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This new journal series is the new face of two former journals:

- The *Scientific Bulletin of Politehnica University of Timisoara, Transaction on Economics and Social Sciences (ranked according to CNCSIS classification in Romania: D class);*
- *The Scientific Bulletin of Politehnica University of Timisoara, Transaction on Management. Economics Engineering. Transportation Engineering (ranked according to CNCSIS classification in Romania: C class).*

This new journal

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CONTENT

Scientific Bulletin
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Transactions on ENGINEERING AND MANAGEMENT

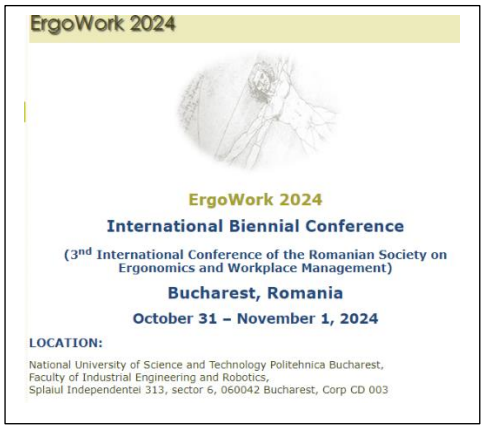
Vol. 10 Issue 1 & 2, 2024

Editorial

Anca DRAGHICI[1]

The 2024 volume, number 1 & 2, of the "***Scientific Bulletin of Politehnica University of Timisoara – Transaction on Engineering and Management***" (ISSN 2392-7364) continue to surprise having an increase visibility due to the journal index in CrossRef (https://www.crossref.org/), CEEOL (https://www.ceeol.com/) and index Copernicus (https://journals.indexcopernicus.com/) databases. In addition, the Editorial Board announced the compliance of the articles published with the Open Science movement and this only thanks to the excellent collaboration and constant support offer by the UPT Library and the Politehnica Publishing House.

All articles of the ***Scientific Bulletin*** 10th volume of 2024 have been reviewed by the members of the *Associated Editors and of the Scientific Committee;* their professional and volunteer review work impact the quality content of the papers included in this volume. Furthermore, the ***Scientific Bulletin*** benefits from the constant support of the R&D staff of the ***Research Center in Engineering and Management (RCEM)***[2] (of the Faculty of Management in Production and Transportation, Politehnica University of Timisoara, FMPT/UPT, Romania); RCEM provide a productive and positive network, and a scientific community through which we support knowledge sharing, buddy schema and trainings (formal or informal).



In 2024, the Faculty of Management in Production and Transportation, Politehnica University of Timisoara has organized ***ErgoWork 2024***, the ***3rd International Conference of the Romanian Society on Ergonomics and Workplace Management*** (Bucharest, Romania, October 31 – November 1, 2024) hosted by the National University of Science and Technology Politehnica Bucharest, Faculty of Industrial Engineering and Robotics, and some articles were selected to be published in the current volume.

The main research topics discussed by the research articles included in the current issue of the Scientific Bulletin of Politehnica University of Timisoara are:

- Employees' Perception of Superior's Conduct: Investigates how employees perceive their direct superiors' behavior and its impact on workplace efficiency.
- Energy Management: An integrated approach to managing energy resources effectively.
- Artificial Intelligence in Management: Explores how AI can shape the future of management practices.
- Smart City Solutions for Timisoara: Analyzes concepts and solutions for transforming Timisoara into a smart city;
- Ergonomics studies of different topics.

The first paper, "***Employees' Perception of Their Superior Conduct***" (authors are a group of researchers from RCEM), investigates and characterize the employees' perception of their superior's managers, more precisely, of the direct superior. The term "conduct" represents the way of behaving, behavior, and the notion of "perception" refers to perspective, point of view towards something.

The second paper "***An Integrated Approach to Energy Management"*** by Marian ION and Constantin-Catalin NICULESCU (PhD students of Politehnica University of Timisoara, Romania) debates the change of paradigm in energy consumption and energy management.

The third paper presents "***A Study on How Artificial Intelligence Can Shape the Future of Management***" by Angel TAT and Marian MOCAN, (from Politehnica University of Timisoara, Romania).

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[2] *Information available at: http://www.mpt.upt.ro/eng/research/research-center.html*

By synthesizing empirical data and theoretical insights, the study elucidates AI's potential to enhance strategic foresight, optimize operational workflows, and personalize employee development.

The fourth paper entitled ***"Analysis of the Concept and Solutions for Transforming Timisoara into a Smart City"*** by Laura ONESCU, Ionel LUNGU, Gabriela BANADUC and Anca DRAGHICI (from Politehnica University of Timisoara, Romania) presents an analysis of theoretical and practical aspects regarding the necessity of transforming cities into smart cities, supported by the actual state of things at Timisoara's City Hall, in parallel with the transition towards the city's transformation into a smart city.

The next four articles were selected from the ErgoWork 2024 conference:

1. "***Case Study on Designing Ergonomic Training and Learning Environments"*** by Cristina-Mihaela FLEACA and Irina SEVERIN (National University of Science and Technology POLITEHNICA of Bucharest, Romania) aims to highlight the key ergonomic elements needed to design classrooms that benefit both learners and trainers. Adhering to these standards can help create optimal, ergonomic learning environments.
2. "***A Study on Continuous Adaptation and Innovation Through Technology and Ergonomics to Improve Health and Safety at Work"*** (by Alexandru-Ionuț MIHAIL, Oana-Roxana CHIVU, Marilena GHEORGHE, Claudia BORDA and Augustin SEMENESCU from National University of Science and Technology Politehnica Bucharest, Romania) explores how innovative technologies can be integrated into occupational health and safety strategies, with a special focus on ergonomics as a starting point;
3. "***Defining Sit-Standing Postures: A Comparative Analysis of Chairless Chair Devices and Conventional Seating Ergonomics***" by Maria MOGA (West University of Timisoara, Romania) have developed a study which aims to investigate the criteria defining sit-standing postures offered by Chairless chair devices through comparative analysis;
4. "***Corporate Factors Affecting Workplace Health and Safety Performance and Management Decisions. A Literature Review***" by Ferenc FARAGÓ and Gyula SZABÓ presents a systematic literature review was conducted of studies published in the field of OHS performance management.

ErgoWork 2024 main organizators:

HU-1506-04-2324
Ergonomics and Human Factors Regional Educational CEEPUS Network

The conference is organized in collaboration with:

International Ergonomics Association
Federation of European Ergonomics Societies

Bulgarian Association of Ergonomics and Human Factors (BAEHF)
Hungarian Ergonomics Society (HES)
Serbia Ergonomics Society of Serbia (SESS)
Croatian Ergonomics Society (CES)
National Research and Development Institute of Occupational Safety - INCDPM "Alexandru Darabont" Bucharest, Romania
Romanian Association of Workplace and Facility Management and (ROFMA)

Scientific Bulletin
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TRANSACTIONS on ENGINEERING AND MANAGEMENT

Volume 10, Number 1 & 2, 2024

Employees' Perception of Their Superior Conduct

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Abstract - This paper investigates and characterize the employees' perception of their superior's managers, more precisely, of the direct superior. The term "conduct" represents the way of behaving, behavior, and the notion of "perception" refers to perspective, point of view towards something.

Keywords: Leadership, Management, Leader's behavior, Manager's behavior, Human resources management (HR).

I. INTRODUCTION

Perception, although subjective, is important. This is the basis of thoughts, attitudes and behaviors towards something. In a corporate environment, these aspects are essential for the proper functioning of the company, for maintaining employee unity to achieve the company's goals and vision. The conduct of the superior and especially the way it is perceived by subordinates is undoubtedly a defining factor for the efficiency of subordinates.

The present study focuses on the relationship between subordinate and superior and can be a tool for companies to correctly evaluate employees with management positions (who have other employees subordinated), employees' perception of the superior being directly correlated with his legitimacy [6]. We also believe that this study will be personally useful to me as a future human resources specialist.

Another aspect we would like to mention is that the concepts of management and leadership are embedded in the notion of superiority. Although there are differences between the two concepts (the leader is the one who creates the vision, focusing on long-term results, inspires, takes risks, while the manager focuses on the present, on medium and short-term results, seek orders, limiting risks), in common language the two notions tend to be interchangeable. For laymen, both the leader and manager are the superior. Therefore, to avoid possible confusion, we will target the two dimensions.

In the present study, we consider the demographic characteristics of the subordinate and superior, but also the impact of other entities external to the subordinate to superior relationship, which can influence perception, but which are part of the company (work colleagues, hierarchical superior of the superior), aspects directly related to the behavioral dimensions of the superior (behavior, integrity, reward, feedback), its features and the traits desired by subordinates in a superior.

II. CONCEPTUAL AND THEORETICAL FRAMEWORK

2.1 The importance of perception towards the superior

It has been proven that there is a directly proportional relationship between an employee's perception of the company, his superior, his work and his results [7], [13], [15], being also a measure of developing the quality of life of work: "Employees' perception (of the job, department, manager, organization) has been widely recommended as a method of improving the quality of life of work" [21]. Therefore, the behavior of the superior is a vital aspect for the life of the subordinate in the company [14], [13], [22]. Thus, it is necessary for the perception towards his conduct to be a positive one, which brings benefits: "The perception of employees can positively influence the productivity of the organization, when they are willing and devoted to the organization's goals" [21]. Otherwise, undesirable repercussions may occur: "the perception of the illegitimacy of the role of the superior can harm labor relations, hinder productivity and cause dysfunction" [6].

2.2 Entities that influence the perception of the superior

We must bear in mind that the formation of an opinion, a perception towards something or someone, is a complex process, which presents both internal and external influences. As [6] stated "Subordinates'

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perception of how entitled the superior is in his role can come from several sources, such as the fairness of the process used to place the superior in his role, defamation and direct observation." Therefore, it is imperative to consider both the external personalities of the subordinate-superior relationship, as well as the dimensions and characteristics of the latter.

2.2.1 External entities

There are several studies that have demonstrated the influence that others can have on us. Whether it is one of the superior's seniors or a co-worker, the effect is the same: taking over attitudes, perceptions through the phenomenon of social contagion or through the tendency of a group to reach consensus [16], [3]. However, the present study considers only the co-workers, respectively the superior's superior, because they are directly involved in the subordinate-superior relationship, being able to exert a strong influence. That's why we're not targeting family and friends. However, there is a possibility that they are part of the company.

In addition to natural persons, legal entities may also be considered. More precisely, the company to which the employee belongs, because through association with the company or by putting into practice the company's decisions, the perception towards the superior undergoes changes: "Further, Costigan, Ilter and Berman (1998) argue that employees' trust in management is based on the results of organizational decisions made by top managers and less on direct experience with actions, words and their character.

Therefore, employee trust in management is interpreted through the policies and practices of the organization" [14].

2.2.2 Superior

There are several aspects that can influence the perception towards the superior: the organization of the schedule and work tasks, the control of their fulfillment, the leadership style, his clothing, the language used, preconceptions, etc. However, since the present study considers conduct, we will only consider the behavioral dimensions of the superior.

a) The behavior of the superior is one of the most important factors influencing perception. It is important for an employee to be treated appropriately, so that he has a positive perception towards his superior and, implicitly, to have satisfaction, confidence, commitment [19].

b) Behavioral integrity of the superior. Concept that has a direct connection with behavior; A more simplistic construct than trust or justice. It is usually measured by the concordance between one's actions and one's words [23]. It is an essential aspect of any relationship, but it is even more important in a corporate environment, where a degree of integrity can affect the individual's life in the company: "(...) there are plenty of theories and ample empirical evidence suggesting that employees' perception of their managers' BI (Behavioral Integrity) will influence their attitudes toward the job, as well as other outcomes" [20].

c) Reward. Proper behavior on the part of the superior in terms of offering reward and punishment may lead to him being perceived as a fair superior or not. In addition, it can reduce job ambiguity, creating a clear picture of what the superior wants from employees [19]. In addition to results related to employee productivity, the effects of appropriate reward behavior can also be cognitive or behavioral, which can have long-term consequences: '... there is also evidence that the manner in which the leader administers rewards and punishments internally affects the employee's cognitive processes, which subsequently influence attitudes and behavior" [19].

d) Feedback provided by superior. For the employee, feedback is one of the most useful means of finding out how effective he is, what he can improve or what he is good at. But it can also be a reason to change the subordinate-superior relationship, especially for the younger generation: "Employees report various reasons why their relationship with their superior can lead to a negative turn, such as not receiving the feedback they need to know to perform, not receiving the recognition they deserve and not receiving the necessary training. According to McCullum (2009), these problems usually stem from young employees, who are accustomed for many years to receiving feedback and training from parents and teachers. For the young employee, sometimes a simple 'thank you' or 'good job' from the supervisor can make huge progress towards job satisfaction" [16]. That's why it's important to give feedback in an appropriate, positive manner.

Regarding the last two dimensions, we considered them because they are direct consequences of behavior, respectively because they can be influenced by the way the superior behaves. For example, feedback can be carried out in a calm, constructive manner, or it can be highlighted by offensive, destructive behavior. Whereas the offering of reward may be rather a consequence of the superior's desire to please himself [1].

2.3 Traits of the superior

The importance of the superior's traits for the present study lies in the fact that they can best describe his behavior. For example, an incompetent superior will act in an incompetent way, while a competent one will act according to this characteristic/label. Also, these traits have a high influence on the perception of the superior by subordinates. In 2002, Furnham conducted a study on employee perceptions of colleagues, superiors and subordinates. The aim was to determine the most desirable characteristics for each category specified above. Although there were psycho-temperamental traits universally desired by the three groups – honesty, competence – there were, of course, specific traits. In the case of the superior, Furnham concise that: "The most desirable characteristics of the superior include future-oriented, animation, impartiality" [9].

In addition to psychological characteristics, there is a possibility that socio-demographic characteristics also have an impact on behavior and perception; people being more willing to positively perceive people in the

same group than those outside the group or to act in a certain way depending on where they come from [25], [11], [10], [2], [26]. However, it is not excluded that the opposite will happen in another study conducted by Furnham, in terms of gender and age, it was observed that, in general, participants do not show a propensity towards male or female superiors, respectively young or old superiors.

However, there is also the possibility of concealment by respondents, as gender or age discrimination is prohibited [9].

2.4 Typologies of the superior

In addition to appropriate traits, it is necessary for superiors to use an appropriate leadership style (or at least be aware of their own leadership style). Therefore, it is important to consider behavioral theories, such as the Blake-Mouton model; model that targets the dynamics of interactions within a team and demonstrates its usefulness when continuous quality development is targeted [18].

Also known as the *Management Grid*, it presents two dimensions of a leader or manager: those concerned with people and those concerned with results [1]. Depending on the position on the graph formed by the two aspects, we find five classifications: Populist, Motivator, Passive, Assertive, Administrator. These typologies depend on the personality of the superior and his seniority in work [12]. The use of one of the taxonomies depends on both the superior and the subordinates he has under his leadership. A passive can be more effective when the team they manage is more experienced, while an assertive would be suitable for giving instructions to inexperienced employees.

2.5 The effects of the perception of the superior's conduct

A positive perception of the subordinate towards the superior can enhance the retention and loyalty of the employee. Increasing results and improving the employee's working life are other examples. It can also lead to a valuable relationship between the two; a relationship based on respect and trust, leading to beneficial results and behaviors: comfort, positive attitude, commitment [24] and increased productivity [21].

On the other hand, an employee's positive perception of his superior can be beneficial to the firm, representing a method of measuring the legitimacy of superiors: "Companies can observe the perception towards the legitimacy of the superior's role by monitoring feelings towards the superior through employee surveys or evaluations. (...) Understanding these perceptions can enable firms to increase efficiency by better matching their control system with their culture of legitimacy" [6].

The employee's perception of the superior's conduct is an important aspect, after which we can guide ourselves in making predictions about the employee's future in the company or about his behavior: "(...) it is perception rather than reality that influences attitudes and then employee behavior" [20]. Therefore, by studying the perspective towards the superior, by analyzing the factors that influence the perception, respectively the features of the superior and the demographic characteristics of the subordinate, results can be obtained that can be considered in improving the employee's working life or even represent the basis for a training program for superiors.

III. METHODOLOGIES

3.1 Methodological Design

Because we aimed for the data to be as representative as possible, it was necessary to get as many answers as possible from as many respondents as possible. Therefore, we used the method of sociological inquiry, having the questionnaire as a research tool. For the first questions we used Likert scales from 1 (None) to 6 (Totally).

For questions regarding personal opinion regarding the behavioral dimensions of the superior, we used a Likert scale from 1 (Very small measure) to 5 (Very large extent), respectively a scale from 1 (Totally untrue) to 5 (Total true), for the types of superior. As for the latter, we built them starting from the set of characteristics of the typologies of the Management Grid, found in [12]. We were also inspired to produce the questionnaire by Furnham's study [9]. We did not use all the traits used by the British researcher, because the study of the distinguished also targets the ideal characteristics desired in coworkers and subordinates, not just superiors. Thus, we created a set of 15 characteristics, of which we asked respondents to choose only 5 and order them according to importance. We also gave them the opportunity to give answers that are not among those we proposed.

Another aspect we would like to mention is that when we mention external agents or external entities that influence perception, actually we refer to the natural and legal persons mentioned within the concept and theoretically who are external to the subordinate-superior relationship, but who can influence the perception of the former towards the conduct of the latter (work colleagues, superior of the superior and company). By the same principle, when we speak of "others", we mean colleagues and work and the superior of the superior taken as a whole, together.

3.2 Objectives and assumptions

As mentioned in the introduction, we want this paper to be a tool through which companies can properly evaluate employees in management positions, to develop appropriate strategies to improve the quality of life of employees. Therefore, to achieve this, we pursued the following goals (G*n*) considering the following assumptions (A*n*):

G1. Identifying how people outside the subordinate-superior relationship, who can influence the perception of the former towards the conduct of the latter (others, the company or the superior) influence the

most the perception of employees towards the conduct of the superior.

G2. Discover how the three behavioral dimensions of the superior (integrity, reward, feedback) influence the perspective of subordinates towards the superior's conduct.

G3. Capturing the characteristics of the ideal superior, as considered by the employees.

G4. Identifying the link between adopting a specific managerial style and subordinates' perception of the superior's conduct.

G5. Identification of differences in perception of employees towards superiors (depending on their social-demographic characteristics).

A1. There is a statistically significant correlation between co-workers' perception of their superior's behavior and their individual perception of their supervisor's behavior.

A2. There is a significant link between the perceived behavioral integrity of the superior and the employees' perception of their conduct.

A3. There are similarities between the characteristics of the ideal superior identified with previous studies.

A4. There is a statistically significant link between the managerial styles adopted and the employee's perception of the superior's conduct.

A5. There are statistically significant differences between male and female employees in subordinates' perception of superior's behavior.

3.3 Data collection and limitations

To collect the data, we used the snowball method. Initially, we sent the questionnaire to several acquaintances for completion and asked them to forward it to others. After a period of time, we sent it (through the Politehnica University's email platform) to other students, with the specification that it targets only people who have a superior, with the request to send it further for completion. Data collection extended for approximately 1 month (February 2023).

The main limitation of this work concerns data collection. However, we tried to overcome this impediment by weighing up when there were significant discrepancies, such as in the case of gender and age of employees.

Another limitation of the work is that perception is very subjective. Thus, various problems may arise in the evaluation of conduct, such as recent effects, halo effect, contrast error or similarity, which can distort the reality.

IV. RESULTS

Following the data gathering, we obtained 316 respondents, aged between 18 and 62. The average is 25.52 years, while the median and mode are 21 and 20 years, respectively (60 respondents), which means that most of the people who responded to the questionnaire are young people. Of these, 79.7% (N=252) are female, while only 19% (N=60) are male. Also, 64.2% (N=203) come from urban areas, and 35.4% (N=112) fall into rural areas. As for the distribution by level of education, it ranges from secondary education to postgraduate studies. However, most respondents say they have completed 12 classes (61.4%, N=194 respondents). This is a natural result, given that half of the respondents are under the age of 21 (see Table 1).

As for the respondents' superiors, as claimed by the respondents to the questionnaire, they are aged between 18 and 76 years, most of them being 40 years old (median=40). Most are male (N=167, mean=52.8%) and come from urban areas (N=185, mean=74.2%).

Table 1: Descriptive analysis on socio-demographic traits of respondents and their superiors

Subordinates			
Variable		Number	%
Age	18-24 years	240	73.6
	25-34 years	38	11.7
	35-49 years	38	11.6
	50-64 years	10	3.1
	Over 65 years old	0	0
Sex	Masculine	60	18.99
	Feminine	252	79.75
Medium	Rural	112	35.44
	Urban	203	64.24
Education	Secondary education	194	61.93
	Higher education	108	34.18
	Other studies	14	4.43
Higher			
Variable		Number	%
Age	18-24 years	9	2.85
	25-34 years	68	21.52
	35-49 years	222	70.25
	50-64 years	26	8.23
	Over 65 years old	1	0.32
Sex	Masculine	156	49.37
	Feminine	142	44.94
Medium	Rural	62	25.94
	Urban	177	74.06
Education	Secondary education	26	11.11
	Higher education	202	86.32
	Other studies	6	2.56

In terms of education level, 63.9% of them graduated from higher education (N=202), 8.2% high school education (N=26), and 26% of respondents did not know or did not want to disclose the level of education of the higher (N=82). The remaining 1.9% graduated from other categories of studies (gymnasium school, post-secondary or technical school of foremen, etc.) (see Table 1).

To verify the first hypothesis, we made a bivariate correlation between employees' perception of the superior's behavior and entities external to the subordinate-superior relationship that can influence the perception of the former towards the latter's behavior, respectively the behavioral dimensions of the superior, which revealed to me that there are statistically significant strong correlations between all the variables mentioned (Sig.<0.001). Unsurprisingly, the superior shows the strongest correlation among the people who can influence the employee's perception of his conduct (R=0.83), followed by his work colleagues (R=0.39), the superior's superior (R=0.17), respectively the company (R=0.28) (see Table 2).

Regarding the dimensions of the superior, the one that showed the highest degree of correlation with the employee's perception of the superior's conduct was integrity, with a value that tends to be very strong (R=0.81), followed the superior provides feedback (R=0.72) and rewards (R=0.63). Based on studies conducted by [19], and [16], we expected there to be a statistically significant link between perception of superior's conduct and reward or feedback. Initially, we didn't think they would have such a strong correlation. Also, we believed that they would register an average correlation, with values between 0.40–0.50. Instead, they exhibit an average correlation level that tends to be strong (see Table 2).

We also wanted to compare the correlation levels between the mentioned variables and the employee's perception of the superior with correlation levels of the same variables as the employee's general perception of the superior. Following the analysis, we found out that there is a statistically significant correlation between the mentioned variables and the general perception (Sig.<0.003), but also that the aspects related to the superior have a lower correlation with the general perception towards him: behavior (R=0.61), the superior himself (R=0.59), behavioral integrity (R=0.54), the way he gives feedback (R=0.49), how they offer rewards (R=0.44) On the other hand, persons external to the subordinate-superior relationship show a higher degree of correlation with the general perception of the employee towards the person to whom he is subordinate than with that regarding his conduct: work colleagues (R=0.49), superior of the superior (R=0.20), company (R=0.39) (see Table 2). From these data we can deduce that the superior influences more easily the perception of his behavior than the general perception of himself. In contrast, co-workers can more easily alter their overall perception of their supervisor than their perception of their superior's behavior (R=0.492) (see Table 3).

Table 2: Correlation between entities outside the subordinate-superior relationship, the behavioral dimensions of the superior and the employee's perception of the superior's conduct

Variable	Pearson Correlation	Sig. (2-tailed)
Superior	0.832	0.000
Integrity	0.811	0.000
Feedback	0.721	0.000
Co-workers	0.637	0.000
Reward	0.392	0.000
Company	0.282	0.000
Superior of the superior	0.173	0.002

Table 3: Correlation between entities outside the subordinate-superior relationship, the behavioral dimensions of the superior and the general perception of the employee towards the superior

Variable	Pearson Correlation	Sig. (2-tailed)
Behavior	0.612	0.000
Superior	0.590	0.000
Integrity	0.546	0.000
Feedback	0.496	0.000
Co-workers	0.492	0.000
Reward	0.441	0.000
Company	0.393	0.000
Superior of the superior	0.202	0.002

We continued the analysis by performing a regression in which the dependent variable is the employee's perception of the superior's conduct, and the independent one is the superior. According to the ANOVA table, the developed model is statistically relevant (Sig<0.01). In the Model Summary tables, we found that 69.1% of the total variation in employee perception of superior's conduct can be explained by superior's perception (adjusted R square=0.69). In the last table, the coefficients, we find the value of the constant (B=0.44) and that of the coefficient (B=0.222). Both the value of the constant and the coefficient are statistically relevant (Sig.<0.05). Another aspect that shows us the relevance is the Lower Bound/Upper Bound intervals, which do not record the value 0, even in the case of the constant (Lower Bound=0.222; Upper Bound=0.704), nor in the case of the coefficient (Lower Bound=0.206; Upper Bound=0.239). Thus, we can calculate the perception towards the conduct of the superior by the formula: 0.440+0.222**perception* towards the superior (see Tables 4a, 4b, 4c).

