being much higher, respectively of 9.5% in Poland, respectively 5.1% in Bulgaria (Fig.6, Eurostat, 2020).

Table 3. Biomass waste recycling (kg per capita) (Eurostat, 2020)

Time	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*
European Union - 28 countries (2013-2020)	66	67	70	72	74	75	80	81	83
Bulgaria	0	11	13	15	8	43	37	34	34
Poland	5	6	5	6	15	17	21	22	27
Romania	32	22	29	23	20	18	18	18	9

Table 4. Recovery rate of construction and demolition waste
(% of recycled construction and demolition waste) (Eurostat, 2020)

Time	*2010*	*2012*	*2014*	*2016*
GEO (Labels)				
European Union - 28 countries	-	-	89	89
Bulgaria	62	12	96	90
Poland	93	92	96	91
Romania	47	67	65	85

Table 5. Circular material utilization rate (% of total material consumption) (Eurostat, 2020)

TIME	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*
European Union - 28 countries (2013-2020)	11.1	10.7	11.5	11.6	11.5	11.7	11.9	11.7
Bulgaria	2.1	1.8	1.9	2.5	2.7	3.1	4.4	5.1
Poland	10.8	9.2	10.6	11.8	12.5	11.6	10.2	9.5
Romania	3.5	2.5	2.6	2.5	2.1	1.7	1.7	1.8

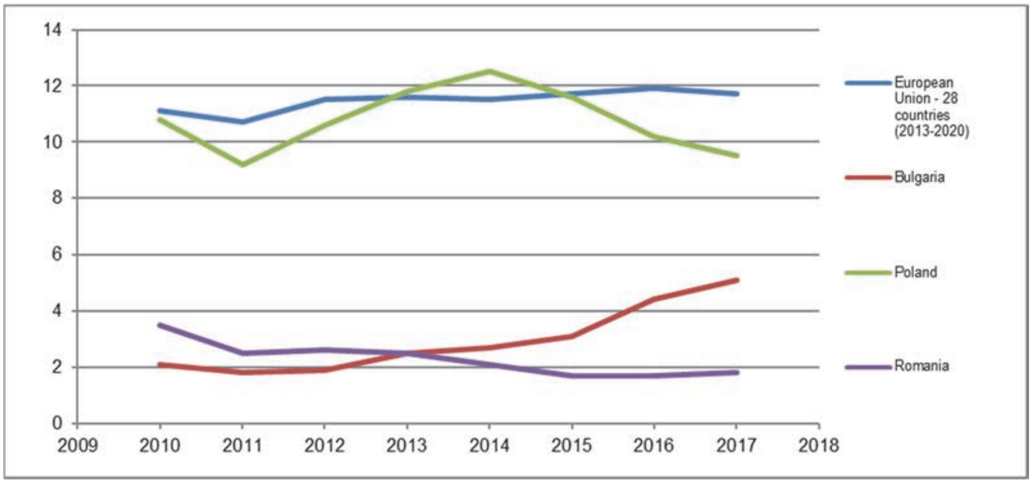

Fig. 6. The variation of the degree of reuse of raw materials in the context of the circular economy (2010 – 2018) (Eurostat, 2020)

4. Conclusions

Research has succeded in developing a new concept of helix spin economy and a framework consisting of correlated matrices, by using decision techniques in uncertainty conditions, with the help of using fuzzy triangular numbers with variable associated indicators; as from a practical and theoretical points of view, the research fulfills its main objective. In the case of embedding both macro and micro connection influences, the given model proposes a structural comprehensive helix spin economy model.Starting from the concept of circular economy, our team developed the new concept of helix spin economy, which integrates the plasma processing technologies of waste from construction industry.

When the Helix Spin economy concept is being developed, interdisciplinary approaches within the use of fuzzy mathematics, as long as uncertainty and risk predictions of technological and socio-economic points of view are being upheld. A rise in importance of the performance strategies and programs implementation analysis is implied.

The main purpose of our article was to develop the new concept called Helical Spin economy and the use of fuzzy numbers to model technological processes, identify, regardless of the field of activity, the main directions of action (material recovery, energy conversion, sustenability, technical material etc), starting from uncertainty management methods, formal or informal, using triangular fuzzy numbers with associated variable indicators.

From a practical point of view, the completion of a future specific map for a field of activity using the principles of helix spin economy, leads to new challenges regarding the analysis of different characteristics such as technological level, economic and social parameters, sustainability, leading to a growing interest in the theoretical and practical aspects of such a specific tool based on fuzzy numbers. The next stage of the research will be focused on the mapping of helix spin economy, in which the use of plasma waste recovering technologies play an important role for construction industry.

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