We also noticed that there are differences between the perception of respondents with higher education and those with secondary education, in terms of total variation. More specifically, the fact that employees with tertiary education (adjusted R square=0.764) show higher values than those with secondary education (adjusted R square=0.633) regarding the percentage in which the total variation in employees' perception of the superior's conduct is influenced by the superior (see Tables 5a and 5b). This difference can be explained by the fact that occupations requiring a lower

level of qualification do not require the cultivation of a special relationship with the superior. There are also differences depending on age, from which it appears that employees aged 25-34 years (adjusted R square=0.805) and 35-49 years (adjusted R square=0.775) are more influential in terms of changing the perception of the superior's conduct than those aged 18-24 years (adjusted R square=0.642) and 50-64 (adjusted R square=0.586) years (see Tables 6a, 6b, 6c, 6d). The fact that young people want to stand out at the beginning of their careers, adopting more consistent proactive behavior than older employees is an explanation of this difference on the age variable.

*Table 4a: Regression between the superior and the employee's perception of his conduct *)*

Model Summary				
Model	R	R Square	Ajusted R Square	Std. Error of the Estimate
1	.832a	.692	.691	.601
a. Predictors: (Constant), apreciere_sup				

*) The "apreciere_sup" refers to the appreciation of the superior by the employees.

*Table 4b: Regression between the superior and the employee's perception of his conduct *)*

ANOVA						
Model		Sum of Squares	df	Mean Square	F	Say.
1	Regression	254.827	1	254.827	704.889	.000 b
	Residual	113.515	314	.362		
	Total	368.342	315			
a.Dependent Variable: Behavior. To what extent do you assess your superior's behavior?						
b. Predictors: (Constant), apreciere_sup						

*) The "apreciere_sup" refers to the appreciation of the superior by the employees.

*Table 4c: Regression between the superior and the employee's perception of his conduct *)*

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Say.
1	(Constant)	.440	.134		3.276	.001
	apreciere_sup	.222	.008	.832	26.550	.000
a. Dependent Variable: behavior. To what extent do you assess your superior's behavior?						

*) The "apreciere_sup" refers to the appreciation of the superior by the employees.

*Table 5a: Regression between the superior and the perception of employees with secondary education towards his conduct *)*

Model Summary				
Model	R	R Square	Ajusted R Square	Std. Error of the Estimate
1	.796b	.633	.631	.613
a. studii_ang_C1 = 1Secondary education				
b. Predictors: (Constant), apreciere_sup				
c. Dependent Variable: Behavior. To what extent do you assess your superior's behavior?				

*) The "apreciere_sup" refers to the appreciation of the superior by the employees and the "studii_ang_C1" refers about the education level of the employees.

*Table 5b: Regression between higher and higher education employees' perception of their conduct *)*

Model Summary				
Model	R	R Square	Ajusted R Square	Std. Error of the Estimate
1	.875b	.766	.764	.590
a. studii_ang_C1 = 2 Higher educations				
b. Predictors: (Constant), apreciere_sup				
c. Dependent Variable: Behavior. To what extent do you assess your superior's behavior?				

*) The "apreciere_sup" refers to the appreciation of the superior by the employees and the "studii_ang_C1" refers to the education level of the employees.

*Table 6a: Regressions between the superior and the employee's perception of his conduct, depending on the age of respondents *)*

Model Summary				
Model	R	R Square	Ajusted R Square	Std. Error of the Estimate
1	.816b	.665	.642	.641
a. varsta_ang_C1 = 1 18-24 years				
b. Predictors: (Constant), apreciere_sup				

*) The "apreciere_sup" refers to the appreciation of the superior by the employees and the "varsta_ang_C1" refers to the age of the employees.

*Table 6b: Regressions between the superior and the employee's perception of his conduct, depending on the age of respondents *)*

Model Summary				
Model	R	R Square	Ajusted R Square	Std. Error of the Estimate
1	.899b	.808	.805	.565
a. varsta_ang_C1 = 2 25-34 years				
b. Predictors: (Constant), apreciere_sup				

*) The "apreciere_sup" refers to the appreciation of the superior by the employees and the "varsta_ang_C1" refers to the age of the employees.

*Table 6c: Regressions between the superior and the employee's perception of his conduct, depending on the age of respondents *)*

Model Summary				
Model	R	R Square	Ajusted R Square	Std. Error of the Estimate
1	.881b	.777	.775	.542
a. varsta_ang_C1 = 3 35-49 years				
b. Predictors: (Constant), apreciere_sup				

*) The "apreciere_sup" refers to the appreciation of the superior by the employees and the "varsta_ang_C1" refers to the age of the employees.

*Table 6d: Regressions between the superior and the employee's perception of his conduct, depending on the age of respondents *)*

Model Summary				
Model	R	R Square	Ajusted R Square	Std. Error of the Estimate
1	.769b	.591	.586	.613
a. varsta_ang_C1 = 4 50-64 years				
b. Predictors: (Constant), apreciere_sup				

*) The "apreciere_sup" refers to the appreciation of the superior by the employees and the "varsta_ang_C1" refers to the age of the employees.

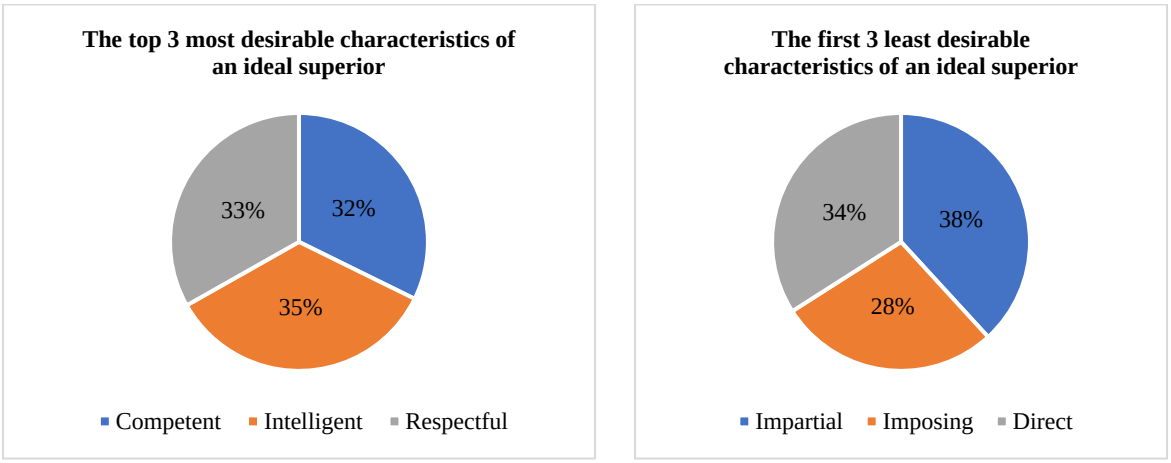

Fig. 1. Research results - Chart 1 and Chart 2

To check the third hypothesis, we conducted a frequency analysis on all characteristics of an ideal superior. Depending on how often they were chosen by respondents, the top three places are occupied by intelligence (N=152), respectful behavior (N=146) and competence (N=142) (see Chart 1). At the opposite pole, in the last places, are the imposing character (N=40), the tendency to be direct with subordinates (N=49) and impartiality (N=55) (see Chart 2).

Following a weighted average, we were also able to get a ranking based on how important those traits are for respondents. Thus, in the first three places we found competence (mean=3.85), intelligence (mean=3.54), respectfulness (mean=3.15). In contrast, the top three least important desirable traits in an ideal superior are ambition (mean=2.47), tendency to be direct (mean=2.51), and determined behavior (mean=2.58). As can be seen, the most common traits, but also the most desired, are those related to professionalism or skills that allow the superior to achieve performance at work (intelligence, competence). Over time, characteristics aimed at sociability are less desirable, except for respectfulness.

One aspect we would like to mention is that we did not consider the variable "other" in our analyses, because it was chosen by very few respondents (N=6). However, we noticed that among other traits that employees would like in an ideal superior, which are not among the options proposed by me, respondents mentioned characteristics related to sociability ("open", "empathetic"), competence at work ("punctuality", "to know the field very well"), but also religiosity ("faith in Jesus").

Regarding the verification of the fourth hypothesis, we calculated the average of typologies; to find out what type of behavior is most common in superiors. Thus, we found out that one perceives most often a behavior specific to the motivator (m=3.78), followed by that characteristic of the accommodating (m=3.58), administrator *(status quo)* (m=3.41). the indifferent (Indifferent) (m=2.90) and the authoritarian (dictatorial) (m=2.56).

After that, we made a correlation between them and the perception of employees towards the superior. Following the analysis, we obtained that there is a correlation between the subordinate's perception of the superior's conduct and his typology (Sig.<0.01). The strength of correlations is small with respect to the following typologies: accommodating, indifferent, authoritarian and administrator. As for the motivator, although we expected it to show a lower correlation level than the accommodator and administrator, it shows the highest degree of correlation (R=0.551). Also, all correlations show positive values, except for those aimed at the indifferent and the dictator, which have negative values. This means that there is an inversely proportional correlation between employees' perception of their superior and these typologies. In other words, the less the superior behaves in an indifferent or authoritarian way, the more positive the perception towards them (see Table 7).

Next, we performed a regression where the independent variable is the employee's perception of adopting a behavior specific to the motivator's typology by the superior, and the dependent one is the subordinates' perception of the superior's conduct, as a result of which, only 36.9% of the total variation in perception towards the superior's conduct can be explained by his adoption of a behavior specific to the motivator's typology (adjusted R square=0.369). The percentage is statistically significant according to materiality (Sig<0.01) (see Tables 8a, 8b).

After that, we checked whether there were differences between the percentages of total change, depending on the socio-demographic characteristics of respondents. Thus, we found that there are differences between male (adjusted R square=0.466) and female (adjusted R square=0.341) respondents (see Tables 9a and 9b). In other words, men would appreciate a motivating superior more than women. One explanation is that, unlike men, women are more motivated to excel in artistic fields [17]. This could also manifest itself in adult life, causing women to rate a motivating superior less than their male counterparts because the nature of their jobs does not coincide with that on which they were motivated from childhood. Also, as in the case of regression between the superior's perception of the subordinate's behavior towards the conduct of the person to whom he is subordinated, there are differences between subordinates aged between 25-34 years (adjusted R square=0.443), respectively 35-49 years (adjusted R square=0.466) and young (adjusted R square=0.297) and older (adjusted R square=0.349) (see Tables 10a, 10b, 10c, 10d). The reason could be like the one that explains that young and old people are not equally influenced by their perception of their superior's behavior. In terms of background and employee studies, they did not register significant differences (Tables 9a, 9b, 10a, 10b).

Table 7: Correlation between the employee's perception of the superior's conduct and the typologies of the Grid

Variable	**Pearson Correlation**	**Sig. (2-tailed)**
Motivator	0.551	0.000
Accommodating	0.285	0.000
Administrator (status quo)	0.267	0.000
Indifferent	-0.303	0.000
Dictator	-0.314	0.000

*Table 8a: Regression between the superior's adoption of the motivator's typology and the employee's perception of his conduct *)*

Model Summary				
Model	R	R Square	Ajusted R Square	Std. Error of the Estimate
1	.609a	.371	.369	.857
a. Predictors: (Constant), motivant_C1				
b. Dependent Variable: Behavior. To what extent do you assess your superior's behavior?				

*) The "motivant_C1" refers to the appreciation of the superior by the employees about motivation.

*Table 8b: Regression between the superior's adoption of the motivator's typology and the employee's perception of his conduct *)*

ANOVA						
Model		Sum of Squares	df	Mean Square	F	Say.
1	Regression	128.761	1	128.761	175.238	.000b
	Residual	218.229	297	.735		
	Total	346.990	298			
a.Dependent Variable: Behavior. To what extent do you assess your superior's behavior?						
b. Predictors: (Constant), motivant_C1						

*) The "motivant_C1" refers to the appreciation of the superior by the employees about motivation.

*Table 9a: Regressions between superiors and male employees' perception of their conduct *)*

Model Summary				
Model	R	R Square	Ajusted R Square	Std. Error of the Estimate
1	.685b	.470	.466	.825
a. sex_ang What is your gender? = 1 Male				
b. Predictors: (Constant), motivant_C1				
c. Dependent Variable: Behavior. To what extent do you assess your superior's behavior?				

*) The "motivant_C1" refers to the appreciation of the superior by the employees about motivation and the "sex_ang" refers about the gender of the employees.

*Table 9b: Regressions between the superior and the perception of female employees towards their conduct *)*

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.588b	.345	.341	.869
a. sex_ang What is your gender? = 2 Female				
b. Predictors: (Constant), motivant_C1				
c. Dependent Variable: Behavior. To what extent do you assess your superior's behavior?				

*) The "motivant_C1" refers to the appreciation of the superior by the employees about motivation and the "sex_ang" refers about the gender of the employees.

*Table 10a: Regressions between the superior and the employee's perception of his conduct, depending on the age of respondents *)*

Model Summary				
Model	R	R Square	Ajusted R Square	Std. Error of the Estimate
1	.587b	.344	.297	.907
a. varsta_ang_C1 = 1 15-24 years				
b. Predictors: (Constant), motivant_C1				

*) The "motivant_C1" refers to the appreciation of the superior by the employees about motivation and the "varsta_ang_C1" refers to the age of the employees.

*Table 10b: Regressions between the superior and the employee's perception of his conduct, depending on the age of respondents *)*

Model Summary				
Model	R	R Square	Ajusted R Square	Std. Error of the Estimate
1	.672b	.452	.443	.913
a. varsta_ang_C1 = 2 25-34 years				
b. Predictors: (Constant), motivant_C1				

*) The "motivant_C1" refers to the appreciation of the superior by the employees about motivation and the "varsta_ang_C1" refers to the age of the employees.

*Table 10c: Regressions between the superior and the employee's perception of his conduct, depending on the age of respondents *)*

Model Summary				
Model	R	R Square	Ajusted R Square	Std. Error of the Estimate
1	.685b	.470	.466	.837
a. varsta_ang_C1 = 3 35-49 years				
b. Predictors: (Constant), motivant_C1				

*) The "motivant_C1" refers to the appreciation of the superior by the employees about motivation and the "varsta_ang_C1" refers to the age of the employees.

*Table 10d: Regressions between the superior and the employee's perception of his conduct, depending on the age of respondents *)*

Model Summary				
Model	R	R Square	Ajusted R Square	Std. Error of the Estimate
1	.598b	.357	.349	.800
a. varsta_ang_C1 = 4 50-64 years				
b. Predictors: (Constant), motivant_C1				

*) The "motivant_C1" refers to the appreciation of the superior by the employees about motivation and the "varsta_ang_C1" refers to the age of the employees.

We also wanted to find out if there is a statistically significant link between the socio-demographic characteristics of the superior and the employees' perception of adopting these typologies. Therefore, we conducted a T-test, which provided me with the fact that there is a link between subordinates' perception of the adoption of an authoritarian style by superiors regarding gender, according to the value of materiality threshold (Sig.(2-tailed) = 0.021) and the interval Lower Bounds (0.209)–Upper Bounds (2.669), which does not register the value 0. Continuing the interpretation, based on differences between averages, we note that male superiors (mean=15.95) are perceived as more authoritative than their female counterparts (mean=14.51) (see Tables 11a and 11b). One possible explanation is that men can be considered tougher, while women are considered gentler, more pleasant. In addition, we found a statistically significant link between the perception of subordinates towards the adoption of an authoritarian style by superiors and the superior's environment of origin, because the materiality threshold does not exceed the value 0.05 (Sig.(2-tailed) = 0.44), and the value 0 is not found in the range Lower Bounds (0.40)–Upper Bounds (3.178). Also, according to the average, superiors in rural areas (mean=16.37) are perceived as more authoritarian than those in urban areas (mean=14.76) (see Tables 12a and 12b). One possible reason is that the importance of a leadership position may differ between those in rural and urban areas. This would mean that rural superiors may be more task-centric than employee-centric when they reach such positions.

*Table 11a: T-test between male and female superiors according to the adoption of a dictator-specific typology *)*

Group Statistics					
	sex_sup What is the gender of your superior?	N	Mean	Std. Deviation	Std. Error Mean
Assertive	1 Male	167	15.95	5.854	.453
	2 Female	149	14.51	5.216	.427

*) The "sex_sup" refers about the gender of the superior.

Table 11b: T-test between male and female superiors according to the adoption of a dictator-specific typology

Independent Samples Test						
T-test for Equality of Means						
		Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Asertive	Equal variances assumes	.022	1.443	.627	.209	2.677
	Equal variances not assumes	.021	1.443	.623	.217	2.669

*Table 12a: T-test between village and city superiors according to the adoption of a dictator-specific typology *)*

Group Statistics					
	mediu_sup What is your superior's background?	N	Mean	Std. Deviation	Std. Error Mean
Asertive	1 Rural	64	16.37	6.066	.756
	2 Urban	185	14.76	5.301	.390

*) The "mediu_sup" refers to the environment of provenance of the superior.

Table 12b: T-test between village and city superiors according to the adoption of a dictator-specific typology

Independent Samples Test						
T-test for Equality of Means						
		Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
					Lower	Upper
ASERTIVE	Equal variances assumes	.044	1.609	.797	.040	3.178
	Equal variances not assumes	.061	1.609	.850	-.078	3.296

To test the latter hypothesis, we performed the T-tests and ANOVA analyses between the social-demographic traits of respondents, respectively superiors and the perception of the latter's conduct. However, we did not obtain statistically significant differences between the perception of the superior's conduct and the sociodemographic characteristics of the superior, respectively of the respondents.

V. CONCLUSIONS AND FINAL REMARKS

At the beginning of the research, we considered that the superior will be the one who most strongly influences the perception of his behavior, while people external to the subordinate-superior relationship will have little influence. The data obtained confirms this hypothesis for me. However, we noticed that the perception of coworkers towards the superior shows a higher correlation with the general perception of respondents towards him, than with the perception towards his conduct. One possible explanation is that, as a rule, the way someone behaves is less interpretable; especially in the workplace, which is a formal environment, requiring the most concise interaction, leaving no room for interpretation, so that the activity is carried out in an appropriate manner, according to the required requirements. This could explain why behavioral integrity shows such a high correlation with the subordinate's perception of the superior's conduct. Instead, the image we form towards someone is rather psychological in nature, which can occur when it meets the opinions of others towards that person.

Regarding the most desirable traits of an ideal superior, an interesting aspect is the characteristic of respectfulness. However, instead of respondents' answers being found in extremities, they are positioned homogeneously on the 5 answer options (with a slight tendency to increase). In other words, respectfulness is the universally desired characteristic in a superior, regardless of its importance.

Also, regarding the desired characteristics in a superior, as mentioned in the objectives and hypothesis's part, we expected to notice similarities with Furnham's study in 2002. However, we found out that there are rather differences between our study and that of the British researcher. For example, although they were rated as some of the most desirable characteristics in the psychologist's study, honesty and openness changed rank low in my rankings. Another example is that impartiality was among the most desirable traits in a superior in Furnham's study [9], but in our own, it ranks third among the most undesirable traits. There is a possibility that these differences are explained because of a difference in methodological approaches between me and the British researcher. However, we believe that these differences are explained rather because of the 20-year difference between our study and Furnham's study. In addition, it is not excluded that these differences also have a cultural bias explanation, because our study was conducted in Romania, while the one in 2002 was conducted in the UK. On the other hand, we also recorded similarities. Competence is among the most desirable characteristics, and animation is one of the characteristics of the motivator typology, which is the most appreciated of the typologies of the Management Grid.

In fact, if we were to achieve an ideal model of superior, according to the data obtained, it would be motivating, intelligent, competent and respectful. In other words, someone we perceive we can rely on, who helps us evolve at work without becoming arrogant. On the other hand, someone authoritarian, imposing, impartial and direct (a person who continually criticizes all his subordinates) is not the most desirable superior.

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An Integrated Approach to Energy Management

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Abstract – Energy is consumed everywhere and by everybody, in different circumstances and in different forms. Life itself is based on energy consumption, among other resources. The crisis human societies have faced since ancient times forced us to identify and use better ways to manage energy. A similar but increasingly aggravating situation humanity is confronting at current times, especially when discussing resources availability correlated with climate change, global economic difficulties or the war in Ukraine, and their impact on energy availability. Starting the 1st industrial revolution, organisations, businesses especially, started searching for ways to improve the use of resources and energy, as well as ways to store energy for longer periods of time. Increasing diversification and complexity of technologies lead in time to increased availability of energy as critical resource for human activities but, also, exposed us to various risks directly or indirectly brought by modern technologies. A strong change of paradigm in energy consumption and energy management must be made with respect to the entire life cycle of energy units, to maintain or improve our current lifestyle in the context of the crisis we are facing now, and we are prone to face in the foreseeable future. In this perspective, we need to step away from localized, sectorial approaches of energy, and move toward an integrated and integrative approach of energy management, focused on 3 important pillars – behaviour (regarding regulations/standards), technology (ICT/ICS technologies), and education.

Keywords: Energy management, integrated approach

I. INTRODUCTION

All crisis situations (e.g., climate, energy, financial, the war at EU border, etc.) guide us to improve resources management and cost control, hopefully with better outcomes in terms of benefits to both, human society and the environment. Limited availability of natural resources, energy included, as well as profitability constraints, correlated with a growing acknowledgement of climate changes and other crisis we are confronting, lead to an increased focus on the need to reduce energy consumption and optimise technological processes to limit the impact of human activities on the environment (Mariano-Hernandez et al., 2021). Environmental education, environmental economics, or engineering, standardisation, interoperability, infrastructure consolidation, energy management, etc., are strong characteristics of the 4th industrial revolution, also known as Industry 4.0, leaning towards increased productivity and efficiency, improved products, and services, reduced consumption of resources, reduced wastes, improved reuse, and recycling. Tendencies in optimizing production processes and activities on a large scale were observed from the early stages of industrialisation and reached the current level over long periods of time, with important costs and consequences on the environment (Klaus Schwab, 2015). Many efforts were made to improve production and delivery workflows, to save energy and costs, to reduce the environmental footprint of human activities while increasing profits and maintaining an optimum level of benefits.

In this perspective, all processes managing production, transport, consumption, and recycling of energy units, to optimize activities and reduce energy usage fall under the concept of energy management system (EnMS). In 2015 the Directorate for Science, Technology, and Innovation – Steel Committee of OECD defined an Energy Management System as "a systematic process for continually improving energy performance and maximising energy savings. The principle of an EnMS is to engage and encourage staff at all levels of an organisation to manage energy use on an on-going basis." (Organisation for Economic Co-operation and Development, 2015). Even if it refers only to organisations, it represents one of the most comprehensive and easily understood definitions of an energy management system.

II. INTEGRATED APPROACH IN ENERGY MANAGEMENT

Until recent years traditional implementations of energy management systems focused on procedures implemented at organizational level to ensure

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conformity to different standards families, such as: ISO/IEC 9000 on quality management, ISO/IEC 50000 on energy management, ISO/IEC 14000 on environmental management). The standards do not apply directly to householding, or professional activities of consumers but still, the standards apply to them indirectly through the standardized functional and technological characteristics of the goods and services they purchase from the market.

The current outlook to energy management, focused on a sectorial, distinct approach, is no longer sufficient for the successful evolution of human society on Earth, and an improved and more reliable approach to energy focused on synergic understanding and integrative measures should be pursued. Thus, with respect to the technological advancements of our times, energy management cannot be approached any longer only from procedural perspectives, as one may understand from the provisions of the ISO 50000 family of standards, but need to deepen on the technological and educational layers more than the standardisation suite recommends at the time of writing. Also, though ISO/IEC 50000 standards are meant to be applied by legal persons (organisations, by their legal definition), their provisions are, as well, useful to common people in managing their homes and other infrastructures they use. Therefore, the present paper concentrates on the need to extend the classical perspective of procedural approach in energy management systems to an integrated one, capable to provide an adapted response from us as individuals but also as an entire society, to current energy and climate provocations the entire globe is facing.

In these perspectives, we are considering a 3-pillars approach of energy management focusing on behaviour pillar (also referred in the paper as the regulations and standards pillar), technology pillar (also referred in the paper as the ICT/ICS technologies pillar), and the educational one, each of them with their own functional and relational attributes. For its effective implementation, it needs to be applied on all social and economic sectors involving natural resources and/or pollution, adding upon the benefits of technology advancements, data usage, and modern education means, with respect to new potential risks brought by modern technologies to the safety and security of people, infrastructures, data, and the environment (Fig. 1).

An integrative approach to energy management, applied to all types of human activities leads to a systematic management of the life cycle of energy units – prospect, production, transport, consumption and (waste) recycling. While the entire life cycle of energy units is important, the consumption phase bears a heavier relevance due to the critical resource status of energy, the benefits it brings to people and the potential effect of its results on the environment.

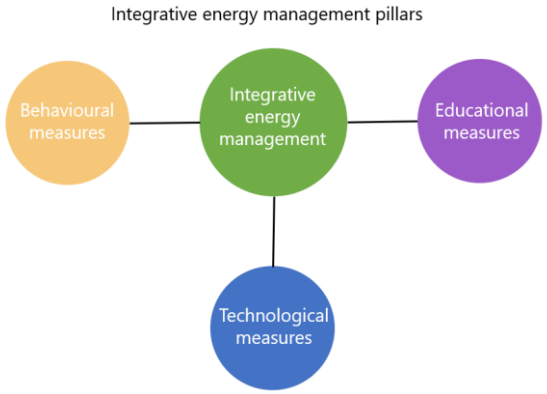

Fig. 1. An integrative energy management approach (IEMA)

Building on the traditional model of an energy management system (EnMS) based on procedural implementations, the paper focuses on the need to expand the traditional concept of energy management to an integrated and integrative perspective of a system of systems type, adding. The pillar of procedural measures and the technological one commonly addresses the organizational level in companies that build infrastructures, which create goods and provide services, while the pillar of educational measures mainly targets the beneficiaries of built infrastructures, equipment and services provided by the market.

This approach comes to build on the principles introduced in the classical implementation of energy management systems, similar to the integrative outlook brought by the present 4th industrial revolution, as highlighted by K. Schwab since 2015 (Klaus Schwab, 2015). Integrated perspectives over energy efficiency and energy management came into attention in the last years in many research papers on sectorial basis (Saletti, Morini and Gambarotta, 2022), (Tian et al., 2018), (Hu et al., 2022), (Liu, Jian and Jia, 2023), (Brandi, Gallo and Capozzoli, 2022), (Arab, Rekik and Krichen, 2023), (Mahmood et al., 2022), (Tan et al., 2023), (Wang, Zheng and Yang, 2023), (Viesi et al., 2023), but still need to get traction for a broader approach as proposed in the present paper.

As it is not the purpose of the paper to detail each pillar but to emphasize the need for an integrative approach of all 3 of them, in the following sections we will briefly review the meaning and influence of the pillars on energy management, based on a SWOT analysis on each pillar.

III. SWOT ANALYSIS ON AN IEMA

A SWOT analysis was performed to highlight several aspects considered on the opportunity to introduce an integrated energy management concept. The analysis is presented in a synthetic form, as follows:

Table 1. Summary on the procedural pillar.

Strengths	**Weaknesses**
• Compliance enforcement • Voluntary compliance • Common framework • Large scale • Consistency, sustainability	• Difficulties in enforcement process • Costly, time consuming • Challenging cybersecurity
Opportunities	**Threats**
• Tighter regulations • Harmonized standards	• Market pushbacks • Risks of ineffectiveness

Table 2. Summary on the (ICofICS) technology pillar.

Strengths	**Weaknesses**
• Performance improvement • Interoperability • Optimization • Real-time operation • Informed decisions	• Higher implementation costs • Difficult pace keeping with technology progress • Cybersecurity risks
Opportunities	**Threats**
• Technology improvements • Informed decisions • Energy technologies integration • Improved energy units' life cycle	• Difficult backwards compatibility • Difficult adaptation • Privacy concerns

Table 3. Summary on the educational pillar.

Strengths	**Weaknesses**
• Easier, large-scale adoption • Improved awareness • People empowering • Sustainable, responsible culture	• Long application time • Difficult resources availability • Illiteracy obstacles
Opportunities	**Threats**
• Sustainable mindset • Continuous learning • Wider audience with Internet	• Difficult scalability and effectiveness • Resistance to change

1) Strengths:
   a) On the regulatory/standardisation pillar:
      i) Facilitates compliance enforcement for legal actors (organisations, by their legal definition) to energy efficiency and environmental management regulations, standards, and codes.
      ii) Facilitates voluntary compliance for small legal actors or other persons interested in energy efficiency and environmental management.
      iii) Provides a common framework for implementing, measuring, and monitoring energy management practices.
      iv) May be applied at larger than national scale, for signers of international treaties and agreements.
      v) Promotes consistent and sustainable energy management across industries and sectors.
   b) On the ICT and ICS technologies pillar:
      i) Enhances the performance of energy management systems.
      ii) Facilitates technological interoperability and integration between different technologies, with different purposes.
      iii) Facilitates the automation and optimization of energy management systems.
      iv) Allows real-time monitoring and control of energy consumption.
      v) Supports informed, data-driven decision-making processes in organisations, to improve their energy efficiency.
   c) On the educational pillar:
      i) Facilitates a general adoption of energy efficiency and environmental management principles on a large scale.
      ii) Improves awareness and understanding of energy management concepts.

iii) Empowers people to adopt energy efficient practices and act for present and for future generations.
iv) Promotes a culture of continuous sustainability and responsible energetic behaviour.

2) Weaknesses:
   a) On the regulatory/standardisation pillar:
      i) Legal compliance and regulation/standard enforcement may be challenging to some actors, considering regional/national regulations, market development level, or general climate conditions.
      ii) Updating or adapting regulations and standards to keep pace with technological advancements may become expensive in terms of cost and time, especially for smaller private legal persons.
   b) On the ICT and ICS technologies pillar:
      i) The initial investment costs for implementing ICT and ICS technologies may be high.
      ii) Technological advancements may be too fast for interested actors to keep up with.
      iii) The fast rhythms of cybersecurity threats and vulnerabilities identification may raise important challenges especially for private legal persons in ensuring a sufficiently robust cybersecurity environment.
   c) On the educational pillar:
      i) Widespread adoption and behaviour changes may take time to effectively manifest on the market.
      ii) Ensuring the availability of comprehensive and accessible educational resources can be challenging.
      iii) Illiteracies rates, especially in disadvantaged communities, may act as important obstacles.

3) Opportunities:
   a) On the regulatory/standardisation pillar:
      i) The increased focus on energy efficiency and sustainability creates opportunities for tighter regulations.
      ii) Collaborative efforts between governments, industries and other stakeholders may lead to better globally harmonized standards.
   b) On the ICT and ICS technologies pillar:
      i) Technological advancements offer strong opportunities for private actors to further improve technologies and energy management.
      ii) Better data may translate into better, informed decisions for policy makers.
      iii) Integration with smart grids and renewable energy sources can optimize energy consumption and reduce dependence on fossil fuels, facilitating an improved environmental management.
      iv) The entire life cycle of energy units may be improved and friendlier with the environment.
   c) On the educational pillar:
      i) Integrating energy management into formal education programs can foster a sustainable mindset from an early age.
      ii) Continuous learning for adults can be a source of future benefits in terms of energy management.
      iii) Promoting or education campaigns and initiatives may use social media tools to reach a wider audience and facilitate faster acknowledgement and behaviour change.

4) Threats:
   a) On the regulatory/standardisation pillar:
      i) Resistance or pushbacks from industries in the application of regulations or standards that can be perceived as burdensome or costly.
      ii) Inadequate estimations on resources of market actors and enforcement capacity may undermine the effectiveness of regulations or standards application.
   b) On the ICT and ICS technologies pillar:
      i) Too rapid technological advancements may lead to backward compatibility issues and the need for frequent updates or replacements.
      ii) Too rapid technological advancements may endanger private actors' capacity for adaptation, increase costs and lead to slow technologies adoption.
      iii) Potential privacy concerns about personal data collection and use may increase public skepticism and social movements against technology.
   c) On the educational pillar:
      i) Limited resources or funding for energy education programs can hinder their scalability and effectiveness in both children's education and adult continuous learning.
      ii) Overcoming the resistance to change among certain individuals or communities may prove challenging.

Based on the aspects highlighted by the SWOT analysis performed on the integrated energy management approach, some conclusions can be drawn:

An integrated approach to energy management, consisting of 3 pillars – the behavioural pillar (also referred in the paper as the regulatory/standardisation pillar), ICT and ICS technologies and educational measures –, provides significant potential to improve energy efficiency, sustainability, and care for the environment. Identified strengths include establishing clear regulations and standards, enabling effective

monitoring and control through ICT and ICS technologies, as well as promoting awareness and behaviour change through educational initiatives. These strengths provide a solid foundation to promote energy efficiency practices and care for the environment. However, a series of challenges need to be addressed as well. Compliance and enforcement issues can arise due to differences in regulations or standardisation measures of governments, while high initial investment costs and cybersecurity risks may become important obstacles to an integrated approach of energy management. In addition, achieving widespread adoption and behaviour change through educational measures requires long-term commitment and availability of resources. Technological challenges, in terms of compatibility, interoperability, technology generated risks or privacy need to be considered as well.

The increased focus on energy efficiency and sustainability creates a favorable environment for stricter regulations and harmonized standards. Technological advancements offer opportunities to improve energy management systems, integration with smart grids and renewable energy sources. Integrating energy management into formal education programs and leveraging digital platforms can reach a wider audience and facilitate behavior change. However, it is essential to be aware of potential threats. Industry resistance, limited enforcement resources, compatibility issues, cybersecurity risks and privacy concerns may alter expected progress. Furthermore, low availability of resources and resistance to change may pose serious challenges in approaching an integrated energy management.

In conclusion, an integrated energy management approach has substantial potential to improve energy efficiency and sustainability. By capitalizing on strengths and opportunities, addressing weaknesses, and mitigating threats, stakeholders can work together to create a more sustainable and energy efficient future. Collaboration between governments, industries, educational institutions, and communities will be the key to the successful implementation and promotion of the integrated energy management approach.

IV. OVERVIEW OF THE BEHAVIOURAL PILLAR

The first, and most accessible pillar we need to consider when discussing energy efficiency in all its aspects, is the behavioural one. Considering that among the main triggers of common people's behaviours are rules and norms applied in the society - known under the legal designation of policies, regulations, and standards –, the pillar will also be referred to as the regulation and standardisation pillar. Thus, behaviour management manifests, in this situation, mostly through regulations and standards on energy management applied mainly to legal and private persons (Fig. 2).

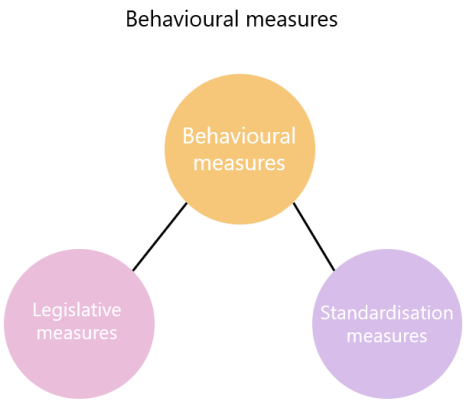

Fig. 2. Behavior management pillar.

The regulation layer is closely dependent to each country's strategic approach on global market positioning, natural resources exploitation, energy production and usage, waste management, acknowledgement of climate crisis, and the impact of environment protection measures on its economy. A rising level of interest in energy management and climate change is shown by all nations, each of them facing different kinds of challenges according to their positioning, climate, and landscape. In this perspective, relevant global or regional agreements were signed by many countries, an appropriate example being the 2015 Paris Agreement signed by more than 120 countries around the globe (United Nations Climate Change, 2018). Thus, despite the differences between national legal frameworks, all nations show strategic interest in solving issues related to energy management and the environment, to provide a stable foundation for all economic sectors development. Classical examples are the construction and the automotive sectors, which are some of the most economically performant and resource consuming sectors. We must note the fact that all developed nations and trade blocs implement, or plan to implement similar strategies and regulation packages, in a common effort to reduce human activities' influence on the environment and limit climate changes.

Aspects related to influence of different sectors' regulatory frameworks on energy sector has been for many years subject to research papers, few representative examples being: (Hamza and Greenwood, 2009), (Li and Sun, 2020), (Bellini and Bonoli, 2018), (Zhou and Wang, 2022), (Kott and Kott, 2018), (Kott, Mrzyglocka-Chojnacka and Kott, 2019)..

Regarding the standardisation layer, the most important family of standards to consider when discussing energy management is the ISO/IEC 50000 series. The first one in the series, ISO/IEC 50001, is the procedural standard globally accepted on energy management, being focused on standardising procedures and behaviours in organisations, with the main objective to reduce energy consumption and increase efficiency, using procedural implementation of energy management systems (EnMS). An energy management system implementation in an organisation

stands on two essential pillars: management commitment, and personnel contribution. Immediate, as well as long term results of ISO 50001 energy management system implementation one will observe, are improved monitoring of consumption, better usage of energy, and optimised workflows, all of them leading to better management of energy inside an organisation, improved cost control and increased revenues on every consumed energy unit. The latest version of the standard is ISO/IEC 50001:2018, and contains the "requirements for establishing, implementing, maintaining, and improving an energy management system (EnMS). The intended outcome is to enable an organization to follow a systematic approach in achieving continual improvement of energy performance and the EnMS." (International Organisation for Standardisation, 2018).

While ISO 50001 deals with the implementation of EnMS in organisations, ISO 50002:2014 specifies the common requirements for energy audits regarding the energy performance of the organisations that implement or have implemented ISO 50001. Also, as standard provisions clearly state, it is applicable to all types of organizations and all forms of energy. ISO 50002 defines an energy audit as a "systematic analysis of energy use and energy consumption within a defined energy audit scope, in order to identify, quantify, and report on the opportunities for improved energy performance" (International Organisation for Standardisation, 2014). Tthe standard defines energy efficiency as a "ratio or other quantitative relationship between an output of performance, service, goods or energy, and an input of energy" (International Organisation for Standardisation, 2014).

An intended compatibility is easily observed between ISO/IEC 50001 and ISO/IEC 14001 – the baseline ISO standard on environmental management. This perspective facilitates voluntary compliance with both standards, and emphasises awareness on the relation between resources consumption, wastes, and the impact of human activities on the environment, with a deeper focus on energy management. Due to their common aspects, we expect ISO 50001 and ISO 14001 standards to drag each other's adoption and get hand in hand wide acceptance by the market. While both standards had, so far, a very limited impact at global level – with about 19000 ISO 50001 certified organisations, and less than 313000 ISO 14001 certified organisations as highlighted by ISO in a 2019 survey (International Organisation for Standardisation, 2022) –, important efforts need to be taken by advanced nations to support wide acceptance and adoption by most market actors, in terms of investments, stimulus, technology, standardisation and planning.

Aspects related to provisions above were already analysed in detail by authors such as (Ofori et al., 2023), (Daddi et al., 2022), (Andersen and Bams, 2022), (Ikram et al., 2020), (Johnstone and Hallberg, 2020), (Johnstone, 2020), (Mosgaard and Kristensen, 2020).

We should emphasize that both families, ISO/IEC 50000 and ISO/IEC 14000 contain several standards, with much wider applicability in terms of energy and environmental management in human, professional activities.

Conformity with ISO 50001 and ISO 14001 represents a voluntary choice for organisations, not an obligation, even if some of their requirements are already in the common sense (e.g., turning of the lights in unused rooms, adapting air conditioning settings to weather and indoor conditions, turning off the engine or air conditioning in unused vehicles, etc.). Thus, it is to be expected that many organisations will comply entirely or partially, but not necessarily certify to any of ISO/IEC 50000, ISO/IEC 14000, or even ISO/IEC 9000 global standards families. Therefore, common measures that may be adopted to reduce energetic consumption without a formal certification include better indoor climate control, more efficient lighting solutions (LED, presence sensing, etc.), turning off equipment outside working periods, optimising workflows, improving logistics, etc.

The baseline standards ISO/IEC 50001 and ISO/IEC 14001 are adapted to all types of organisations interested in a systematic approach to energy and environmental management, they are not intended for direct application by common people. Still, everyone may find inside principles and methods to apply in their own environments, thus making ISO 50001 and, eventually, ISO 14001, a general guidance set largely applicable to energy and environmental management measures, instead of formalized standards targeting only legal persons. Another aspect worth emphasizing is that the standards apply indirectly to all persons through the functionalities and limitations of technologies for energy distribution and consumer usage, technically making everyone subject to regulations and standardization. Behavioral pillar measures apply to all members of a state, subject to the national or sectorial regulations and standardisation.

V. OVERVIEW OF THE TECHNOLOGICAL PILLAR

When considering the technological aspects of energy management systems in various industries or sectors, such as the construction, automotive or production sectors, the first thing we need to consider is the fact that an EnMS is a collection of ICT and ICS technologies and infrastructures designed to manage planning, monitoring, control and optimising activities for production, transport, and/or usage of energy units, while maintaining an expected and constant level of functionality and comfort for users. Waste management resulting from the usage of energy units is also of great importance, with an important impact on energy efficiency and environmental management (Fig. 3).

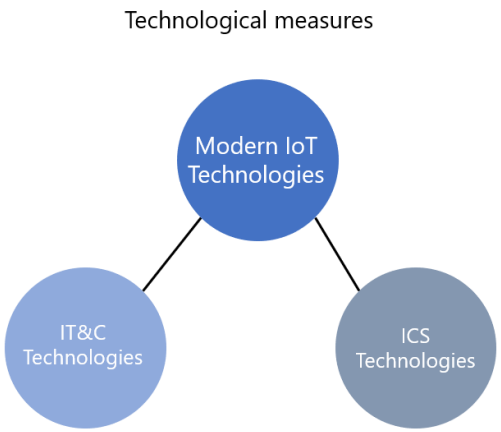

Fig. 3. Technology management pillar.

There is an intrinsic relation between the organisational and the technological perspective of an energy management system, better highlighted within the recurrent application of the PDCA (Plan, Do, Check, Act) improvement cycle. The output of one becomes an input to the other in a continuous loop, with measurable results in terms of reducing an organisation's energy footprint, a general reduction of consumption and waste, and increased productivity and efficiency. Thus, modern smart technologies provide improved control of energy use, stronger integration with means belonging to the behavioural perspective, and facilitate informed, better decisions on energy management by people and organisations.

Considering the multidisciplinary characteristics of modern technologies, with respect to the topic of the paper, we see as a certain fact that common or highly specialised technologies are used congruently in sectors such as construction, automotive, industrial, or agricultural production with the purpose to increase energy efficiency and reduce the impact on the environment. Among these technologies we find general engineering technologies and materials, fuels, materials science, ICS technologies (e.g., SCADA technologies, (Industrial) Internet of Things, data communications, data protocols, automatic control systems, sensor elements and actuators, data processing and visualization), ICT infrastructures (e.g., hardware infrastructure, software components, networking, and cybersecurity equipment) etc. The resulting level of technological integration means that an energy management system can be considered in an integrated perspective as a system of systems that operate independently of each other but controlled and correlated, exchange data with each other and possibly with a system central administration, resulting in an increased energy efficiency of a system (building, vehicle, etc.) while maintaining or increasing the level of safety, functionality and comfort to its users.

Another element that must be accounted for from a technical perspective in energy management systems, in addition to the effective application of planned measures through devices and technical equipment, is represented by the quality of the measurements. Data quality and their proper timely representation, generally regarded as data correctness, are some of the most important aspects in the digitalization field, valid in any field of activity. In all areas, including energy management and energy efficiency of physical infrastructures managed by EnMSs, data correctness must be ensured throughout their entire life cycle, depending not only on the result of the operational or historical processing of the data in question, but also on the decisions made by human decision-makers or artificial intelligence systems based on the available data. From a technical point of view, energy management systems may be regarded as control systems based on a mix of modern ICS and ICT technologies for monitoring, controlling, and optimizing energy consumption inside and/or outside a physical system/infrastructure, including the operation or usage of managed infrastructures. The use of data collections, their temporal sequencing, sensory and actuation technologies, combined with data calculation and analysis technologies, allow a more efficient use of energy, in all the forms energy may be found. Thus, this means that the performance and accuracy of an energy management system directly depend on the accuracy of measurements of the controlled parameters, and their interpretations. Changes in the technical, environmental or control parameters that may occur in the measurement or actuation equipment, result in data changes in the data storage, processing, and presentation system, directly influencing all human or automatic decisions regarding energy management. Electrical or electronic "noise" in physical measurements can alter energy management decisions in the same way.

Considering the long history of ICS technology applications, the subject was comprehensively covered in scientific papers in the last 40-50 years. The last decade marked the transition from traditional ICS technologies to (Industrial) Internet of Things, also covered extensively in scientific papers. Still, some subjects like those related to reliability, cybersecurity, remained constant in time independent to the economic sector, as may be seen in papers such as (Lun et al., 2019), (Li et al., 2019), (Dong et al., 2022), (Li et al., 2019), (Sándor et al., 2019), (Fitz, Theiler and Smarsly, 2019), (Oks et al., 2019), (Asghar, Hu and Zeadally, 2019), (Bharathidasan et al., 2022), (Georgiadou, Psarrou and Askounis, 2023), (Sanders, Bronk and Bazilian, 2022), etc.

In optimization, aspects related to data transmission are subject to similar conditions and constraints. As well, constraints regarding cyber security of energy management systems need to be pondered carefully, due to its impact on the ICS/ICT systems, data, the managed physical infrastructures, or the people using them. The usage of artificial intelligence technologies also presents new challenges from induced controlling and privacy perspectives, which need to be managed in the future, including the ethical use of artificial intelligence.

Similar aspects on the impact of data quality in smart environments were covered by many scientific

papers, such as (Sha and Shi, 2008), (Canto et al., 2015), (Morewood, 2023), (Koziel et al., 2021), (Kim et al., 2022), (Bi et al., 2022), (Alwan et al., 2022).

In addition, the impact the continuous digitization and the miniaturization of electronic components and equipment have in the design and implementation of energy management systems is expected to make the share of automatic energy management systems grow continuously. As well, the technological mix of ICT and ICS technologies, the use of advanced sensor technologies and actuators such as modern SCADA or (I)IoT technologies, cloud computing or artificial intelligence technologies will lead to a general increase in energy efficiency and better control over consumption.

The increased use of smart devices in day to day professional and domestic life rests itself on a few pillars. Among them, the growing technological complexity of production and services' processes, improved functionalities, technological accessibility, energy consumption and security – physical and cyber security. Aspects related to soft functionalities, accessibility, presentation, or physical security might be handled by users, based on easier learning processes.

Instead, aspects regarding hard-coded functionalities, technological complexity, energy efficiency and cybersecurity are most of the time hardwired in the equipment and provide no real control to users. In this perspective, energy efficiency and cybersecurity of smart equipment and systems must be carefully pondered at both, manufacturer, and user levels, to ensure the optimizing of risks and a reduced energy footprint while maintaining the appropriate level of functionality and design of products and services.

Therefore, they need to be approached at a technological level by the manufacturers, and at a behavioural level by users, based on policies, regulations and standards enforced by governments. A third option considers a common, integrated approach, using optimizing management methodologies and systems. To better facilitate these approaches common, easily accessible procedures, functions and tools must be in place for all users, providing intuitive and easy to understand functionalities and interfaces.

An additional impetus is currently given to the increase of energy efficiency in all possible ways, by the energy crisis and the war launched by the Russian Federation in Europe due, on one hand, to the medium and long-term impact on the availability of energy resources and its effect upon the basic needs of mankind as well as, on the other hand due to the negative effect on the environment and climate changes that will further limit the ability to satisfy people's needs on large scales, beginning with their basic ones (water, food, home, security).

On the opposite side, we must highlight the fact that increased use of electric and electronic technologies, especially old and obsolete technologies, leads to increased levels of energy consumption, if not carefully pondered. However, it is highly expected that the digitization process of automatic processes in energy management systems will continue in an accelerated manner in a way that maximizes the benefits for energy systems at the expense of the negative impact on consumption and the environment.

In addition, considering specific markets trends such as the accelerated migration to electric means of transport, thus generating a growing pressure on national and even global energy systems, energy efficiency becomes increasingly important in today's world.

VI. OVERVIEW OF THE EDUCATIONAL PILLAR

The third pillar to consider in an integrated approach of energy management, the educational one, must increase public knowledge in energy management and its societal and environmental consequences to common people and youngsters, supporting actual efforts to reduce human impact on the environment while maintaining energy availability as strategic resource. As well, awareness and educational activities should facilitate future efforts on reducing energy consumption, optimizing activities, and developing new, innovative technologies aiding in achieving the proposed purposes (Fig. 4).

In a traditional approach, still dominant in the research community and public literature(Kang et al., 2021), (Mitra et al., 2020), (Chen et al., 2021), (Guo et al., 2020), (Lu and Lai, 2018), (Pelenur and Cruickshank, 2012), (Vogel, Lundqvist and Arias, 2015), (Lia et al., 2021), (Fuchs, Aghajanzadeh and Therkelsen, 2020), (Majaty, Touzani and Kasseh, 2023), the educational approach in adult populations in developed countries manifest mostly in professional environments and is mainly related to the implementation of ISO standards on energy or environmental management. An increasing importance gets the component of environmental education in schools, which is expected to facilitate a greater level of attention and empathy to environmental problems, in mature ages. Although the component does not explicitly address aspects of increasing energy efficiency, it deals with aspects of reducing energy consumption with an impact on increasing the efficiency of the use of energy units, regardless of how they are manifested.

User behavior can have a significant impact on the energy efficiency of a building, vehicle or other types of physical built infrastructure and the effectiveness of an energy management system in managing energy consumption. Examples are at hand in this matter, such as users in a building using excessive lighting or air conditioning, unjustified use of electrical equipment or utilities.

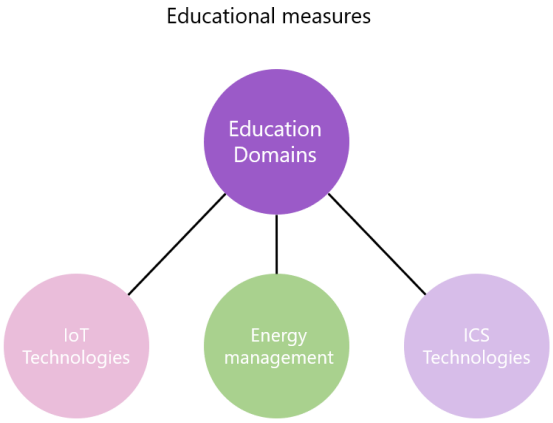

Fig. 4. Education management pillar

All these types of behavior lead to higher levels of energy consumption at infrastructure level with significant impact at community level (e.g., excessive, unjustified use of cold water or hot water in dry areas, excessive use of electricity during low levels of production, etc.) or the environment (e.g., large quantities of waste, household garbage, air/water pollutants, etc.). Users can also voluntarily reduce the efficiency of indoor air conditioning systems by using them when the air conditioning is not needed or by opening windows when the indoor air conditioning is on. Similarly, when users of a built infrastructure voluntarily and unjustifiably increase temperature settings, or when they do not turn off lights and electrical and electronic equipment that are not in use, an energy management system cannot achieve its energy saving potential. At the same time, in the case of smart EnMS systems, if the users of a building, vehicle or other type of physical infrastructure do not follow the indoor climate recommendations provided by EnMS, the system may not be able optimize energy consumption as effectively.

In addition to the technological mechanisms for adapting energy management systems to the way of occupying and using an artificial infrastructure, to overcome the high influence of user behavior on energy efficiency, it is important to first educate the occupants or users of physical infrastructures about the importance of efficient behavior from an energy efficiency the point of view and encourage them to adopt energy-saving habits. All ways should be used to transmit the message to common consumers, starting from the family and early school ages to mature adults' public information and continuous learning.

Thus, we appreciate that general aspects of increasing energy efficiency must be addressed systematically and consistently throughout people's lives. Relying only on commercial or government level demand response programs based on incentives or costs, it might not be enough to cover all aspects related to energy efficiency and, in strong correlation, environmental management. We also appreciate that demand response programs have a measurable impact only in their implementation period and with limited effect in the long term. Leaving a defining, prolonged impact on general habits of the population, in terms of increasing energy efficiency and reducing energy consumption, requires a much more comprehensive and longer approach to education.

As already mentioned, other aspects such as the level of knowledge regarding cyber security can influence the behavior of a user of energy management systems and can significantly alter their ability to optimize energy consumption and increase energy efficiency.

In uncorrelated ways, aspects related to education and its long-term influence on energy efficiency and energy management were subject to scientific papers for the last 30 years. Facts on these subjects may be found in papers such as (Bowonder, 1984), (Newborough *et al.*, 1991), (AlFaris, Juaidi and Manzano-Agugliaro, 2016), (Sučić, Anđelković and Tomšić, 2015), (Ahir and Chakraborty, 2021), (Xu *et al.*, 2021), (Xie *et al.*, 2021), etc.

VII. CONCLUSIONS

Increasing the energy efficiency of human activities can no longer be reduced only to voluntary compliance of organizations with environmental and energy management standards. It is necessary that all processes throughout the entire life cycle of an energy unit become compliant with a multisectoral integrative (but at the same time as personalized as possible) set of norms, rules, standards, and technologies that leads to a general reduction of energy consumption and the amount of waste generated by human activities. The crisis situations that humankind is currently going through, as well as the level of technological development, make a new integrative approach to the concept of energy management system as necessary as possible. As the energy efficiency of infrastructures manifests itself at all stages of the life of a building, a vehicle or another type of built infrastructure, the processes that must be considered are not only very diverse, but also of different difficulties and complexities, requiring distinct approaches on the at least 3 major pillars of action: a behavioral/procedural pillar, a technological pillar and an educational one.

Considering the duration of use of a physical infrastructure controlled by an energy management system, the usefulness of measures to increase energy efficiency takes on new dimensions that change with the purposes of using the infrastructure, as well as with the general technological evolution that brings continuous changes of raw materials, materials, technologies, and technological processes applied throughout the entire life of the former. Energy management has, through all its valences, a major potential to increase the efficiency of the use of limited natural resources, to increase energy efficiency and to reduce the energy impact of controlled infrastructures, on the environment, while maintaining an acceptable level of utility and comfort for their users.

Many of the aspects we raised in the paper were reviewed over time by many researchers, mostly in a limited, sectorial approach. As technology evolves and continuously provides new opportunities, considering the current stage of the climate crisis and other present or predictable crisis (e.g., energy crisis, financial crisis, wars at EU border and other places in the world, etc.), our society needs to follow a new, improved, comprehensive, path to energy efficiency.

The synergic approach to energy efficiency through 3 main pillars – the procedural, technological and educational pillars – will lead to a better perception of energy efficiency in population and will have the effect of accelerating the implementation of the necessary procedural and technological measures for the entire lifetime of an energy unit. Therefore, efficient usage of energy in human activities requires a day-to-day management of energy consumption on both, professional and personal levels, the use of dedicated technological systems and social responsibility, in order to identify an equilibrium, point between costs and benefits at individual, societal and environmental level. The educational perspective operates on both, procedural and technological layers, in the most direct way, as common understanding and acceptance of rules and technologies represents the key to successfully implement energy management in professional and personal environments.

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A Study on How Artificial Intelligence Can Shape the Future of Management

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Abstract – The advent of Artificial Intelligence (AI) presents unprecedented opportunities for redefining management practices across various industries. This paper investigates the multifaceted impact of AI on management, with a particular emphasis on its influence on decision-making processes, operational efficiencies, and human resource management. By synthesizing empirical data and theoretical insights, the study elucidates AI's potential to enhance strategic foresight, optimize operational workflows, and personalize employee development. Through a mixed-methods approach, combining case studies with statistical analysis, this research highlights the transformative potential of AI, while also acknowledging the ethical and practical challenges it poses.

Keywords: Artificial Intelligence, Decision-Making, Operational Efficiency, Human Resource Management, Strategic Planning

I. INTRODUCTION

The integration of Artificial Intelligence (AI) into the fabric of organizational management heralds a paradigm shift, promising unprecedented efficiencies, decision-making capabilities, and a redefinition of traditional managerial roles. As the digital revolution accelerates, AI technologies—ranging from predictive analytics and machine learning to natural language processing and robotics—are at the forefront of transforming management practices across sectors. This paper seeks to delve into the multifaceted implications of AI for management, investigating how it reshapes strategic planning, operational efficiency, and human resource management.

The potential of AI in management extends beyond automation, offering strategic insights that can significantly enhance decision-making processes. Through the analysis of vast datasets, AI enables managers to predict market trends, assess risks, and identify opportunities with a degree of accuracy and speed unattainable through human analysis alone. This predictive capability is pivotal for strategic planning, allowing organizations to adapt more dynamically to market changes. Furthermore, AI-driven automation and optimization promise to revolutionize operational efficiency. By streamlining processes, reducing errors, and optimizing resource allocation, AI technologies can significantly lower operational costs and improve productivity. In the realm of human resource management, AI offers tools for talent acquisition, performance monitoring, and personalized employee development, potentially enhancing job satisfaction and organizational commitment. Yet, the integration of AI into management practices is not without challenges. Ethical considerations, data privacy, and the potential displacement of jobs necessitate careful consideration. Moreover, the effective adoption of AI requires significant organizational change, including the upskilling of employees and the adaptation of managerial roles to leverage AI technologies effectively.

This paper aims to explore these opportunities and challenges, providing insights into the current state and prospects of AI in management. Through a comprehensive review of literature and empirical analysis, it seeks to contribute to the understanding of AI's transformative potential in the field of management.

II. THEORETICAL BACKGROUND

The theoretical underpinnings of Artificial Intelligence (AI) in management practices are multifaceted, reflecting a convergence of computer science, cognitive psychology, operations research, and management theory. This section delves into the theoretical frameworks that inform the application of AI in management, categorizing the discussion into three primary areas: the decision-making paradigm, operational efficiency, and human resource management. Each area encapsulates a distinct body of

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literature that collectively shapes our understanding of AI's role in modern management.

A. Decision-Making Paradigm

Central to the discourse on AI in management is the decision-making paradigm. Simon's (1977) seminal work on administrative behavior and decision-making posits that organizational decisions are bounded by rationality, where individuals seek satisfactory solutions rather than optimal ones due to cognitive limitations. AI, through its computational prowess and ability to process vast datasets, extends this bounded rationality, enabling what Burrell and Morgan (1979) describe as an 'enlightened' decision-making process. AI technologies facilitate a shift from heuristic-based to data-driven decisions, embedding predictive analytics and probabilistic forecasting into strategic planning processes. This evolution resonates with the rational decision-making model, wherein AI tools offer a mechanism for navigating the complexities and uncertainties inherent in organizational decision-making.

B. Operational Efficiency

The theoretical foundations of operational efficiency in management are significantly augmented by AI applications. The principles of scientific management, as articulated by Taylor (1911), emphasize the optimization of labor productivity through the systematic study of workflows and tasks. AI technologies operationalize these principles at an unprecedented scale, automating routine tasks and optimizing resource allocation through algorithms and machine learning models. Moreover, the resource-based view (RBV) of the firm, as proposed by Wernerfelt (1984) and further developed by Barney (1991), posits that competitive advantage stems from the firm's unique resources and capabilities. AI technologies emerge as a pivotal resource, enhancing the firm's operational capabilities and providing a strategic asset that drives sustainable competitive advantage.

C. Human Resource Management

In the domain of human resource management (HRM), the theoretical dialogue encompasses the human capital theory (Becker, 1964) and the theory of organizational behavior. Human capital theory underscores the value of employees' skills, knowledge, and abilities as central to organizational performance and competitive advantage. AI influences HRM practices by enabling personalized learning and development, predictive talent acquisition, and performance management, thereby optimizing the human capital within organizations. Furthermore, the application of AI in HRM aligns with the socio-technical systems theory (Trist & Bamforth, 1951), which advocates for the integration of technical and social systems within organizations. AI-driven HRM tools exemplify this integration, fostering a symbiotic relationship between technology and human resources that enhances employee satisfaction and organizational effectiveness.

III. METHODOLOGY

The methodology employed in this study is designed to explore the impact of Artificial Intelligence (AI) on management practices, with a particular focus on decision-making processes, operational efficiency, and human resource management. This research adopts a mixed-methods approach, integrating quantitative and qualitative analyses to provide a comprehensive understanding of AI's role in modern organizational management.

A. Quantitative Analysis

The quantitative component of this research involves the administration of a survey to management professionals across various industries, including finance, healthcare, manufacturing, and technology. The survey comprises questions related to the adoption, application, and perceived effects of AI technologies in their organizations. Key variables measured include the level of AI integration in business processes, the impact of AI on operational efficiency, decision-making effectiveness, and employee satisfaction.

- Sample Selection: The sample consists of 300 management professionals randomly selected from a database of organizations that have publicly reported AI initiatives. Stratified sampling will be used to ensure representation across different sectors and organizational sizes.
- Data Collection: Data will be collected through an online survey platform, ensuring anonymity and confidentiality for all participants. The survey will include Likert-scale questions, multiple-choice questions, and open-ended responses to gather both quantitative and qualitative data.
- Data Analysis: Statistical analysis, including descriptive statistics, correlation analysis, and regression models, will be conducted using SPSS software. This analysis aims to identify patterns and relationships between AI adoption and key management outcomes.

B. Qualitative Analysis

The qualitative component consists of in-depth case studies of five organizations that are considered leaders in AI adoption within their respective industries. These case studies will provide insights into the practical application of AI technologies, the challenges encountered during implementation, and the strategies developed to maximize the benefits of AI in management. Data Collection: Information for the case studies will be gathered through semi-structured interviews with key stakeholders, including C-suite executives, IT managers, and HR professionals. Additional data will be collected from internal

documents, AI project reports, and performance metrics before and after AI implementation.

Data Analysis: Thematic analysis will be employed to analyze the qualitative data, identifying common themes, patterns, and insights across the case studies. NVivo software will be used to facilitate the coding and organization of qualitative data.

C. Ethical Considerations

This study adheres to ethical research standards, ensuring the privacy, confidentiality, and voluntary participation of all respondents. The research proposal has been reviewed and approved by the Institutional Review Board (IRB).

D. Limitations

This research acknowledges potential limitations, including response bias in the survey and the selection bias of case study organizations. Efforts will be made to mitigate these limitations through careful survey design and the transparent selection of case studies.

IV. CHALLENGES AND OPPORTUNITIES

The integration of AI into management practices presents a dual-faced narrative of challenges and opportunities. As organizations navigate the evolving landscape of AI, they encounter a spectrum of complexities ranging from ethical dilemmas to transformative operational capabilities. This section delineates the multifaceted challenges posed by AI implementation and elucidates the opportunities it fosters for reinventing management paradigms.

A. Challenges

- Ethical and Privacy Concerns: The deployment of AI in management raises significant ethical questions, particularly concerning data privacy and surveillance. AI systems, reliant on vast datasets for training and operation, may inadvertently compromise employee privacy or bias decision-making processes. Ethical frameworks and privacy regulations, therefore, become paramount in guiding AI's application in sensitive areas such as performance monitoring and talent acquisition.
- Technological Integration and Skill Gaps: Integrating AI technologies into existing organizational infrastructures poses technical challenges that necessitate substantial investments in hardware, software, and cybersecurity measures. Concurrently, a skill gap emerges as the workforce may lack the requisite knowledge to interact with sophisticated AI systems. Bridging this gap requires comprehensive upskilling programs and a reevaluation of educational curricula to prepare future managers for an AI-augmented workplace.
- Job Displacement Anxiety: Automation anxiety, stemming from the fear of job displacement, presents a significant challenge to AI adoption. While AI has the potential to automate routine tasks, organizations must navigate the socio-psychological impact of such technologies on the workforce. Transparent communication and the redefinition of job roles are essential to mitigating these concerns and fostering an adaptive organizational culture.

B. Opportunities

- Enhanced Decision-Making: AI introduces unparalleled opportunities for enhancing decision-making efficacy within management. Through advanced data analytics and machine learning algorithms, AI systems can uncover insights hidden in big data, enabling managers to make informed, predictive decisions. This capability not only streamlines strategic planning but also empowers dynamic, real-time decision-making in response to market changes.
- Operational Efficiency: AI's ability to automate routine tasks, optimize workflows, and predict operational needs transforms organizational efficiency. By freeing human resources from mundane tasks, AI allows teams to focus on strategic, value-added activities. Furthermore, AI-driven optimization of supply chains and resource allocation significantly reduces operational costs and improves productivity.
- Innovative Human Resource Management: AI technologies offer innovative tools for human resource management, from AI-powered recruitment platforms that enhance talent acquisition to personalized learning systems that support employee development. These tools not only improve the HRM process's efficiency but also contribute to a more engaged, satisfied workforce.
- Driving Sustainable Competitive Advantage: By leveraging AI, organizations can develop unique capabilities that drive sustainable competitive advantage. AI's predictive insights, operational efficiencies, and enhanced HRM practices position organizations to lead in their respective markets. Moreover, AI's potential to foster innovation opens new avenues for product and service development, further solidifying an organization's competitive position.

V. CASE STUDIES

The practical application of Artificial Intelligence (AI) in management is best illustrated through case studies that provide real-world insights into the deployment, challenges, and successes of AI integration within organizations. This section presents

three case studies across diverse industries, shedding light on how AI technologies have been leveraged to enhance decision-making processes, improve operational efficiency, and transform human resource management practices.

a) Case Study 1: Retail Industry – AI in Customer Experience and Inventory Management

A leading retail chain implemented AI to personalize customer experience and optimize inventory management. By utilizing machine learning algorithms, the company developed a recommendation system that tailors product suggestions to individual customer preferences based on their browsing and purchasing history. Additionally, AI-driven predictive analytics were employed to forecast demand and manage inventory levels efficiently, resulting in reduced stockouts and overstock situations.

- Challenges: The primary challenge was ensuring data privacy and security, as the recommendation system required access to sensitive customer information. Integrating AI with existing IT infrastructure also posed technical challenges.
- Opportunities: The AI implementation enhanced customer satisfaction through personalized experiences, leading to increased sales and customer loyalty. Improved inventory management significantly reduced costs and increased operational efficiency.

b) Case Study 2: Healthcare Industry – AI for Diagnostic Accuracy and Treatment Planning

A healthcare institution adopted AI to assist in diagnostic processes and treatment planning for cancer patients. AI algorithms analyzed medical imaging data to identify patterns and anomalies that may be indicative of cancerous growth, aiding physicians in making more accurate diagnoses. Furthermore, AI was used to analyze patient data and past treatment outcomes to recommend personalized treatment plans.

- Challenges: The accuracy of AI predictions and the ethical implications of AI-assisted decision-making in critical healthcare decisions were major concerns. Ensuring the AI system's recommendations were interpretable by physicians was also a challenge.
- Opportunities: The use of AI significantly improved diagnostic accuracy and enabled the development of personalized treatment plans, potentially improving patient outcomes. It also allowed healthcare professionals to allocate more time to patient care rather than administrative tasks.

c) Case Study 3: Manufacturing Industry – AI in Predictive Maintenance and Quality Control

A manufacturing company integrated AI into its operations to predict equipment failures and enhance quality control. Using IoT sensors and AI algorithms, the company developed a predictive maintenance system that identified equipment anomalies and predicted failures before they occurred, minimizing downtime. AI was also applied in quality control processes, where computer vision systems inspected products for defects at a speed and accuracy unattainable by human inspectors.

- Challenges: The initial investment cost for AI technologies and training personnel to operate the AI systems were significant challenges. Ensuring the predictive maintenance system's accuracy and reliability was also crucial.
- Opportunities: AI-driven predictive maintenance led to significant cost savings by reducing unplanned downtime and extending equipment life. The AI-enhanced quality control process improved product quality and customer satisfaction while reducing waste.

VI. DISCUSSION

The integration of Artificial Intelligence (AI) into management practices signifies a paradigm shift in how organizations operate, make decisions, and manage their workforce. Through the lens of the presented case studies, this discussion delves into the implications of AI for the future of management, highlighting the nuanced interplay between technological innovation and managerial acumen.

a) AI as a Catalyst for Strategic Decision-Making

The application of AI in enhancing decision-making processes underscores the shift towards data-driven management. AI's capability to process and analyze vast datasets transcends human limitations, offering insights that were previously unattainable. This evolution from intuition-based to evidence-based decision-making necessitates a re-evaluation of traditional managerial roles. Managers must now possess not only the strategic foresight to leverage AI-generated insights but also the wisdom to interpret these insights within the broader organizational context. The challenge lies in maintaining a balance between leveraging AI for its analytical capabilities and ensuring that strategic decisions are aligned with organizational values and objectives.

b) Operational Efficiency and the Role of AI

Operational efficiency, as illustrated in the case studies, benefits significantly from AI through process automation, predictive maintenance, and quality control. However, the transition to AI-driven operations introduces complexities related to technology integration, workforce adaptation, and the continuous evolution of AI capabilities. The opportunity for organizations lies in harnessing AI not as a replacement for human effort but as a complement

that enhances human skills and creativity. This symbiotic relationship between AI and the human workforce is pivotal in realizing the full potential of AI in operational contexts.

c) Human Resource Management in the Age of AI

The impact of AI on human resource management (HRM) extends beyond automation of administrative tasks to encompass talent acquisition, employee development, and performance management. AI's potential to personalize employee experiences and facilitate talent development presents an opportunity to redefine HRM practices. However, this transformation also raises ethical considerations regarding privacy, bias, and the impersonal nature of AI interactions. Organizations must navigate these challenges by fostering an ethical AI culture, where transparency, fairness, and human-centricity guide AI implementation in HRM.

VII. CONCLUSIONS AND FUTURE RESEARCH DIRECTIONS

This discussion points to several avenues for future research. Investigating the long-term strategic impacts of AI on organizational competitiveness, exploring the ethical dimensions of AI in management, and examining the workforce's adaptability to AI-driven changes are critical areas that warrant further exploration. Additionally, research into the development of managerial competencies in the age of AI can provide insights into the evolving role of managers.

The advent of AI in management practices represents a transformative force that reshapes organizational landscapes. While the challenges of integrating AI are non-trivial, the opportunities it presents for enhancing decision-making, operational efficiency, and HRM are profound. As organizations continue to navigate the complexities of AI adoption, the role of managers evolves to encompass AI stewardship, ethical oversight, and strategic leveraging of AI capabilities. The future of management, thus, lies in the effective integration of AI technologies within the fabric of organizational practices, guided by ethical principles and a human-centric approach.

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Analysis of the Concept and Solutions for Transforming Timisoara into a Smart City

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Abstract – Of utmost importance for assuring humanity's sustainability is the cities and smart regions development, a problem that involves a multitude of factors and is extremely complex. Even though this fact is known by the international communities, the local and public administrations of Romania use the concepts and intelligent solutions modestly. In the present work an analysis of some theoretical aspects is presented regarding the necessity of transforming cities into smart cities, like a study that illustrates the actual state of things at Timisoara's City Hall in parallel with the transition towards the city's transformation into a smart city. The successful testing and validation of a smart city's strategy at Timisoara's City Hall ensures that it is appropriate for its usage by the country's other public administrations.

Keywords: Smart cities, smart regions, smart systems, smart interconnection, smart processes, collaborative governing, integrated public management.

I. INTRODUCTION

Worldwide, the community policy creates the premises that more cities will become smart cities. In this regard, strategies, action plans, programs, initiatives and declarations were adopted for which more and more funding is allocated. For cities to become smart, public systems need to be implemented, structured and coordinated in a way that can easily be managed and sustained.

In Romania, the need to recover the development deficit compared to western countries of the European Union can be ensured through conception, adoption and implementation of a cities and smart regions development model funded through the scientific research and adapted to the local's specific characteristics.

A complete strategy for bringing Timisoara in the digital era „Smart City and Digital Transformation strategy Timisoara" [1] was developed by Timisoara's City Hall, together with international experts and the actor's local ecosystem, which includes IT companies, the university environment, NGO's and many interested civilians. Many projects proposed through this strategy are in the present implementation phase, while other projects are in the preparation phase. The strategy will be implemented in the 2022-2027 period.

1.1 General aspects at a global level

Worldwide, the community policy creates the premises that more cities will become smart cities. In this regard, strategies, action plans, programs, initiatives and declarations were adopted for which more and more funding is allocated.

„Smart cities as a new industrial policies engine in Europe" [2] was a title for an approved document by the Economic and Social European Committee in 2015. This laid the foundations for a new strategy for supporting and developing Smart City's projects. The European Union and its member states consider that cities are „laboratories for a more dynamic and digital Europe" [3], where measures meant for generating growth accompanied by social development and the employment rate can be experimented. This happens in the context of urbanization that intensifies.

Within the framework of strategic development of cities worldwide, the concept of a "smart city" was one of the most vast, popular and dynamic concepts of the last 10 years. Furthermore, in essence, it is a multidisciplinary concept, which combines method elements and impact measurements from fields such as innovation, sustainability, entrepreneurship,

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technological prototyping, urbanism and civic implication.

To define precisely the meaning of a smart city, we must refer to Boyd Cohen's work [4], an American researcher, which deals with entrepreneurship, sustainability, urban strategies and climate changes. His motivation and professional progress were defining factors for releasing the concept of smart city in the global professional community in the year 2012.

Boyd Cohen noticed three evolution stages of the cities that adopted and implemented the model, namely:

- Smart cities 1.0 - This includes the cities in Romania;
- Smart cities 2.0 – This category includes the smartest cities worldwide: Singapore, Hong Kong, Boston, Barcelona, London;
- Smart cities 3.0 – This includes Oslo and Amsterdam.

Boyd Cohen highlights the fact that, from the city's practice, the ideal approach seems to be a combination of options 2.0 and 3.0, because public administrations need to continue offering new opportunities. However, citizens need to be viewed not just as beneficiaries of solutions, but as active creators, capable of identifying developmental needs quicker than municipal officials.

The Smart City wheel was developed by Boyd Cohen and Rob Adams in 2012 and exemplifies the way that innovation and technology can help cities in becoming more intelligent [4].

In the present, Institute for Management Development (IMD) from Switzerland produces the most thorough annual report on the smart cities from around the world. It uses technological and economic data for ranking the cities, in addition to evaluating citizens' opinions regarding the city's intelligence. There is a wide range of different cities, such as, in descending order, Cairo (106), Mumbai (93), Bucharest (87), Lisbon (75), Paris (61), Warsaw (55), Chicago (41), Hong Kong (32), Vienna (25), Sidney (18), Oslo (5) and Singapore (1). As a first example, Singapore is known as the "intelligent nation" [4]. Its strategy was released in 2014 and follows a revolution of the way people use technology for accomplishing their highest ideals and for living a better life together. Vienna wishes to become the city with the highest life quality worldwide before 2050 and Europe's capital of digitization [5].

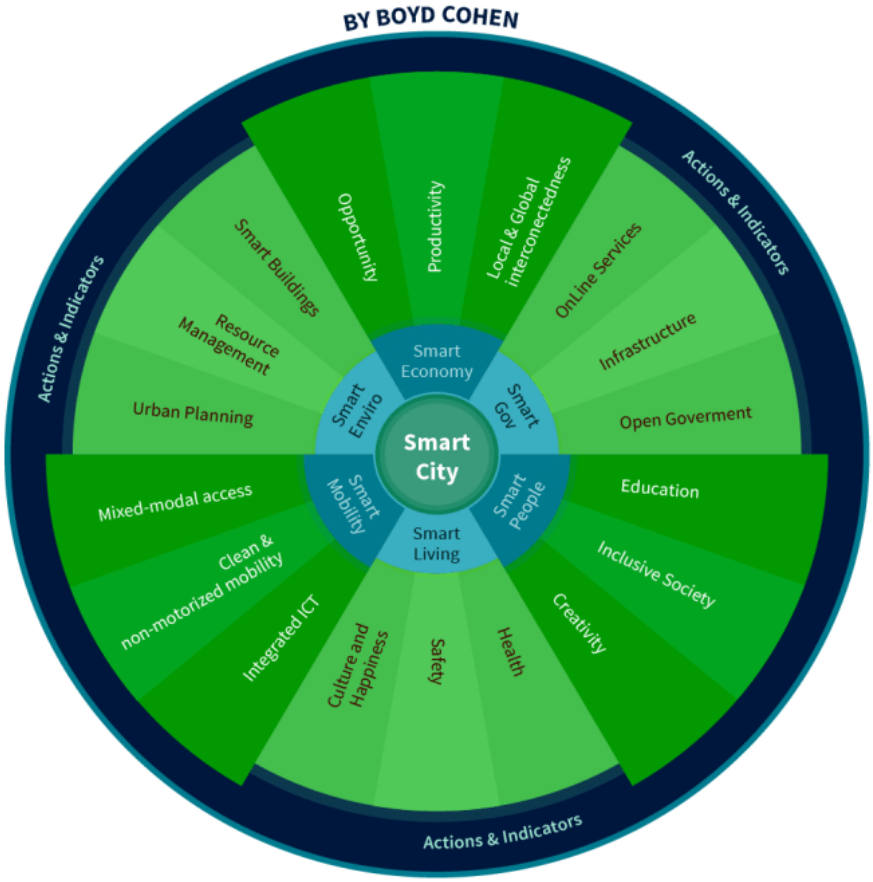

Fig. 1. The Smart City wheel [4]

Barcelona – the most innovative project of open data in Europe, proposes a Catalan recipe for a urban creative community, built on participatory democracy and policies that value citizens collective intelligence [6]. Lund is considered as the Swedish emblem of open innovation and invests permanently in the animation of a vibrant entrepreneurial culture.

1.2. General aspects at the national level

At Romania's level, the need to recover the development deficit compared to western countries of the European Union can be ensured through conception, adoption and implementation of a cities and smart regions development model funded through the scientific research and adapted to the local's specific characteristics. In Romania, intelligent solutions are very rarely used by the local public administrations. Romania's development based on some intelligent models for cities and regions development is necessary.

In Romania, projects of city smart transformation have existed and still do exist. In June of 2022, the sixth edition of the radiography of the smart city projects from Romania included 1001 initiatives in 144 big, medium and small cities in the country that are in the present in the project stage or are already finished, in comparison to the 860 projects in 124 cities in June 2021. Thus, a total of 470 finished smart city projects in Romania to date. With 115 projects, sector town halls and the general capital's city hall occupies the detached first place on national level. With just 49 projects, Alba Iulia, which has occupied first place in the last years, falls on the fourth place in 2022. In the ranking, Sibiu and the fourth sector of Bucharest have 35 projects each. Oradea and Timisoara occupied the sixth place in 2022, each with 26 projects, whilst Arad and Slanic Moldova occupy the second spot, with 25 projects. Bistrita occupies 20th place (20 points), Harsova (19 points), and Brasov occupies 10th place equal to Botosani (18 points).

1.3. General aspects at the local level

A complete strategy for bringing Timisoara into the digital era was developed by Timisoara's City Hall in 2022. The strategy policy is concentrated on 7 major strategic fields which affect citizens everyday lives: the quality of public services, decisional transparency and participatory governance, innovation and the economic environment, the attraction and retention of the qualified work force, environment and sanitation, culture and recreation, public transport and mobility.

In total, 165 strategic projects are included, 27 of which are in implementation process in the present. For assuring that the projects are finished and monitored, 62 performance indicators will be annually updated. A partner will be responsible for each project.

The strategy of a smart city illustrates the fact that Timisoara is expressing its commitment to enter the international community of smart cities, with an approach centered on citizens, which activate at the same time the structural and innovation capital of the city:

- "The innovation accessible to all!" is the strategy's Smart City and Digital Transformation motto 2022-2027.
- "Timisoara 2027: European location favorite for human resources involved in product development and innovative resources" is the vision for the Smart City strategy and Digital Transformation 2022-2027.
- The mission of the Smart City and Digital Transformation Strategy 2022-2027 is to boost the evolution of the municipality of Timisoara by capitalizing on the collective intelligence of citizens.

The smart city of Timisoara is based on the following objectives:

1. "City for all" [7], "Sustainable city" [8] and "Smart and impactful public investments" [9]. These goals include favorable environmental conditions, easy interactions between citizens and the city, and positive public interventions in everyday life.
2. The objectives "Every citizen has a voice" [10] and "Smart City is Fun City Timisoara" [11] illustrate the efforts of the smart city of Timisoara to "create closeness" with its citizens. Citizens will make public decisions, and the city becomes a "favorite" place for work, play and above all the feeling of "home".
3. The ambitions "Vibrant ecosystem of innovation" [12] and "Timisoara - Attractive city for talents from the international environment" [13] represent the higher level of the intelligent city of Timisoara, the genuine ability to generate value and innovation, which creates the unique framework of smart city development.

II. THE UNDERSTANDING AND IMPLEMENTATION OF THE SMART CITY CONCEPT BY THE TIMISOARA MUNICIPALITY

This paper presents the current situation regarding sustainable development at Timisoara City Hall in parallel with the transition to the transformation of the city into a smart city. In the smart city strategy, there are three distinct objectives: "City for All",

"Sustainable City" and "Smart and Impactful Public Investments", which aim to create favorable environmental conditions, facilitate easy interactions between the city and citizens, and achieve public interventions that have a positive impact on everyday life.

Ambition number five within the Smart City Strategy, named Timisoara – The Sustainable City, aims to implement a balanced way of managing the city's essential resources by implementing interventions that reduce expenses, increase the supply of renewable energy and optimize the use of energy.

Digital technologies and processes will be implemented to improve the city's quality of life and environmental factors. Integrated approaches of (re)building biodiversity corridors, energy efficiency and sustainable waste management at city level are crucial to this goal.

A. Timisoara - The city for all

This aims at the accessibility of public services through modern technological means. With 17.7% of the population over 65, this could be a challenge. Payment of fees and submission of various applications are done in writing or physically, because the technology of interaction with citizens is incomplete, incomplete and difficult to understand. The aim is to develop an integrated way of delivering public services, which is supported by optimized digital administrative processes and makes it easy for citizens and companies to interact with public institutions. The "City for all" ambition was ranked first in the first stakeholder consultation, which shows how urgent the intervention is. In addition, this pillar of the strategy's vision focuses on providing digital solutions to make public infrastructure and services accessible to vulnerable groups such as the elderly, disabled and non-digital. The smart city concept is related to the ability to produce human capital through education and creativity, as well as digital and civic inclusion.

Table 1: Implemented feeds

Categories	**Flux name**
HR	Delegation flow during leave
HR	Flux of onboarding/dis-boarding of HR system of the new employees and past employees
HR	Onboarding/dis-boarding flow from HR systems of new and former employees
Room 12/24	Processing flow of the child's allowance application
Room 12/24	Flow of registration/registration of entry documents in the PMT
Room 12/24	Flow of adding and processing complaints submitted by citizens
Room 12/24	Notification category configuration flow
Room 12/24	Notification category configuration flow
Urbanism	Street nomenclature creation and management flow
Town planning	Processing flow of the urban planning certificate issuance request
Town planning	Flow of approval and issuance of building or demolition permit
Economic	Flow of receipt of invoice and order to pay
IT	AD account management flow
IT	Helpdesk&Ticketing flow for IT management problems
IT	IT HW inventory management flow
IT	Onboarding/unboarding flow from IT systems (HW allocation, IT systems access) of new and former employees
Management	Electronic signature document management flow (documents, user, and position in the document)
Management	Bulk electronic signature management flow in standard format documents
Management	Signature flow stream with electronic seal application and issue number/date
Management	Internal task distribution flow
Management	Management flow of list of signatories with digital certificate (electronic signature)
Communication	Posting flow of announcements (press releases) on the new PMT information portal
Secretariat	Flow of proposal and approval of HCL projects
Room 12/24	Natural persons nomenclature flow
Room 12/24	Nomenclature flow of legal entities
Room 12/24	Nomenclature of problems with their grouping on the structure and summary
Room 12/24	Nomenclature of localities grouped by locality, county, country
Room 12/24	Flow of problematic types in the registry
HR	Employee nomenclature flow
HR	Employee account creation flow

The sustainable development target is decent work and economic growth. This is achieved by separating economic growth from environmentally damaging elements, sectoral diversification and emphasis on social aspects.

In 2023, Timisoara City Hall began the process of implementing the institution's computerization strategy. This started by analyzing, proposing and implementing better technical and organizational solutions, as well as developing and guaranteeing the integrability, compatibility and interoperability of the systems and modules that were implemented. Thus, 30 feeds were implemented using Webcon technology on a Microsoft M365/Exchange platform is presented in Table 1.

B. Timisoara - intelligent and impactful public investments

Even if the traffic data in Timisoara show a decrease in congestion indicators, the problems with the accessibility and communication of the city center with the periphery continue to be a further concern

within this objective. Mobility is the dimension that is addressed in the smart city project, which includes efficient transport in the city, an integrated multimodal transport system and access to real-time information through technology. Inclusive, safe, resilient and sustainable cities are the goals of sustainable development.

The public administration of the municipality of Timisoara has as priorities in the European programming period 2021-2027 the promotion and prioritization of European investment projects that help reduce carbon emissions using clean energy sources, green-blue investments and compliance with the principle of "do no harm in significantly" (DNSH) [14]. These are included in the recovery and resilience plan for the post-COVID-19 phase. The total value of the projects is over 991 million lei, of which the eligible value is over 830 million lei.

During the 2014-2020 programming period, the municipality of Timisoara was a project partner or project leader and implemented 61 projects in accordance with financing contracts and partnership agreements totaling 1,012.21 million lei. The municipality's absorption rate was 0% in 2017-2018, 0.14% in 2019, 1.87% in 2020, 13.68% in 2021 and about 30% in 2022.

Therefore, on December 31, 2022, financing contracts were concluded for eight projects and nine financing applications were evaluated for a total of 1,611.32 million lei. In accordance with the area of influence of the municipality of Timisoara, in 2023 an extensive participatory process was implemented to create an integrated urban development strategy (SIDU). The process was based on the consultation and involvement of local actors and the community, so that a complete picture of the dynamics of territorial development can be obtained and identify relevant and current local challenges that will affect the development of the municipality in the coming years.

Through this strategy, the municipality of Timisoara aims to become a reference European metropolis in 2030, promoting innovation, sustainability and multiculturalism, emphasizing the development of the local community and quality of life. In addition to defining the mission of the municipality, SIDU will have a particularly important role in financing the urban development projects of the municipality and the functional urban area. These projects will be established in accordance with the strategic objectives and policies established at European and national level during the 2021–2027 programming period.

The development idea includes six strategic objectives and four main directions for the city. SIDU is based on four pillars: sustainable development that focuses on the needs of the local community; investments that are based on smart specialization and knowledge; capitalizing on the touristic and cultural capital offered by the title of European Capital of Culture; and the creation of green-blue corridors to transform Timisoara into a climate-neutral metropolis.

The six strategic objectives focus on the following elements:

Strategic objective 1 is to improve the quality of people's lives and the opportunities for social development at the level of the municipality of Timisoara and the towns in the Functional Urban Area by improving the public services dedicated to citizens and by increasing the quality of urban public spaces.

Strategic objective 2 is to develop the economy of the municipality of Timisoara according to the new trends in innovation, technology and knowledge, fields that generate high added value and offer attractive jobs with competitive salaries.

Strategic objective 3 is to develop urban mobility in the municipality of Timisoara and ZUF based on clear and firm principles regarding changing travel behavior and the use of alternative means of travel.

Strategic objective 4 is the sustainable development of the city and functional urban area, with clear commitments to climate neutrality, with a focus on reducing greenhouse gas emissions and promoting investments that help adapt to and mitigate climate change.

Strategic objective 5 is to define the identity and position of the city of Timisoara as a national leader in the cultural-tourism field and as a pole of attraction on European cultural and tourist routes.

Strategic objective 6 is about strengthening the process by which it establishes itself as a model of local public administration that bases its public policies on open dialogue with all its citizens and emphasizes innovation, sustainability and quality of life.

In 2023, new sources of non-reimbursable financing were found and grants worth over 410 million lei were accepted for investment projects from the Development Program of the Municipality of Timisoara. Five funding applications were submitted. In the same period, seven new financing contracts were signed based on the applications submitted in the previous year.

Projects with a non-refundable value of 929.45 million lei were contracted for the European period 2021-2027, including the Recovery and Resilience Plan 2020-2026, starting in 2022.

Table 2: Grant funds solicited and accessed in 2023 (source www.primariatm.ro)

Projects submitted and contracted in 2023	Millions of lei/amounts contracted	Amounts requested
Waste management	55,45	0
Energy efficiency	44	0
Urban mobility	163	157
Energy	0	32
Education	221	221

Table 3: Projects under implementation (source www.primariatm.ro)

POIM 2014-2020
9%
POR 2014-2020
40%
PNRR 2020-2026
40%
POCA 2014-2020
0%
POAT 2014-2020
1%
PRV 2021-2027
10%

The implementation of projects financed by non-reimbursable funds focuses on the following areas of intervention:

The objective of waste management is to accelerate the expansion and modernization of waste management systems, emphasizing separate collection, prevention, reduction, reuse and recovery. This will be done to comply with the applicable directives and to move to the circular economy.

The objective of the green transition is to increase the built stock by implementing an integrated approach to energy efficiency and the transition to green and smart buildings. This will provide respect for the aesthetics and architectural quality of the fund, as well as the creation of appropriate mechanisms to monitor the performance of the built fund and ensure the technical capacity to implement the investments.

The objective of sustainable urban mobility is to ensure sustainable development of Timisoara by investing in the local public transport infrastructure. This will support resilience and green circulation in the city, while reducing disparities in neighboring suburban areas.

The objective of energy and the environment is to deal with climate change by increasing energy efficiency through the development of intelligent energy production and transport systems, as well as by promoting the use of renewable resources. This will contribute to a modern, competitive and efficient economy that is decoupled from the use of resources in line with the objectives of the European Green Deal (EGP) and the EU Zero Pollution Action Plan.

The objective of tourism and culture is to create a memorial dedicated to the recognition of the dramas caused by people and society during the totalitarian regime, to educate future generations in an interactive and participatory way, so that past mistakes are not repeated and to build a society based on European values.

The objective of education is to increase the resilience of the education system by modernizing infrastructure and related equipment to match current and future labor market needs, so that everyone can participate in a high-quality, contemporary and inclusive educational process.

The health objective is to increase the resilience of the Romanian health system by increasing the accessibility, safety, quality and functionality of medical services and health infrastructure.

The objective of administrative capacity is to create a modern public administration that has competent and well-managed human resources, efficient and transparent management of the use of resources and an appropriate institutional-administrative structure that can help achieve the goals of the Europe 2020 Strategy.

Social inclusion objective: The aim is to support the poverty reduction process and help vulnerable groups overcome the situation of social exclusion. This is done in accordance with the principles of the European Pillar of Social Rights, which include community-led local development and the protection of the right to social dignity.

In addition, on the C12 – Health component of PNRR 2020–2026, projects worth 42.83 million lei were submitted in collaboration with the Timișoara Municipal Emergency Hospital and the "Louis Țurcanu" Children's Hospital in Timișoara. The municipality is the main orderer of credits, and the hospitals are project leaders.

Between January 1 and December 31, 2023, actions were carried out with the aim of initiating or continuing the development and implementation of nineteen investment objectives in the design phase, which will be implemented in different fields of intervention: urban regeneration - public spaces and block of housing blocks; historical monuments - public spaces and buildings; urban mobility; road infrastructure; energy efficiency.

Table 4: Funding AREAS (source www.primariatm.ro)

waste management	55.450.785,75
the green transition	188.799.758,42
urban mobility	1.171.235.501,57
tourism and culture	22.353.298,72
education	581.336.364,64
health	70.887.273,58
capacity	11.775.521,72
energy and environmental protection	164.101.696,23
social inclusion	22.861.948,87

Table 5: The SWOT diagram (1)

INTERNAL FACTORS	**STRENGTHS** Optimizing the traffic congestion average Increase in the total number of passengers in public transport Increasing appetite for bicycle transportation in the warm season The existence of foreign investments in the domain of 5G communications	**WEAKNESSES** Lack of connection between the city and the outskirts by means of multimodal transport The growing pressure of peripheral real estate expansion on transport and parking infrastructure Lack of use of traffic data in the prevention of traffic violations Still small number of charging stations for electric vehicles
EXTERNAL FACTORS	**OPPORTUNITIES** The use of public transport data to expand it on the segments where there is a need Developing smart city applications by testing fast connectivity	**THREATS** The overcrowding of the city is proportional to the desire to buy cars Lack of possibilities to expand the road infrastructure without affecting pedestrians Traffic maintenance correlated with air quality degradation and PM2.5 particulate matter

Regarding the awareness of social responsibility, there has been a decrease in the process of citizen involvement in public life due to lack of civic education, digital skills or local history. Citizens cannot report irregularities in real time because the platform does not have traceability in the IT system and a predetermined response time.

Timisoara is among the 80 cities in the world that use the participatory governance method. This method involves collaboration between civil society and local government to develop a local action plan. An essential characteristic of a democratic state is open government, which plays an important role in modernizing public activity. Since October 2020, Timisoara has been included in the Local Partnership Program for Open Government (Open Government Partnership or OGP Local). In these circumstances, the participatory budget was implemented for the first time at the level of the municipality of Timișoara in 2022, through a public consultation and a "Timișoara Decide!"[15] campaign. As can be seen, https://covid19.primariatm.ro/ and https://oxigen.primariatm.ro/#/ are two applications that served as examples of good practice during the pandemic and were rewarded by the government. Both platforms provided support to the people of Timisoara and encouraged the community to solve common problems.

In November 2021, the launch of the public participatory platform "DECIDEM" represented a landmark moment. The platform is seen as a primary tool for citizen involvement in city programs and their participation in decision-making.

It was built on the Barcelona model, which is considered the most inventive open data project in Europe. It was made entirely by volunteers and was inspired by the voice and needs of the local community.

The Timisoara Decide 2024 campaign invites citizens to be actively involved in the governance of the city and to set priorities for spending 4 million lei from the local budget. From May 10 to June 30, projects can be submitted, and from August 23 to September 23, people can vote on projects that others have proposed through questions, suggestions or additions.

As an example, in 2023 the campaign "Timisoara Decide!" invited citizens to be actively involved in the management of the city and to set priorities for spending 4.2 million lei from the local budget. They could do this by submitting projects (March 31–May 15), asking questions, offering suggestions or additions, and voting on projects (June 1–July 2).

During the voting period that started on June 1 and continued July 2, 8,228 voters were registered, which is an increase of 1,513 voters, which is a 23% increase from the previous year. 18,693 votes were registered, 565 less than in 2022, when there were 19,258 votes, which means a decrease of 3%. Of those who voted, 47% supported 5 projects, which is the maximum number of projects possible. The number of these projects has doubled compared to the previous edition.

The Timisoara Municipality Infocenter offered Romanian and foreign visitors useful information about the city, such as accommodation, local and national transport, tourist attractions, monuments, attractions and cultural programs. These include cultural programs such as concerts, festivals, theater performances, opera, fairs, exhibitions and more. There are also leisure options, offers from local tour operators, and guided tours.

Table 6: Top 10 neighborhoods by number of voters, for the years 2022-2023

2022	2023
1. Soarelui 2. Calea Giroculuii 3. Circumvalațiunii 4. Calea Șagului 5. Dâmbovița 6. I.I. de la Brad 7. Ciarda Roșie 8. Elisabetin 9. Aradului Vest 10. Fabric	1. Dâmbovița 2. Calea Șagului 3. Ciarda Roșie 4. Plopi 5. Lunei 6. Campus Universitar 7. Calea Giroculuii 8. Soarelui 9. Fabric 10 I. I. de la Brad

Table 7 Comparative situation of the number of tourists

YEAR	**2020**	**2021**	**2022**	**2023**
January	311	23	51	177
February	984	59	91	695
March	375	23	146	157
April	10	60	288	360
May	16	120	401	681
June	31	133	331	550
July	69	323	679	695
August	143	741	814	1.159
September	168	651	493	1.060
October	64	222	407	965
November	49	142	557	598
December	35	101	151	367
TOTAL	**2.245**	**2.598**	**4.409**	**7.464**

Table 8: Analysis of the number of tourists

Years	Total arrivals
2020	122.182
2021	153.794
2022	212.785
2023	261.705

In 2023, 7,464 tourists received advice from the Tourist Information Centre. About 25% of them were Romanian tourists, and 75% were foreign tourists. Table 7 presents the comparative situation, per month, of the last four years of the number of tourists who visited the Tourist Information Center. Except for the first quarter of 2020, the number of beneficiaries of the info center services in each month of 2023 is significantly higher than in previous months. The months of August, September and October were the months with the most visitors.

The analysis of the number of tourists who visited Timisoara in the period 2020-2023 was carried out based on the statistical data provided by the National Institute of Statistics (INSSE). The data is updated until November 2023.

Through the objectives "Every citizen has a voice" and "Smart City is Fun City Timisoara", the municipality of Timisoara should become the favorite place of its inhabitants for work, fun and especially for the feeling of "home".

The ability of the intelligent city of Timisoara to "create closeness" with citizens is illustrated by the slogan "Every citizen has a voice".

Citizens will make public decisions, and the city becomes a "favorite" place for work, play and above all the feeling of "home". Timisoara has the prerequisites of a cohesive urban community with over 325 thousand people and over 440 thousand in the metropolitan area. The revitalization of the civic and participatory spirit can be achieved through the automation, transparency and traceability of the consultative process through digital technologies.

The objective is to create a participatory culture at city level by creating digital tools created by the public administration to involve the private environment and citizens in public debates and decisions. On the other hand, this encourages proactive attitudes and encourages citizens to be more interested in participating in consultations on the future of the city.

The sustainable development target mentioned is the reduction of inequalities. This goal emphasizes the meritocratic nature of society and ensures that everyone has access to resources.

The ambition "Vibrant ecosystem of innovation" and the ambition "Timisoara - Attractive city for talents from the international environment" were established to define the smart city of Timisoara. The Sustainable Development Target focuses on industry, innovation and infrastructure, as sustainable industry requires sustainable infrastructure and innovation is essential for efficient industry. The focus is also on decent work and economic growth: guaranteeing decent jobs for all, for sustained, open and sustainable economic growth, for full and productive employment of the workforce. Universities provide highly skilled human capital that is essential for a smart city, but not sufficient for industry demand.

Table 9: The SWOT diagram (2)

INTERNAL FACTORS	**STRENGTHS** There are several organized forms of public debate and consultation: 20 neighborhood councils, the National Minority Council Timisoara is recognized as a city of cultural activity Identification of current trends through the Quality-of-Life barometer in Timisoara Municipality The town hall monitor, distributed free of charge, allows citizens to be officially informed without access to technology The launch of the Decidem Platform based on the best international practices that assumes the role of a technological vehicle in participatory democracy	**WEAKNESSES** The exercise of participating in public debates has been restricted in recent years to simple actions through social media Large-scale participatory culture (participatory democracy) was not supported by specific activities based on a smart policy or goal Collapse of event attendance Lack of a city app to facilitate participation in cultural or sporting events or activities An important segment of citizens who live in the peri urban and interact daily with Timisoara, are not represented in the consultative processes The lack of citizen involvement translates into a decrease in voter turnout
EXTERNAL FACTORS	**OPPORTUNITIES** Facilitating online consultative interaction with Advisory Councils Development of a procedure for recruitment, selection and implementation of smart city project ideas for Timisoara Attracting young people in the process of debating or co-creating some projects Facilitating participation in events through dedicated applications Continued investment in cultural infrastructure (cinema halls, Multiplexity)	**THREATS** Amplification of the feeling of detachment \distance from the city due to the frustration created by the lack of dialogue between the main actors of the city to solve the problems Creating discrepancies between different groups of citizens or decreasing the legitimacy of public projects

The municipality of Timisoara will be able to counterbalance the trend by implementing a smart city strategy and by maintaining an active presence in international networks. This will allow the involvement of diaspora talents in the development projects of the municipality.

As for smart cities, the focus is on the economy: entrepreneurship and innovation, labor productivity and international economic connectivity.

The segment of the population engaged in higher and high school education is essential for the smart city strategy. In 2020, there were 43,582 students, many of them with master's or doctoral degrees. In the past, the university campus in Timisoara was able to grow, but in the long term, the demographic phenomenon and the high school graduation rate have affected it and will continue to do so.

In 2019, there were 9,133 graduates from all universities and postgraduate cyclists, an increase from 2015. However, this number is still insufficient to meet the demands of industry, at least in the technology segment. When we consider high school graduates as well as vocational and technical education graduates, their number has remained above 4,000 over the past five years. Local graduates are not enough to support an increasing number of higher education graduates in the future. It is constantly necessary to attract regional, cross-border or even international talent.

In the past, Timisoara did not have many unemployed people, which makes it difficult to attract future investments that are looking for a large amount of available or potential labor. Considering the pandemic, the share of unemployed at the end of the year rose to 0.9 percent, doubling from the previous year. According to the share of employees in relation to the population, the economic parts that do nothing indicate the weight they bear. Compared to previous years, this was an increase of 38.4% in 2019. However, this trend should be approached with caution, as it may be affected by the decline of the young population and the migration of the local population to the suburbs. The data collected by the Intercommunity Development Association "Polul de Crestrere Timișoara" (ADI-PCT) must be regularly correlated with those from the growth pole.

Also, domestic and international flight passengers are other factors that are considered in how attractive a city or region is. Their volume decreased by over 70% in 2020, from 470,631. Passengers were over 1.5 million between 2017 and 2019.

Currently, Timisoara has 16 "twins" and 6 European cooperation networks to connect to other European cities. They allow the exchange of

experience, as well as the connection to sources of information or the creation of projects that are related to those that are common.

Universities provide highly skilled human capital that is essential for a smart city, but not sufficient for industry demand. The municipality of Timisoara will be able to counterbalance the trend by implementing a smart city strategy and by maintaining an active presence in international networks. This will allow the involvement of diaspora talents in the development projects of the municipality.

Table 10: The SWOT diagram (3)

INTERNAL FACTORS	**STRENGTHS** The high school system, along with vocational and technical education, constantly provides around 4000 graduates The university system continues to attract talents from outside Timisoara The university system offers around 9000 graduates annually Timisoara City Hall is internationally connected and a partner in substantial projects, including Urban-Act type The university system has specific research infrastructures, including in the field of ICT	**WEAKNESSES** Timisoara's participation in international networks has not yet been exploited to its full potential There is still no public policy (strategy, projects, initiatives) to attract international talent in the interest of the local business environment or the administration The relationship between ICT infrastructures and companies is not dynamic enough to allow the development of solutions for smart city initiatives for now
EXTERNAL FACTORS	**OPPORTUNITIES** The positioning of Timisoara as a city offers opportunities and support for smart city projects Specialists can be attracted to solve challenges related to smart city initiatives, on existing partnership platforms. European funding opportunities for the development of entrepreneurship that can be better adapted to real needs through specific smart city promotion and debate mechanisms	**THREATS** The needs of talent companies are growing and cannot be met only with the internal resources of Timisoara The presence of multinationals discourages the local entrepreneurial spirit that cannot compete on salary levels

V. CONCLUSIONS AND FINAL REMARKS

All over the world, community policy is creating the conditions for more and more cities to become smart cities. In this sense, strategies, action plans, programs, initiatives and declarations have been adopted for which more and more funding is being allocated. For cities to become smart, public systems must be implemented, structured and coordinated in such a way that they become manageable and sustainable.

At the level of Romania, the need to recover the development deficit compared to the western countries of the European Union can be ensured by designing, adopting and implementing a model for the development of smart cities and regions, based on scientific research and adapted to specific local characteristics.

For Timisoara to become a smart city, a complete strategy is needed to bring Timisoara into the digital age. The strategy developed by Timisoara City Hall in 2022 aims at seven major areas that focus on the lives of citizens: the quality of public services, participatory governance and decision-making transparency, the economic environment, the attraction of qualified labor, the environment and sanitation, culture, public transport and mobility. There are, in total, 165 strategic projects, of which 27 are currently in the implementation process. Many projects proposed by this strategy are currently in the implementation phase, while other projects are in the preparation phase.

In accordance with the smart city strategy, Timisoara demonstrates its commitment to join the global community by establishing a culture that involves all citizens of the city by the creation of a complete way of delivering public services, supported by optimized digital administrative processes, which facilitate the easy interaction of citizens and companies in the relationship with public institutions.

Vulnerable groups can gain access to infrastructure and public services using digital solutions:

- Creating an innovative environment that is cohesive, interconnected and transparent, which will stimulate the number of startups, increase the share of enterprises that launch their products and services on international markets, and stimulate the overall research-development-innovation capacity at the level of Town.
- Developing a repeatable process of attracting human resources, especially from the diaspora, to involve them in concrete projects and initiatives for the development of the city.

In addition, creating a city brand will make Timisoara attract startup founders and technology-based enterprises from other countries. Digitization also aims to make the city more accessible for tourists, managing the city's essential resources in a balanced way through interventions that reduce losses, improve consumption and increase the supply of renewable energy. Thus, the following measures could be taken:

- Creating an attractive environment in the city by implementing measures that will improve Timisoara's current offer in terms of entertainment, culture and sports, social interaction and cultural events.
- Creating the best smart city digital infrastructure and the necessary digital tools to help public institutions ensure that public investments are sustainable and maximize their use for the benefit of the community.

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Case Study on Designing Ergonomic Training and Learning Environments

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Abstract – In today's competitive world, education is key to developing future skills. To support effective learning, it's important to provide employees with ergonomically designed spaces and prioritizing ergonomic principles in training classrooms ensures health and learning efficiency. International standards like ISO EN 6385:2016 and ANSI/HFES 100-2007, along with national regulations, guide the designing of ergonomic classroom environments. This paper aims to highlight the key ergonomic elements needed to design classrooms that benefit both learners and trainers. Adhering to these standards can help create optimal, ergonomic learning environments.

Keywords: ergonomics, workplace management, efficiency, environment

I. INTRODUCTION

Educational institutes, but companies, too are environments for learning and developing skills and competencies for this competitive world. To support effective learning, it's important to provide employees and learners with ergonomically designed spaces to enhance learning experience and overall efficiency. A well-designed classroom not only boosts training effectiveness, but also fosters engagement. This paper explores the key parameters and elements necessary for designing ergonomic classrooms that benefit both learners and trainers.

To achieve the aim of the paper, a case study was approached regarding the key aspects of an ergonomic learning environment that support both health and learning efficiency. There have been followed guidelines, international standards, along with specific national regulations to realize a comprehensive study for requirements of a well-designed ergonomic classroom. ISO EN 6385:2016 emphasizes the importance of ergonomics in designing work systems. It suggests using ergonomic principles throughout the entire project, from start to finish. The standard aims to make tasks efficient and safe by considering human abilities and limitations. It also encourages collaboration among experts from different fields to create better work environments. Additionally, it highlights the need for work systems to be adaptable, so they can meet the needs of different users and adapt conditions over time.

II. GENERAL CONSIDERATIONS

As ergonomics' requirements evolved over the years and its' specifications become mandatory in institutions and organizations, these two should be concerned about improving the designing of ergonomic training and learning environments. Also, according to literature, applying ergonomics and human factors (E/HF) principles and practices, as well as implementing ergonomics programs, has been proven to enhance performance, productivity, competitiveness, and safety and health across various occupational sectors [10]. The world's largest scientific association for *Human Factors and Ergonomics* (HF/ E) *Society* founded in 1957 support also the professional in the field for improving and implementing these requirements. This discipline is often mistaken for anthropometry, which focuses on human dimensions. This confusion occurs because ergonomics, being a multidisciplinary field, includes anthropometric aspects. However, ergonomics extends beyond this to encompass psychological, sociological, engineering, and biological studies, as well as workplace safety, design, and more [1].

It's important to understand that ergonomics is applied to maximize process efficiency while prioritizing the well-being of the workforce and remember that the goal of Human Factors and Ergonomics (HF/ E) is to better integrate people into systems, creating cohesive units that enhance both performance and well-being [6]. The researchers state also that the primary goal of ergonomics is to adapt the task to suit the individual, rather than forcing the individual to adapt to the task [5].

When referring to designing ergonomics environments it is relevant that in the initial phase of

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job design, the task demands should ideally be within the capacity of a fixed percentage of the population, ensuring that 75% to 95% of individuals are accommodated [5]. When designing an ergonomic room for learning, it's essential to consider several key elements. Proper positioning of the computer monitor is crucial to prevent neck and eye strain. According to ISO 9241, the preferred viewing distance for a typical user is greater than 40 cm, with a preferred character size range of 20-22 arcminutes. Additionally, the design of the work chair is vital to prevent musculoskeletal disorders affecting the back, legs, buttocks, and arms. The backrest should provide adequate lumbar support and sufficient clearance for the buttocks. These considerations help create a comfortable and productive learning environment [13]. These days, the excessive use of computers appears to be a well-known problem for workers and learners; a study in domain turned out that the current computer usage practices among office staff result in various related health issues [3]. For certain jobs, ergonomic position has become a serious topic of occupational health and safety. Other people become conscious of their condition as they encounter medical disorders and need rehabilitation and dedicated therapy.

So, the need and obligation to develop ergonomic environments for training and learning is urgent and the responsibility of those who offer such services is greater.

III. CASE STUDY

The case study of this paper highlights exactly the requirements and elements that should be followed in designing an ergonomic environment for learning and teaching. That's being said, it was proposed that a classroom both for educational institutions and organizations meet ergonomic requirements and maximize the learning experience.

Hence, during teaching hours in educational institutions or organizations, teachers and instructors often spend long periods of time teaching and learning. This can lead to various injury risks due to poor posture or prolonged static positions, such as shoulder or neck tension, upper back pain, and discomfort in the back and knees when standing [11].

The motivation for study has risen following rehabilitation of classrooms in the university and noticing how frequent inadequate ergonomic learning organization is present in different environments.

This case study highlights the ergonomics aspect of the learning environments to avoid these types of injury. First, the aspects that should be taken into consideration when designing an ergonomic training and learning environment are [8]:

- Altitude, depth and space;
- Whole body movement;
- Lightening conditions;
- Noise;
- Vibration;
- Climate.

For that, the case study starts from designing the *space* of a classroom both for companies and for the educational institutions, with standard dimensions. There are specific dimensions and guidelines to consider and can vary depending on the type of the institution and the number of students or learners. But, for the case study it has been considered the typical classroom in an educational institution with a range of 46 to 84 m^2 for 20 to 30 learners [2]. Also, classroom Layout Clearances are the necessary spaces kept between different elements in a classroom to ensure functionality and accessibility. This involves maintaining adequate spacing between aisles and rows of desks or tables so that students can move around comfortably without causing disruptions like in Figures 1 and Figures 2.

It's also important to have clearances on the sides, front, and back of the room, like in Figure 3, to allow for additional movement and activities. Additionally, there should be enough space around the teacher's desk to enable free movement and interaction with students. These clearances are essential for fostering an ergonomic learning environment. They ensure easy access for all students and provide an ergonomic space for teaching.

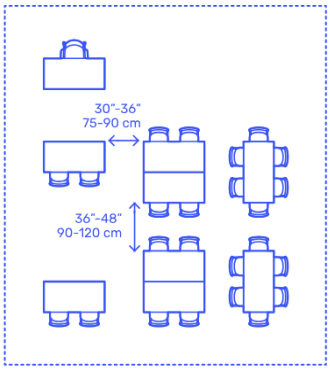

Fig. 1. The values of lateral distance between desks and distance between chairs (upper view) [2].

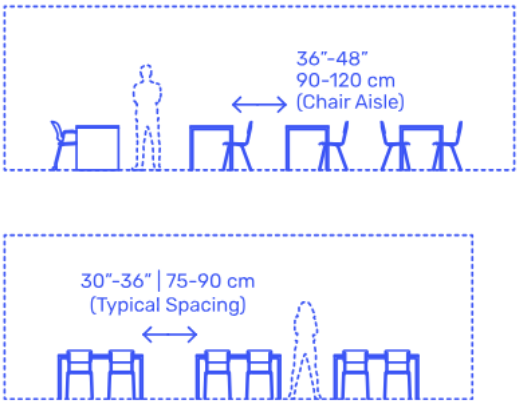

Fig. 2. The values of lateral distance between desks and distance between chairs (side view) [2].

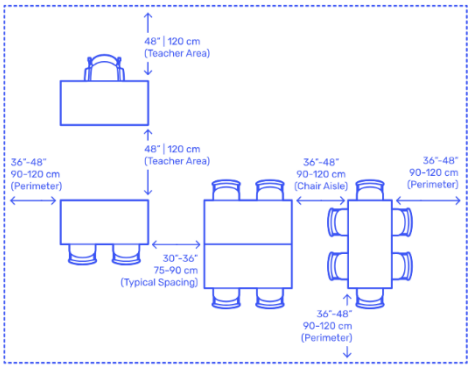

Fig. 3. The perimeter clearance values around the room [2].

Fig. 4. The layout of a seminar or collaborative classroom [2].

Fig. 5. The layout of a seminar or collaborative classroom (another model) [2].

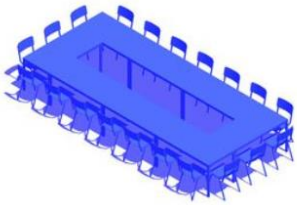

Fig. 6. The layout of a seminar or collaborative classroom (other model) [2].

Fig. 7. The layout of a traditional classroom/ training room V

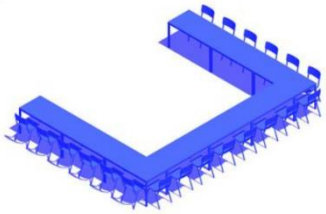

Fig. 8. The layout of a lecture hall [2].

Fig. 9. The layout of a auditoria room [2].

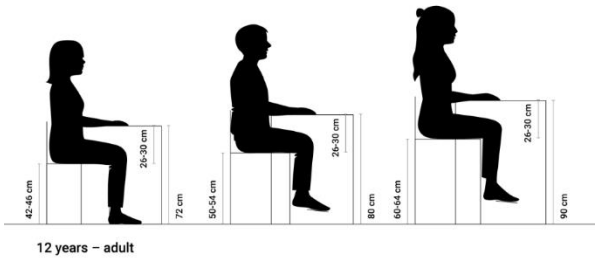

Fig. 10. The correct chair's seat depth and height [9].

The clearances are customized to fit the classroom's size and the number of occupants, striking a balance between space utilization and comfort [2]. So, for a typical ergonomic space should be respected the following:

- Lateral distance between desks 75-90 cm and distance between chair aisle 90-120 cm;
- Teacher's area distance 120 cm (around 1.44 m^2);
- The perimeter clearance around the room should be also around 14400 cm^2 (1.44 m^2).

Traditionally, there are four types of rooms for learning (depending on the number of persons that are supported): seminar or collaborative classrooms like in Figure 4, Figure 5 and Figure 6, traditional classrooms like in Figure 7, lecture halls like in Figure 8 and auditoria like in Figure 9 [12], but in the modern era it is possible to create new types of learning environments if they are ergonomic. But referring to the traditional ones, there are some ergonomic requirements that should be respected.

The next elements are referring to body *movements.* Here enter the furniture and the ergonomics aspects that must be taken into consideration for an optimum learning experience. An ergonomic furniture is the one that is adjustable and facilitates posture support and a right position during working. The chair's seat depth should be adjusted to match the correct height (as can be seen in Figure 10). If the front edge of the seat extends beyond the knee fold, the seat is too deep, causing you to sit with straight legs or slide forward, leading to a rounded back. Conversely, if the seat depth is too short, the legs lack sufficient support. To ensure the right seat depth, choose a chair designed for the appropriate age group of the learners [9].

Also, according to Anders Larsson, the Next Education Manager Kinnarps, selecting the right furniture can enhance workplace ergonomics for various learning environmental staff. Chairs that can be hung on desks simplify cleaning for the custodial staff, while flexible furniture with castors or stackable chairs is often appreciated by the caretaker [9].

Table 1. Types of chairs in ergonomic rooms (x-preferred, A- acceptable, N/A – not acceptable) [12]

	Tiered	Fixed Seat	Fixed Table	Moveable Seat	Moveable Table	Tablet
Seminar	N/A	N/A	N/A	X	X	N/A
Classroom	A	N/A	A	X	X	N/A
Lecture	X	A	X	A	N/A	A
Auditorium	X	X	N/A	N/A	N/A	A

Fig. 11. The proper support for lumbar area, according to [4]

Fig. 12. The appropriate torso-to-high angle position, according to [4]

When discussing chairs that should be ergonomically functional, it is important to know the suitable type, as shown in Tabel 1. Not all classrooms need fixed chairs, precisely to offer flexibility in the configuration of the classroom according to the needs of exercises in seminars and classrooms. Also, the need for fixed furniture in reading rooms and auditoriums is due to the very large number of people and the very purpose of the rooms to keep the audience attentive and direct everyone's concentration to a single point, namely the podium on which they are speaking.

As mentioned, to meet the ergonomic requirements of various users, it is advisable to offer seating solutions that are adaptable (for instance, seats that can be adjusted in terms of depth, width, and height) or to provide an assortment of different types of seats. Auditorium seating should be fixed seats and have a width of 61 cm, unless restricted by the row curve. For auditoriums accommodating 200 or more individuals, it is essential that the tablet armchairs are designed with dimensions of 82 cm and provide a clearance of 31 cm in the front when the tablet arm is extended for use, in accordance with the CT code. The seating should feature a downward sloping waterfall profile at the front edge. It is crucial that every seat offers adequate lumbar support, akin to what is depicted in Figure 11, with backrests that align with the spine's natural curve and permit a range of motion as illustrated in Figure 12. In sections where seating is fixed, there should be an option for flexible seating to accommodate those unable to utilize the standard seats, ensuring that this additional seating is consistent with the fixed seats' design. [12].

If it is about the tables associated with each place, these can seat 1, 2, or 3 students, with at least 30 inches per student. Each learner needs a minimum work surface area of 0,35 m^2 for notetaking and materials. Table depths range from 46 to 61 cm, with 46 cm wide tables preferred and 92 cm of space in front. Tablet arms are only for theater seating. The required tablet should have a minimum size of 31 cm by 38 cm, which corresponds to a surface area of 0.12 m^2. It is important to design the workspace so that 10% to 15% of the tablet surfaces cater to left-handed individuals. Additionally, the seating should be equipped with casters that are suitable for the specific type of flooring, whether it be carpet or Vinyl Composition Tile (VCT). Lastly, the furniture must be designed to be compatible with technological needs, including the incorporation of power and data pathways. [12].

Regarding the classrooms *lightening*, it should be considered to use natural light, different lighting modes, and be controllable to save energy. Rooms can be divided into zones based on available daylight, with each light adjusting to the current light level in its area [12]. Also, proper lighting is essential for reducing eye strain and maintaining focus according to ISO EN 6385:2016 [7]. The standard suggests using a combination of natural and artificial lighting to ensure adequate lightening conditions. It also emphasizes the importance of minimizing glare and shadows to create a comfortable visual environment. According to [12] there are five functional lighting zones:

-*zone 1*: in the main classroom, the lights above where students sit should make it easy for them to read and write. The best lights for this are the kind that go into the ceiling and shine most of their light (65%) up to bounce off the ceiling, while the rest (35%) shines down. This way, the room gets bright without harsh shadows. Hanging lights should be avoided because they can create uneven lights;

-*zone 2:* for the front of the classroom where the whiteboard and lectern are, the lights need to be bright enough so everyone can see clearly even when all the room's lights are on. The brightness of these lights should be the same as the rest of the lights in the room.

-zone 3: non-projection whiteboard: light the whiteboard so the instructor can write on it during AV (audiovisuals) presentations without light spilling onto the projected image;

-zone 4: projection whiteboard: use the same lighting as zone 3 when not projecting;

-zone 5: instructor workstation: ensure the instructor can read the notes and use audiovisuals (AV) equipment even in poor light conditions during projections [12]. And the intensity of light (normally in lumen, but here in Foot candle according to [12]) is represented in Table 2. Also, all light fixtures should

be the same color temperature, ideally set at 3200 Kelvin. A range between 3000 and 3500 Kelvin is acceptable, provided that all fixtures maintain uniformity.

Among the last ergonomic elements to analyze are *ventilation and acoustic*, which will be addressed in the sections below. In classrooms close to loud areas, it's important to use walls, floors, and ceilings that are built to block noise better. This means using materials that have high Standard Test Conditions ratings, which measure how well sound is stopped. Make sure that the classroom is well insulated against noise coming from next door, as well as from above and below.

Whenever possible, have an acoustic consultant review the classroom's acoustic requirements. Minimum NC (Noise Criterion) ratings should be: 0-59 seats: NC 30-35 or less; 60-149 seats: NC 25-30 or less; 150+ seats: NC 20-25 or less [12]. The NC (Noise Criterion) rating is determined by measuring the sound pressure levels across different frequency bands and comparing them to predefined NC curves.

Classroom walls should have a minimum sound transmission class (Standard Test Conditions) of 50, as recommended by ANSI S1.4-1983 (R 2006). Individual equipment such as fans, ductwork, and diffusers should not exceed Noise Criterion 25 throughout the load range, as recommended by ANSI S12.60-2002 [12].

According to ISO EN 6385:2016, good ventilation is important for maintaining air quality and thermal comfort and ensuring adequate airflow and temperature control to create a comfortable and healthy work environment. Certainly, clean environment is also understood, meaning frequent cleaning, lack of dust, proper ventilation and comfortable atmosphere.

IV. CONCLUSIONS

In conclusion, this study highlights the critical role of ergonomics in designing effective training and learning environments. The study presents some basic facts about ergonomics as a science to understand the need for improving learning and teaching activities in both companies and educational institutions.

The case study highlights and argues all the important aspects of ergonomics that are applied to the design of learning environments and the measures that should be taken accordingly. By analyzing the key elements such as appropriate furniture for good body movement, the noise level, optimal lighting, adequate ventilation, and sufficient space are essential for fostering a comprehensive learning atmosphere space, for creating ergonomic classrooms. By integrating ergonomic principles, we can create spaces that enhance comfort, safety, and productivity for learners.

The study demonstrates that ergonomic design not only addresses physical well-being but also supports cognitive and emotional engagement.

Table 2. The values of light intensity in foot candle [12].

	Day Light Mode	General Mode Non-Day Lighting	Audiovisual Mode
Student desk	30-200 fc	30-70 fc	Minimum 10 fc
Whiteboard	30 fc vertical minimum	30 fc vertical minimum	N/A
Screen	N/A	N/A	8 fc vertical
Walls	10 fc vertical	10 fc vertical	N/ A

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A Study on Continuous Adaptation and Innovation Through Technology and Ergonomics to Improve Health and Safety at Work

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Abstract – Many sectors, including occupational health and safety, are significantly impacted in today's rapidly evolving technological landscape. Companies are increasingly compelled to integrate innovative technologies to address emerging challenges. Technology plays a crucial role in enhancing employee safety and health, from advancements in protective equipment to implementing sophisticated monitoring and accident prevention systems. Additionally, the integration of ergonomic solutions, driven by technological advancements, further contributes to optimizing workplace safety and improving overall well-being.

Keywords: ergonomics, internet of things, health and safety, occupational health and safety, technology.

I. INTRODUCTION

In recent decades, workplaces have undergone major changes and health and safety issues have diversified considerably. Employers now face not only traditional risks such as accidents and exposure to hazardous substances, but also new challenges such as work-related stress and illnesses caused by modern technologies. These constant changes have created an urgent need for innovative solutions and continuous adaptation to ensure a safe and healthy working environment for all employees [1].

This article explores how innovative technologies can be integrated into occupational health and safety strategies, with a special focus on ergonomics as a starting point. We discuss the concrete benefits of these technologies as well as the associated challenges and ethical dilemmas. Through relevant case studies and practical examples, the article will emphasize both the potential of these technologies to improve the safety and health of employees and the need for a well-thought-out and strategic approach to their implementation.

II. EMERGING TECHNOLOGIES IN OCCUPATIONAL SAFETY AND HEALTH

In the field of occupational safety and health, emerging technologies play a crucial role in improving working conditions and preventing accidents. These include artificial intelligence (AI), the Internet of Things (IoT), augmented reality (AR) and collaborative robots. AI and IoT enable continuous monitoring of the work environment and early risk detection. Augmented reality provides interactive training and simulations of dangerous scenarios, and collaborative robots can take over dangerous tasks, reducing employees' exposure to risks. Even offering a straightforward software solution that allows employees to easily access information about potential risks with just one click constitutes a significant advancement in the field of occupational safety and health. These technologies contribute significantly to creating a safer and healthier work environment while optimizing operational efficiency [2].

Going in deep with the literature review, there have been underlined that emerging technologies in occupational safety and health (OSH) are transforming how workplaces manage risks and ensure worker well-being. These technologies, driven by advancements in Industry 4.0, include wearable sensors, extended reality, exoskeletons, applied observability, digital twins, and digitalization in health programs. Each of these innovations offers unique benefits and challenges, contributing to a safer and more efficient work environment.

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The main developments supported by the literature are:

- Wearable Sensors and Extended Reality provide real-time monitoring of workers' health and safety, alerting them to potential hazards and reducing onsite injury risks. These sensors can track vital signs and environmental conditions, offering immediate feedback [3, 4].
- Extended reality technologies, such as virtual reality (VR) and augmented reality (AR), enhance safety training by simulating realistic scenarios without exposing workers to actual hazards. This immersive training can improve hazard recognition and response skills [3].
- Exoskeletons and Robotics are being integrated into workplaces to reduce physical strain and injury risks, particularly in physically demanding tasks. These technologies assist workers in lifting heavy objects and performing repetitive tasks, thereby minimizing ergonomic hazards [3].
- Applied Observability is an emerging approach that shifts occupational health and safety from a reactive to a predictive model. By continuously monitoring and analyzing data, organizations can identify potential hazards and improve safety practices proactively [5].
- Digital Twins, which are digital replicas of physical assets, offer a novel way to enhance workplace safety. They enable the simulation and analysis of work environments, helping to identify risks and optimize safety measures. However, creating human-focused digital twins is complex and requires sophisticated integration of hardware and software [6].
- Digitalization in Health Programs facilitates risk assessments, fitness evaluations, and health surveillance. Technologies like telemedicine and advanced diagnostic tools enable early detection of work-related illnesses, improving overall worker health and productivity [7, 8].

While these technologies offer significant advancements in OSH, they also present challenges such as integration complexity, data privacy concerns, and the need for cross-generational collaboration to overcome technological adoption barriers. Addressing these challenges is crucial for maximizing the benefits of these emerging technologies in occupational safety and health.

III. BENEFITS OF TECHNOLOGICAL INNOVATION IN OCCUPATIONAL SAFETY AND HEALTH IN ROMANIA

The implementation of innovative occupational health and safety technologies offers multiple benefits, contributing to increased safety, efficiency and comfort for employees. Here are some of the main benefits [9]:

A. Reducing accidents and preventing risks

Automated monitoring and alerting are made possible by IoT and AI technologies, which enable real-time tracking of working conditions and the rapid identification of risks. Sensors and machine learning algorithms can detect issues like toxic spills or unsafe working environments and send immediate alerts to the security team. Minimizing accidents involves utilizing collaborative robots (cobots) and advanced protective gear to eliminate hazardous tasks for workers. This approach not only lowers the risk of accidents but also enhances employee morale and job satisfaction. For instance, in automotive manufacturing, cobots handle repetitive and risky tasks, such as managing heavy components, which helps to reduce incidents related to manual handling.

B. Increasing efficiency and productivity

Enhancing work processes involves leveraging new technologies like AI and augmented reality to boost efficiency and minimize downtime. AI systems analyze operational data to identify opportunities for process improvements and automate repetitive tasks, resulting in higher productivity. In terms of employee comfort and safety, health monitoring technologies such as smart wristbands or biometric sensor headsets play a crucial role. These devices allow for early detection of potential health issues, enabling swift interventions and preventing accidents. For instance, in the construction sector, smart bracelets track vital signs and alert the first aid team if signs of illness or fatigue are detected.

C. Improving occupational safety training and education

Interactive training and realistic simulations are revolutionized by augmented and virtual reality, which turns security training into an engaging and lifelike experience. This approach allows employees to practice emergency scenarios safely, significantly enhancing information retention and crisis preparedness. In addition, mobile apps and AR solutions offer employees immediate access to information and guidance directly on their devices. This capability aids in adhering to safety procedures and accelerates emergency response.

D. Improving communication and collaboration

Advanced communication and collaboration platforms, including cloud-based solutions and integrated communication tools, facilitate swift information sharing and effective coordination between security teams and employees. Furthermore, continuous monitoring systems and real-time feedback offer valuable insights to both employees and management, supporting ongoing improvements in occupational health and safety practices.

IV. CHALLENGES AND CONSIDERATIONS IN TECHNOLOGY DEPLOYMENT IN ROMANIA

Enterprise integration is the use of technology and methodologies to tightly connect everything in an IT landscape - including applications, data, cloud, cloud, APIs, processes, and devices. It combines multiple integration approaches into one combined effort with a governance model.

The implementation of emerging technologies in Romania faces several specific challenges, reflecting the country's general difficulties in software adoption compared to other European countries. We will explore these challenges, providing relevant data and graphs to illustrate the situation, thus highlighting the complexity of integrating software solutions in Romania, which implicitly translates into the fact that also in the field of occupational health and safety the adoption of specific software is a real challenge.

As shown in Fig. 1, in 2023, e-business software usage was highest in the Nordic countries and Belgium. Almost half of the enterprises in all sectors (except agriculture, forestry and fishing, mining and quarrying), excluding the financial sector, with 10-49 employees in the European Union have adopted e-business applications (ERP, CRM and/or BI). Among EU countries, the percentage of enterprises using these applications varied significantly: it reached 69.5% in Denmark, 65.8% in Finland and 62% in Belgium, while in Romania it stood at 21.1%, in Bulgaria at 21%, and in Slovakia at 25.3% [10].

In terms of enterprises with 50-249 employees, as depicted in Figure 2, Romania ranked 33.5%, Bulgaria 46.3%, Slovakia 50.9%, Denmark 89.5%, and Finland is the top leader with 91.6% [10].

As illustrated in Figure 3, for companies with more than 250 employees, the situation has changed as follows: Romania was at 58.9%, Bulgaria at 72.3%, Slovakia at 85.6%, and Denmark and Finland tied at 98.6% [9].

Romania has a relatively low adoption of e-business software in all size categories of enterprises, but the difference is more pronounced in small and medium-sized enterprises. This may reflect barriers such as lack of resources, lack of knowledge or lack of confidence in the technological benefits.

It is essential for Romania to invest in digital literacy, IT infrastructure, and supportive policies to encourage the adoption of e-business technologies and improving e-business technology adoption can help Romanian enterprises increase their productivity and competitiveness in the European and global markets. Collaboration between the government and the private sector can facilitate the deployment of e-business solutions, through financial incentives, technical advice, and awareness campaigns.

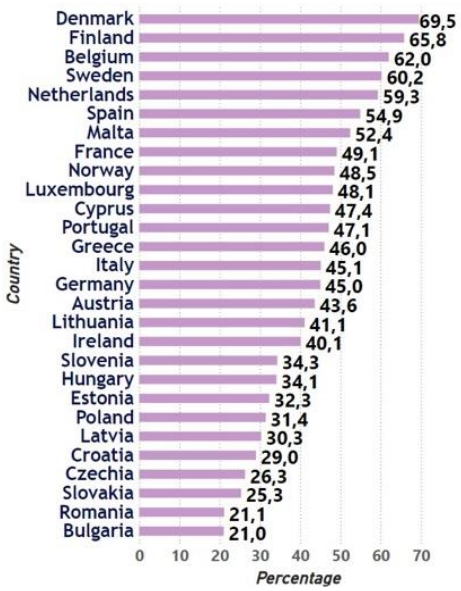

Fig. 1. Companies between 10-49 employees using e-business software (ERP, CRM and/or BI) [10].

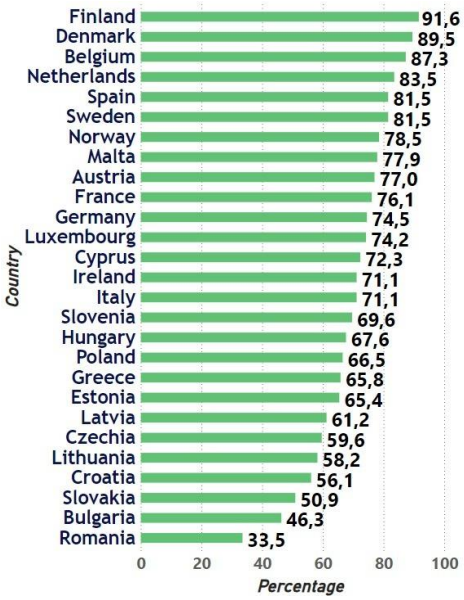

Fig. 2. Companies between 50-249 employees using e-business software (ERP, CRM and/or BI) [10].

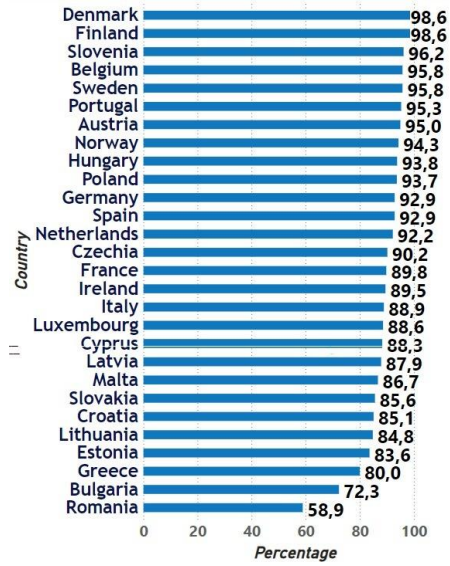

Fig. 3. Companies with more than 250 employees use e-business software (ERP, CRM and/or BI) [10].

Given the data analyzed, a good start for the integration of digitization in the field of OSH (Occupational Health and Safety) could be the area of ergonomics. The implementation of digital solutions in ergonomics can increase technological awareness and adoption, as the improvement of working conditions is directly related to the comfort and health of employees. By demonstrating the tangible benefits of digitization, companies may be encouraged to adopt other digital solutions.

Digital ergonomic solutions can also help to identify and reduce health and safety risks, which can lead to a decrease in workplace accidents and improved productivity. Thus, an initial focus on ergonomics can facilitate a smoother and more accepted transition to full digitization in the EHS sector, benefiting both employees and employers [11].

V. ERGONOMICS AND ITS BENEFITS

Ergonomics is the science of adapting the workplace, equipment and tasks to meet the physical and psychological needs of employees. Well-implemented ergonomics can decrease the risks of accidents and musculoskeletal disorders while improving worker comfort and efficiency [12].

In the digital age, adapting to the needs of remote workers is crucial to maintaining a healthy and safe working environment. One of the most innovative solutions is the integration of ergonomics into a dedicated occupational health and safety (OHS) mobile app. This functionality not only supports employee well-being, but also contributes to a significant increase in productivity and efficiency.

The main benefits of ergonomics include reduced pain and discomfort, increased efficiency and

productivity, improved employee health and well-being, reduced occupational health and safety costs.

The book, *Ikigai*, written by Héctor García and Francesc Miralles, introduces us to the Japanese concept of 'Ikigai', which translates as 'meaning of life' or 'purpose of being'. This philosophy suggests that discovering a purpose in life is essential for living a long, healthy and happy life. Ikigai represents the intersection of what you love, what the world needs, what you can be paid to do and what you do well.

Applying Ikigai principles to occupational health and safety can radically change the way employees perceive and experience working life, namely:

- Finding meaning in work involves creating an environment where employees can discover and pursue personal purpose, blending professional and personal fulfillment in a balanced manner.
- Maintaining a healthy work-life balance is essential for preventing burnout and supporting both mental and physical well-being.

Ergonomics contributes significantly to this balance, improving comfort and productivity at work and thus facilitating finding personal purpose in daily activities.

A dedicated OSH mobile app may also include an ergonomics section, which provides exercise sets customized to the user's work activity. In addition, the app can integrate guided sessions, exercise timers and monthly reports per employee, providing a complete solution for improving health and comfort in the workplace. These exercises are designed to help employees maintain proper posture and an active lifestyle and can be graphically exemplified through images or videos. In addition to the physical benefits, they also contribute to mental well-being, thus supporting finding and maintaining personal purpose (Ikigai). Examples of ergonomic exercises for maintaining an active and healthy lifestyle that can be incorporated into such an application include:

- Stretching fingers and wrists, which improves flexibility and reduces the risk of musculoskeletal disorders.
- Neck and shoulder stretch which can contribute to relaxing tense muscles contribute to general well-being and stress reduction.
- Correct body positioning, by suggesting practical tips and video guides for setting up an ergonomic workspace, promoting a healthier and more balanced working life.

Ergonomic challenges and games that blend fun with health can also be included in the application's development. For example, the following activities could be featured:

- Interactive challenges that may allow the employees to engage in activities that merge ergonomic exercises with enjoyment, encouraging them to adopt healthy routines and explore personal purpose in a fun and stimulating manner.
- Competitions and rewards that may guide the employees to create a dynamic work environment where they are motivated to develop healthy habits and discover their ikigai through interactive activities and rewards [13,14].

Another few main benefits for both the employer and the employee of integrating ergonomics into such OSH Application would be:

- Encouraging a healthy work-life balance helps mitigate the risks of stress and burnout.
- Employees who find purpose in their daily activities tend to be more motivated, productive, and satisfied with their jobs.
- Applying ergonomic principles fosters a positive organizational culture, where employees feel valued and supported [12-14].

VI. CONCLUSIONS AND RECOMMENDATIONS

Continuous Adaptation and Innovation Through Technology and Ergonomics to Improve Health and Safety at Work approach has been opening the way to the Continuous Adaptation and Innovation (CAI) which is a strategic approach that involves the ongoing development and implementation of new technologies and ergonomic principles to enhance workplace health and safety. It recognizes that the workplace is a dynamic environment, and that proactive measures are essential to mitigate risks and protect employees.

Fig. 4. Example of fingers and wrist stretching exercises [15, 16]

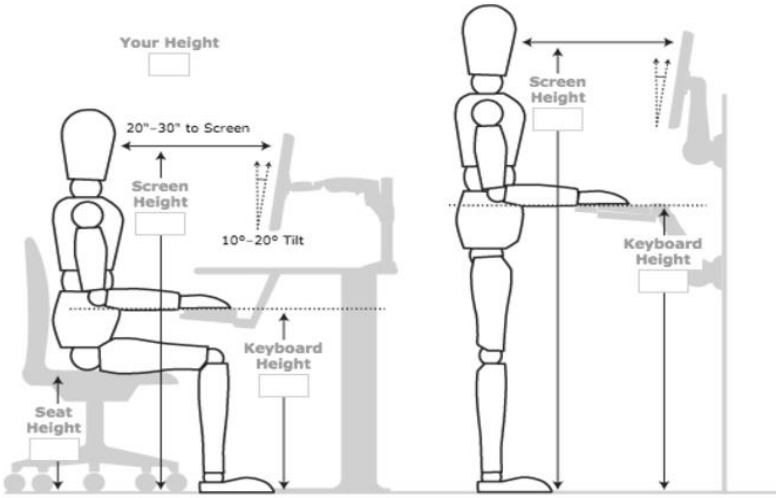

Fig. 5. Practical recommendations on how to adjust home workspaces [17]

Key Components of CAI:

1. Technology Adoption:
- IoT and Wearables: Sensors and wearable devices can monitor real-time conditions, detect hazards, and provide early warnings.
- Automation: Robotic systems can reduce manual labor, preventing repetitive strain injuries and exposure to hazardous substances.
- Virtual and Augmented Reality: These technologies can provide immersive training experiences, simulating dangerous scenarios without risk.
- Data Analytics: Analyzing large datasets can identify trends, predict risks, and inform preventive measures.
2. Ergonomic Design:
- Workplace Assessments: Regular evaluations of workstations and tasks to ensure they are ergonomically sound.
- Adjustable Equipment: Furniture and tools that can be customized to fit individual workers' needs.
- Proper Posture and Movement: Training employees in correct body posture and movement to prevent musculoskeletal disorders.
- Work-Life Balance: Promoting practices like flexible work arrangements and stress management to improve overall well-being.
3. Continuous Improvement:
- Feedback and Evaluation: Gathering input from employees and conducting regular assessments to identify areas for improvement.
- Research and Development: Staying updated on the latest technologies and ergonomic principles.
- Collaboration: Partnering with experts in health and safety, ergonomics, and technology to develop innovative solutions.

Several benefits of CAI have been collected based on our research, both from the actual literature and from practical experience (consulting and education activities):

- Reduced Injuries and Illnesses: Implementing CAI can significantly reduce the occurrence of workplace accidents and health problems;
- Improved Productivity: A safer and healthier workforce leads to increased productivity and reduced absenteeism;
- Enhanced Employee Morale: Employees feel valued and supported when their well-being is prioritized;
- Compliance with Regulations: CAI helps businesses meet regulatory requirements related to health and safety;
- Cost Savings: Preventing injuries and illnesses can result in long-term cost savings.

By embracing continuous adaptation and innovation, organizations can create safer, healthier, and more productive work environments for their employees.

Furthermore, in the context of the present paper, technological innovations such as AI, IoT, augmented reality and virtual reality have significant potential to improve health and safety at work, particularly through implementing digital ergonomic solutions. These technologies help to reduce accidents, increase efficiency and improve training and collaboration within organizations, thus facilitating a safer and healthier working environment. Although Romania ranks last in terms of OSH software integration, there is nevertheless a development trend in this direction. We encourage companies to explore the funding opportunities available through European programs such as the European Social Fund (ESF) and the Competitiveness Operational Programme (POC), as well as government grants dedicated to innovation and digitalization.

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Defining Sit-Standing Postures: A Comparative Analysis of Chairless Chair Devices and Conventional Seating Ergonomics

Maria MOGA[1]

Abstract – This study investigates the criteria defining sit-standing postures offered by Chairless chair devices through comparative analysis. It evaluates the applicability of conventional sitting posture criteria, including balance, body segment orientation, and biomechanics, in defining unconventional postures. Findings indicate that sit-standing postures exhibit a distinct center of gravity, unique support polygons, and specific body segment geometries. Devices such as those developed by Noonee and Archelis facilitate a posture that is intermediate between sitting and standing, enhancing visual control and interaction with the workspace. This research underscores the potential ergonomic and functional benefits of these innovative seating solutions, warranting further exploration

Keywords: Sitting Posture, Sit-Standing Posture, Lumbar Load, Chairless Chair, Biomechanics.

I. INTRODUCTION

There are numerous instances where terms, situations, or concepts are used without sufficient definition. This can largely be attributed to their general familiarity, understanding, and assumed self-evidence. The term "sitting posture" in ergonomics serves as an example of this phenomenon. The need for precision has led to specialized literature successfully delineating the physical and functional framework for this posture, including Etienne Grandjean's 1976 work, which analyzes the ergonomic implications and consequences of sitting posture [1].

This article aims to identify the criteria that could underpin the definition of the posture provided by sit-standing or chairless chair devices. In the past decade, more and more concepts have been developed to assist the orthostatic posture. These projects, most notably those developed by the companies Noonee [2], are generically referred to as "Chairless Chair". Older projects, such as the chairs designed by Opsvik, developed and available on the market since the 1980s, propose a similar posture, intermediate between the orthostatic and seated posture.

To delineate the useful criteria for defining the posture, we applied the method of comparative analysis. We identified the criteria used in the delimitation of conventional sitting posture and assessed their utility for defining this unconventional posture type. For defining the sitting posture, we created a synopsis of published studies with the following selection elements identified in the keywords: sitting posture plus biomechanics, lumbar lordosis, lumbar discomfort, efficiency, characteristics. The studies highlighted characteristic elements which were subsequently transformed into defining criteria. Applying these same criteria to the unconventional posture allowed us to confirm our working hypothesis.

II. STATIC CRITERION

The criterion offered by the equilibrium condition is useful because, unlike conventional sitting postures, sit-standing postures provide a much stricter ratio between the body segment centers of gravity and the support polygon. The common center of gravity can be determined in the lateral representation plane by summing the centers of gravity of the body segments. It is expected that the common center of gravity is closer to the trunk than in conventional seating situations. This is mainly due to the angle between the thigh and the trunk.

A second particularity of the sit-standing posture is the configuration of the support polygon. In all situations, the footprint of the feet is contained within the support polygon. The posterior extension with support located behind the heel increases the surface area of the support polygon differently, depending on the distance between the heel and the additional contact point.

A third characteristic of balance in the sit-standing posture is the simultaneous accumulation of two conditions: a common center of gravity positioned at a

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higher height than in conventional seated postures, and at the same time, a more restricted support polygon. Hence, it is evident that the balance pyramid is less stable for sit-standing postures compared to conventional ones. This aspect may seem like a disadvantage at first glance, but it is important to note that the orthostatic posture is characterized by an even more precarious balance pyramid without it being an inconvenience for maintaining balance. Being an intermediate posture between standing and sitting, it retains the dynamic characteristics of the former but with the desideratum of relaxing the triple extension chain, as in the case of the latter.

III. MORPHOLOGICAL CRITERION

While the previous criterion was valuable for describing the sit-standing posture from the point of view of balance, the morphological criterion describes the spatial orientation of the body segments, which we can call the geometry of the body segments.

The first morphological characteristic of the sit-standing posture is the verticality of the trunk. Considering the skeletal volume of the thorax and pelvis, we can observe a similarity between their positions in the sit- standing posture and the orthostatic posture (Fig 1. and Fig. 2). The two skeletal volumes have almost identical orientation and inclination to those in standing: the pelvis is in anterior rotation, rotated forward, and the thorax is in posterior tilt, inclined backward. The longitudinal axes of the two skeletal volumes intersect in the abdomen area, retro-umbilical. This characteristic is found in both the orthostatic and sit-standing postures.

A second morphological characteristic is the orientation of the cephalic extremity, which, as in the case of the orthostatic posture, has the Frankfurt horizontal parallel to the ground, for the condition of balanced muscle tone.

A third morphological characteristic is derived from the analysis of the lower limb segments. The thigh is lowered below the horizontal with a variable value depending on the design of the sit-standing device.

The knee flexion angle is greater than in the conventional seated posture, its value also being determined by the design of the sit- standing device. In response to the increased angles of the hip and knee, they are compensated by a smaller dorsiflexion angle of the foot relative to the leg. This dorsiflexion angle of the ankle appears to be a limiting factor for the other two, knee and hip, due to the limited capacity of human subjects to tolerate dorsiflexion values for extended periods (weight loading, edema, advanced age) [3] [4].

Concluding the morphological criterion, we can observe that the region encompassing the pelvis, abdomen, thorax, and cervico-cephalic segment have a superimposable geometry to that of the orthostatic posture, while the lower limb segment offers a succession of alternating angles.

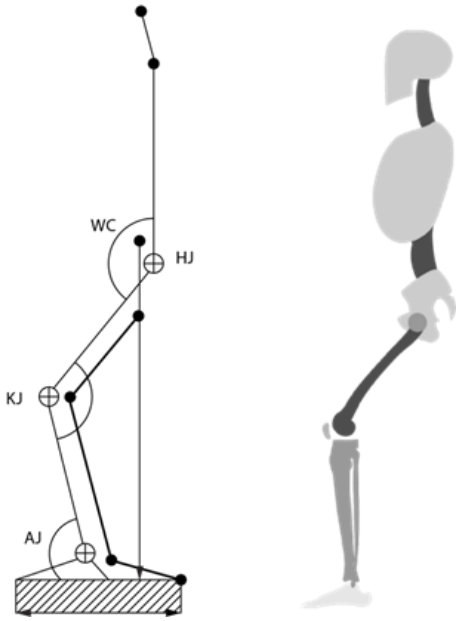

Fig. 1. Schematics of Nonee device

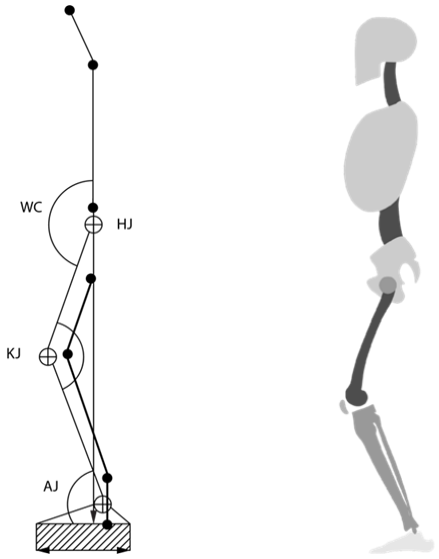

Fig. 2. Schematics of Archelis device

IV. BIOMECHANICAL CRITERION

In both conventional seated and sit-standing postures, the thorax and pelvis form a functional unit whose morphology and conformation are predictable. The thorax and pelvis respond to each other in terms of inclination, with both skeletal volumes being united by the muscle couple of spinal extensors and abdominal muscles.

The functional unit of thorax-pelvis explains why an anterior tilt of the pelvis is accompanied by a posterior tilt of the thorax. This conformation is specific to the orthostatic posture and is sought after in the design of both conventional and unconventional seating instruments. A separate discussion concerns the neutral lumbar spine [5].

This term, without excluding the tilting interplay between the thorax and pelvis, questions whether the orthostatic posture ensures a neutral spine. Regardless, the muscle couple formed between the spinal extensors and abdominals is responsible for the distinct tilting of the thorax and pelvis. In the conventional seated posture, this muscle couple is incapable of spontaneously producing the desired effects: distinct tilting of the thorax and pelvis alongside lumbar lordosis. For this reason, conventional instruments offer lumbar and thoracic support in their design concepts.

These two components represent a constant in the design of conventional seating instruments for any purpose today. The development of unconventional seating instruments, such as kneeling chairs, saddle chairs, and recently sit-standing devices, benefits from liberation from the imperative of lumbar and thoracic support.

The observation that increasing the flexion angle between the thigh and trunk brings the lumbar spine closer to values like those in orthostatic posture and neutral position continues to be a subject of interest for biomechanical explanations, structural conditioning, and the concepts of the most revolutionary sit-standing designs. The muscle couple of spinal extensors and abdominals are not the only ones involved in the biomechanics of the posture [9].

Relative to a thorax fixed to the pelvis, the cervical spine and cephalic extremity find equilibrium through the interplay of neck muscles, the anterior rectus of the head, and sternocleidomastoid muscles. The thigh clearly delineates between conventional and unconventional postures. Increasing the flexion angle between the thigh and trunk can be achieved without engaging the triple extension chain [10 - 14].

In the intermediate sit-standing position, the tonus and activation of this chain are supplemented by various support structures of the unconventional posture. In the case of kneeling chairs, there is support for the knees. In the case of saddle chairs, the inclined seat surface is combined with the horizontal plane of the floor. For sit-standing devices, we encounter blocked knee joint flexion and posterior support for the calcaneal region [6].

In kneeling chairs, saddle chairs, and sit- standing devices, there are solutions to limit ankle, knee, and hip flexion to intermediate values, between orthostatic and conventional seated postures. For devices identified on the market, Noonee and Archelis, ground support behind the heel serves to offload weight borne by the support structure. The weight of the trunk is transferred through a component collinear with the axis of the thigh and another component perpendicular to the same axis, which is borne by the device's support structure. Archelis and Noonee offer containment around the thigh in the form of an exoskeleton. [15].

The exoskeletal structure around the leg supports the weight and transmits it to the ground. The similarity between kneeling chairs, saddle chairs, and sit- standing instruments relates to the increased angle between the thigh and trunk, the transfer of trunk weight through the seat in saddle chairs, through the seat and knee support in kneeling chairs, and through the exoskeleton of the thigh and leg in sit-standing instruments. The exoskeleton of the thigh and leg has a dual role, transmitting the weight of the trunk to each other and blocking knee joint flexion at the specified value [7].

V. FUNCTIONAL CRITERION

The functionality of the seated posture differs in unconventional sit-standing instruments compared to conventional instruments. The term functionality encompasses the relationship between the trunk and upper limbs to the working area and the visual control of work areas and the ambient space [8].

By increasing the flexion angle between the thigh and trunk, the work plane approaches the trunk, especially as the trunk maintains the verticality of the orthostatic posture. This results in a more advanced position of the upper limb origin (scapulohumeral joint).

In contrast to conventional seated posture, where the trunk is often reclined on the backrest, and the visual field is determined by a retracted position of the head, sit-standing postures seem to offer several advantages. The higher and more advanced position of the head allows for much better visual control over the work areas and the depth of the visual field.

VI. PHYSICAL AND FUNCTIONAL CLEARANCE

The difference in body segment geometry generates different dimensions for conventional versus unconventional seating instruments. While the width of seating instruments is determined by the bitrochanteric and possibly bihumeral diameter for both types of seated postures, the depth dimensions differ. For conventional seating instruments, depth is much smaller than the distance between the popliteal space and buttocks (Fig. 3 and Fig. 4).

Functional clearance is also modified by reducing the clearance for the thigh and knee. On the other hand, head clearance is greater for unconventional seating instruments [16]. Changes in physical and functional clearance lead to modifications in the spatial distribution of physical volumes, functional volumes, and traffic spaces.

Thus, transitioning from a conventional seated to a vertical position requires more functional space (moving the chair back, freeing the thighs and knees from clearance limits). Using unconventional seating instruments offers another difference in traffic and interaction spaces, allowing for more efficient organization.

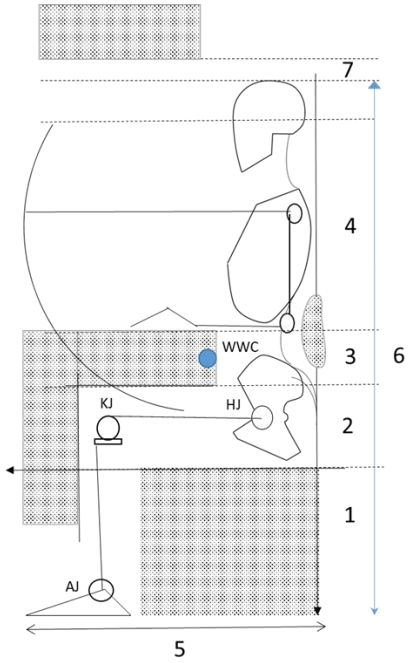

Fig. 3. Siting dimensions
1. Seat Height
2. Thigh Clearance
3. Work Surface Volume
4. Eye Level Height
5. Functional Depth
6. Functional Height
7. Head Clearance

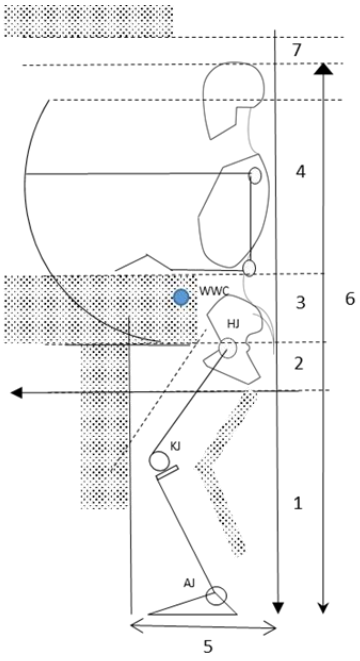

Fig. 4. Standing dimensions
1. Seat Height
2. Thigh Clearance
3. Work Surface Volume
4. Eye Level Height
5. Functional Depth
6. Functional Height
7. Head Clearance

VII. CONCLUSIONS

The utilization of the criteria is valuable for defining the unconventional sit- standing posture. This description can be independent of that of Chairless chair instruments. The importance of defining posture is underscored by the concept of human-centered design. The design solution must be a response to the morphological structure of the human body, rather than the other way around.

The sitting function should naturally align with the human body's biomechanical reality, and the design solution for sitting instruments should conceptually coincide with the structural provisions required to achieve the sitting function.

The definition of posture, as analyzed by Keegan and Grandjean, can be applied to the analysis of a new posture, which we term unconventional. In specialized literature, this posture can also be referred to by other names, as follows:

1. Declined Sitting: "Best Ways to Sit with Lower Back Pain (from an Ergonomist)," Ergonomic Trends, https://ergonomictrends.com/best-ways- to-sit-with-back-pain/, accessed 9 June 2024.
2. Balanced Sitting: "Balanced Sitting Posture on Forward Sloping Seat," A.C. Mandal, MD, http://www.acmandal.com/, accessed 9, June 2024.
3. Semi-kneeling.

Regardless of the type of seated posture, the geometry of body segments and their functional relationship to the supportive structure of the chair and the surrounding space can serve as the instrument for characterization. We consider that this analysis could be furthered by including cultural, aesthetic, and public expectation criteria regarding innovative concepts.

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Corporate Factors Affecting Workplace Health and Safety Performance and Management Decisions. A Literature Review

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Abstract – The environment of companies, especially large companies, is complex and rapidly changing. In addition to the technical and economic conditions that directly influence the operation, the effects of external factors also fundamentally change the operation of companies. The corporate processes affecting occupational health and safety (OHS) have also become complex, and this represents a serious challenge for the managers. Knowing the factors and processes affecting the company's OHS performance is necessary for managerial decisions that improve its effectiveness. The purpose of this work is to delve into the methods companies use to monitor and manage OHS performance. A systematic literature review was conducted of studies published in the field of OHS performance management. This overview provides knowledge about which methods determine the OHS management of companies. The review highlights and discusses performance management strategies and the main difficulties, constraints and challenges managers face in influencing OHS performance. The study concludes that improving OHS performance has become a complex task for medium and large companies. Most of the literature investigating safety performance management focuses on the technical issues of overall measurement. Limited attention is paid to the use of information from the measurement of OHS performance, and to the factors influencing managerial decisions resulting in improved performance.

Keywords: Occupational health and safety; Safety performance; Safety management; Review

I. INTRODUCTION

The European Commission's Strategic Framework on Safety and Health at Work 2021-2027 [1] underlines that the protection of workers' health from risks at work is a key element in achieving sustainable working conditions. In addition, there are also economic arguments in favour of workers' personal well-being. In addition to reducing the costs of workplace accidents, the aim is to ensure a more productive and sustainable business. The role of health and safety at work was highlighted by the Covid-19 pandemic, as workplaces played a key role in managing the pandemic, protecting workers' health and thus ensuring the continuity of activities critical to the functioning of the economy and society. Accordingly, the current EU strategy for health and safety at work aims to maintain and further develop the priority given to health and safety at work.

The regulatory framework developed by the EU and the Member States provides a basis for identifying risks at work and the measures needed to prevent them. Effectiveness is ensured by the tripartite system of occupational safety and health, i.e. the involvement of employers and workers, alongside the state, in the design and implementation of occupational safety and health measures.

The OSH Strategy 2014-2020 [2] focused on the prevention of work-related diseases, the management of demographic change and the implementation of legislation. The strategy for 2021-2027 focuses on ever-faster change and the increasingly complex workplaces that this will bring. Accordingly, while maintaining the priorities of the previous period, it has set three priorities:

- Anticipating and managing the new challenges of sustainability and digitalization, and the changes brought about by demographic change;
- Better prevention of accidents and illnesses at work;
- Preparing for possible future health crises.

Achieving these goals will require active involvement of industry and business, alongside action by the EU and Member States.

The EU's OSH strategy already foresees the concept of Industry 5.0, which will enable the economy to become more environmentally conscious, sustainable and ensure worker well-being through technological change and innovation.

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Reducing the environmental impact of production processes, the transition to green industry requires new trends, new skills, new jobs - in other words, major changes in the workplace. The focus shifts from ownership to stakeholder value, reinforcing the role and contribution of industry to society. Workers' well-being becomes the focus of production activity. It uses new processes and technologies to create well-being in the workplace. It aims to achieve a sustainable, people-centered European industry.

People focus, well-being at work, new technologies, innovation. So many new tasks and challenges for safety and health professionals and managers in companies. Creating safe and healthy workplaces, continuously improving and managing safety and health performance in a context of constant change requires a constant development of professional knowledge and the acquisition and application of competences and experience beyond safety and health expertise. The safety performance of a company is influenced by several factors that challenge managers. Management decisions to improve the effectiveness of health and safety at work require knowledge of these factors.

Several researchers have looked at the factors that influence a company's OSH performance. The key drivers identified by Mohammadi et al. were motivation, company regulations, competencies, safety inputs, resources, working conditions, company culture, employee attitudes, and management systems [3]. According to Pęciłło, organizational factors are the determinants of employees' attitudes and safe behavior towards occupational health and safety. His research shows a strong link between organizational factors and safe worker behavior and risk attitudes [4]. Paul and Maiti have also shown that safety performance is significantly influenced by human factors such as job satisfaction and organizational factors such as regular training or encouraging managerial behavior [5]. Fabiano et al. highlighted the role of behavior, safety attitudes and attitudes towards risk as individual dimensions that influence OSH performance in companies [6]. Among the organizational factors, the role of communication, job stress and motivation were emphasized. Ghahramani [7] underlined the commitment of senior managers to safety and the active involvement and support of employees.

The rapidly changing economic, sociological and technical environment is a constant challenge for business leaders. Knowledge of the corporate information and organizational processes that can inform decisions to improve health and safety at work will determine the effectiveness of any OSH manager's efforts. The world of work is undergoing fundamental changes and these changes affect the conditions for safe working conditions. OSH professionals are faced with new challenges that require preparedness to deal with a rapidly changing industrial and manufacturing environment. Particularly, OSH managers must not only understand and manage the new risks generated by constant change, but also compete for the attention of decision-makers and for the available company resources.

The aim of our study is to review the literature to identify the most recent research and to explore the factors that underpin managerial decision-making to improve OSH performance and influence its effectiveness.

II. METHODOLOGY AND SEARCH CRITERIA

2.1. Preparation of the study

To understand the direction and results of recent research in the field of occupational health and safety management, we examined the publications published in the last 5 years (2018-2023) using the systematic literature review method.

A systematic literature review is a specific method that allows you to identify, select and evaluate all the literature related to a specific research question or topic [8].

2.2. Literature search

A systematic literature search was conducted using the PRISMA protocol. [9] PRISMA stands for "Preferred Reporting Items for Systematic Reviews and Meta-Analyses" and is a generally accepted protocol. PRISMA aims to improve the transparency and scientific merit of a systematic review or meta-analysis. The protocol is also frequently used in literature research in the field of occupational health and safety [10 – 12].

The literature research was conducted between December 2023 and March 2024. A deductive approach was used for the literature review as illustrated in Figure 1. Keywords from 30 previous relevant articles were collected into one document. The keywords were used to create a word cloud using the online word cloud generator software worldclouds.com. The full content of the same article was used to create word clouds per article. The list of words in the resulting word clouds was exported to a csv file using the word cloud software and aggregated. Finally, using the aggregated list, another word cloud was created as shown in Figure 2. The most frequently occurring words were used as search terms.

Word clouding is a commonly used method to display textual data in a graphical format, providing a visual aid for evaluation. They can be used effectively to filter large amounts of text data as a starting point for further analysis [13]. A word cloud is a visual representation of the frequency of words in a text. The more frequently a word appears in the text being analyzed, the larger the word in the generated image. Word clouds can be used as a simple tool to identify the focus of written text [14].

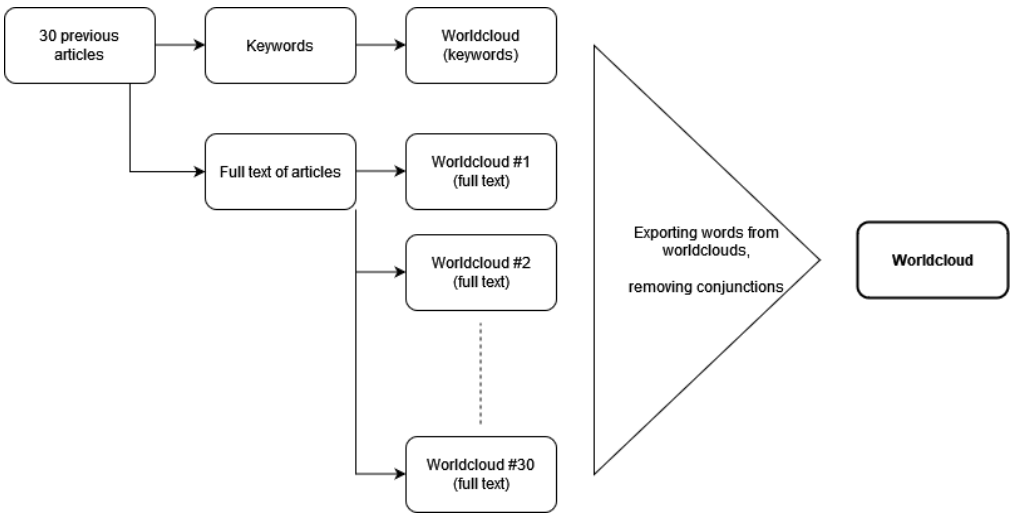

Fig. 1. Deductive approach to defining keywords.
Source: own editing.

Fig. 2. The word cloud of keywords. Source: own editing.

Table 1 Preliminary results

Database	Number of publications
Scopus	731
Web of Science	176
Google Scholar	48

In the text analysis we carried out, the most frequently used words in order of number of occurrences were SAFETY, MANAGEMENT, OCCUPATIONAL and PERFORMANCE.

The search term was created using the keywords found. The filtering was performed on three bibliographic databases, Scopus, Web of Science and Google Scholar. The selection criteria were defined as publications on the topic of occupational safety and health in medium and large enterprises.

The period covered is from 2018 to 2023. We have narrowed the search to articles published in this period to find out the latest research from the scientific community. The bibliographic search is limited to research conducted in medium and large companies in the European Union or the United States. Articles available in full in English were included. After an initial screening of the databases, several hits were received on transport, construction jobs and health care, for which exclusion criteria were set and the screening was repeated.

The search term used in the Scopus database is occupational AND safety AND performance AND management AND NOT construction. Web of Science database term: (Title) AND safety (Title) AND performance (Title) AND management (Title) NOT construction (Title) NOT road (Title) NOT vehicle (TITLE). The results of the preliminary search are shown in Table 1. The literature research process is shown in Figure 3.

2.3 Literature selection, pertinence criteria

In the process of filtering scientific databases, it was inevitable that duplicated publications would appear, as the same document could be indexed into different databases. After excluding duplicates, 924 hits were found. The first matching criterion for these references was determined by analyzing the title, abstract and keywords, filtering out publications that did not cover medium or large company activities or that fell outside the territorial scope. Thus, publications on hospital care, construction and transport were filtered out. The selected publications were analyzed to find new, relevant articles for our study. This selection resulted in 82 hits, which were downloaded for archiving, as the full text of these more relevant articles had to be read.

After reading the full content of the articles, we considered relevant those studies that met the predefined criteria and that contained relevant studies and new research findings related to our research topic. The final analysis resulted in a selection of 49 articles.

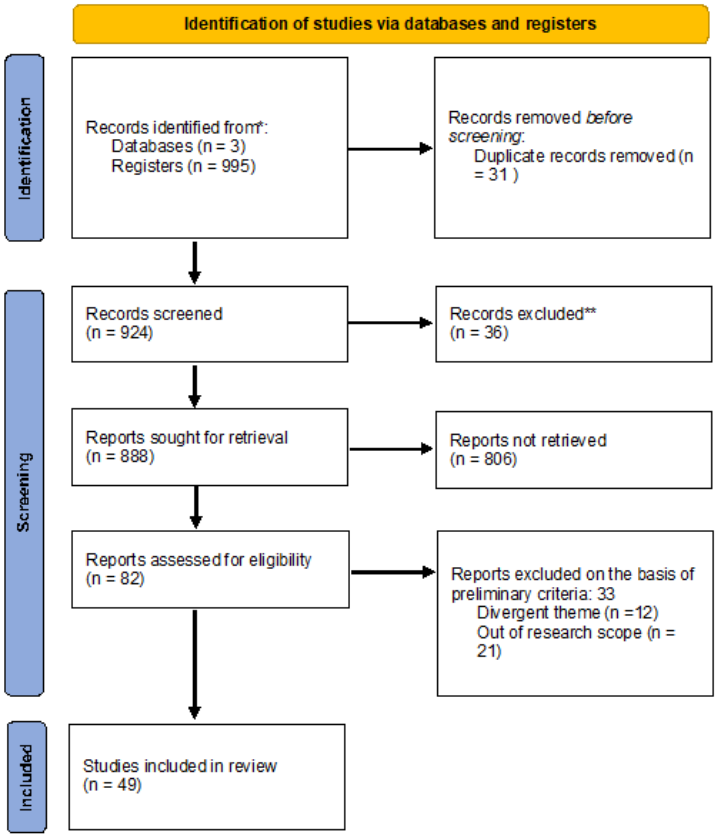

Fig. 3. Flowchart of the systematic literature review.
Source: Own editing based on PRISMA recommendation.

Table 2 Research results examined additional factors affecting safety performance, including corporate culture, organizational factors, accident analysis, safety-related measures, among others

#	Research area	Articles
1	Key performance indicators	10
2	Management systems	8
3	Employees, human factors	6
4	Performance management, performance evaluation	5
5	Leadership behavior	5
6	Risk assessment, risk management	5
7	Corporate culture	4
8	Organizational factors	2
9	Accident analysis	2
10	Safety measures	1
11	Process safety	1

III. RESULTS AND DISCUSSION

3.1. Literature classification

The selected publications were grouped into the categories presented in Table 2, based on the purpose and topic of the study.

Of the publications identified in the literature review, 10 research topics focused on key performance indicators, 8 on OSH management systems, 6 on employees and human factors, 5 on performance management and performance evaluation, 5 publications on management behavior and 5 on risk assessment and management. Further research examined additional factors affecting safety performance, including corporate culture, organizational factors, accident analysis, safety-related measures, among others (Table 2).

3.2. Analysis of the reviewed literature

Johanson et al. on the further development of the conceptual framework for integrated performance management systems [15] aimed at helping to understand performance management systems in organizations. They identified some problems, including the need for coherence between the different system elements, not only in terms of functional and contextual factors, but also in terms of underlying beliefs and values.

The benefits of integrating an occupational health and safety management system into a corporate management system have also been examined in other studies. The results of these studies have shown that integrated performance management is a prerequisite for results- and resource-efficient OHS management [16].

Vidosav et al. also stress the importance of integrating management systems to achieve an organizational approach, to reduce production costs, to make good use of resources, to motivate workers

and to meet the needs of customers and stakeholders [17] and developed an integrated risk management model for standardized management systems.

According to Peter and Genserik, the effectiveness of increasing awareness and proactivity is greatly influenced by approaching the problem from a systems perspective [18]. This offers a way forward in understanding and proactively managing risk, safety and sustainable performance in organizations and ultimately in society.

Blokland proposes systemic organizational culture fit model [19]. By looking at sociotechnical systems from a systems perspective, he shows that mental models guide the behavior of sociotechnical systems and determine their outcomes. This is also the case for individuals who are themselves systems and as such are elements of these socio-technical systems. Individual behaviors are derived from individual perceptions (mental models). These individual behaviors ideally generate the desired outcomes of the system (team/organization/society) and create value.

However, mental models and their associated individual behaviors have undesirable, value-destroying consequences. Therefore, understanding and managing mental models in organizations is of paramount importance for achieving safety and sustainable safe performance. This implies the need to create the necessary mental models in organizations and society that create success, while avoiding or eliminating harmful perceptions and ideas to protect the value created.

Creating and managing mental models involves leadership; leadership skills; and the ability to develop a shared vision, mission and ambition, as this helps to define what is valuable and enables alignment of individual mental models. This enables the development of well-aligned corporate cultures that create and protect value and generate sustainable, secure performance.

After an analysis of performance assessment methods for occupational health and safety management systems, Riascos points to the need to be familiar with the methods and indicators used to effectively use Occupational Health and Safety Management System (OHSMS) to improve safety performance [20].

Johanson and colleagues have been investigating the interaction between the sustainability business model and the internal performance management system [21]. They propose to manage health and safety at work as a key element of the business and to manage its processes within the business processes accordingly. The study concluded that if the performance management system is decoupled from the business model, the long and short-term occupational health and safety benefits and sustainable value propositions for stakeholders will not be realized.

The integration of performance management and risk management at the conceptual level puts a new perspective on the previously competing understandings of performance and risk supporting the idea that risk research and practice can be improved to meet performance needs, and vice versa [22]. An integrated perspective on performance and risk has the potential to create significant innovations in the overall planning and decision making of organizations, for example in corporate performance management or corporate risk management.

Several researchers have questioned the strategies needed for effective risk management, as well as human error, looking at both positive and negative consequences. In this context, Galanti examined risk management in the context of the pandemic COVID-19 emergency [23]. His results confirm what emerges from recent literature that organizations urgently need to create a culture of intelligent risk-taking that leads to learning and better knowledge, and that involves the participation of all employees. It also stresses the benefits of error management training in emergency situations.

A recurring question in OSH management research is whether the adoption of management system standards is related to operational performance. Management system standards have been implemented by hundreds of thousands of companies worldwide, but it remains unclear whether organizations that adopt these standards perform better than others and whether the adoption of these standards improves performance. This question has also been raised in the context of the OHSAS 18001 (Occupational Health and Safety Management System) standard. The results of Viswanathan et al. suggest that the safety performance of companies that adopt the standard is higher than that of companies that do not [24]. However, the direct impact of the implementation of a management system is not clear. The research concludes that the implementation and certification of management systems is more common in companies that are already striving to improve their OSH performance.

Other studies have also shown that certified workplaces perform better than non-certified workplaces in terms of OSH tasks [25]. Madsen et al. concluded that those with certified management systems provide higher levels of occupational health and safety management than those without.

The effects of OHSAS 18001 on relevant occupational health and safety outcomes, such as reducing the number of accidents at work, are under-researched in scientific literature. The impact of this standard on other aspects of performance such as profitability and productivity has received more attention. The results of the study by Heras-Saizarbitoria et al. show that OHSAS 18001 certification is only loosely associated with improved performance in terms of the rate of workplace accidents [26]. They found that the propensity for OHSAS 18001 certification is more specific to economic sectors that show worse performance in terms of workplace accident rates. There is evidence of a negative selection effect of the main international

management standard for occupational health and safety.

Research has shown that there is a significant gap between the accident scenarios predicted by corporate safety management systems and the actual scenarios observed in major accidents. This gap points to flawed risk assessments, leaving hazards unmitigated, compromising the safety of workers, endangering the environment and jeopardising the continuity of the company. Lindhout and colleagues have compiled a literature review on this topic, based on a review of scientific literature, to provide a summary of the published views on how to deal with the problems [27]. Their findings suggest that safety managers who attempt to reduce and eventually close this gap are not only faced with the pitfalls of poor safety studies, but also with the acceptance of "unknown risk" as a phenomenon. They conclude that companies are lulled to sleep by inadequate process safety indicators. This is compounded by the unsettled debate between paradigms for improving process safety in a dynamic industrial environment.

In addition to management systems, research has also focused on the application of performance indicators and the interpretation and use of the information conveyed by indicators.

Caldarescu et al. found a direct correlation between the two types of indicators by examining the relationship between lagging performance indicators and leading performance indicators [28]. They suggested that further studies can be conducted to correctly identify the minimum number and types of performance indicators that can contribute to improving the performance of OSH management.

Walaski [29] also examined the role of lagging and leading indicators and called for a shift to leading indicators.

Vranješ et al. investigated the effectiveness of selecting performance indicators with the help of workers to optimize the management of occupational safety and health [30].

Pera and colleagues proposed a conceptual framework for defining key indicators for measuring safety performance [31]. The aim is to develop a structured pathway for identifying indicators from literature and those widely used by experts for all elements of a management system.

Bayramova et al. based on a literature review of leading indicators [32] found that important elements of leading indicators are invaluable tools. Their application offers organizations the opportunity to track not only past errors and accidents, but also performance indicators that lead to improvements in health and safety at work. Despite their tangible benefits, the definition, application and function of leading indicators are mostly unclear and inconsistent in literature.

Process safety indicators can be used to predict the possibility of major accidents in manufacturing processes. Shmitz et al. have shown that organizational factors have an indirect effect on accident processes by strongly influencing the quality and reliability of safety barriers [33]. Qualitative and quantitative monitoring of organizational factors can provide a picture of their functioning and effectiveness.

Researchers in Norway have developed a method for developing safety indicators based on systems engineering considerations [34]. Traditional approaches use probabilistic risk assessment or linear accident models, which assume that accidents are linear chains of events and do not consider complex system factors and interactions. In their approach, they used the STAMP (System-Theoretic Accident Model and Processes) accident causation model to identify system-specific indicators. The results of their studies show that STAMP-based modelling allows a better understanding of safety systems. The STAMP-based indicator development process helps to focus on specific issues that could lead to a threat. The process considers human and organizational factors as well as technical elements.

Zwetsloot stressed the importance of leading indicators for preventive OSH management [35] in describing the process of developing proactive leading indicators of safety, health and well-being at work. Proactive lead indicators not only serve to better manage and control OSH processes, but also support the development of a preventive culture.

Other researchers have presented a data-driven method for observing the basic functions of security constraints to rule out human interpretation errors. [36] The approach converts process safety performance indicators (PSPIs) into online, globally available safety indicators that eliminate variability in human interpretation.

The management of security, and of security barriers, involves the use of performance information, i.e. the use of security performance indicators. For this information to be useful, the indicators must be of sufficient quality to meet certain predefined quality criteria. Without a good quality demonstration, indicators are generally not able to provide sufficient evidence to support the management of the queue, which can lead to poor decisions. Selvik et al. examined the use of so-called SMART criteria to assess the quality of safety performance indicators in the manufacturing industry [37]. The acronym SMART covers five key aspects and criteria for evaluating the quality of an indicator: 'specificity', 'measurability' or 'manageability', 'achievability', 'relevance' and 'time-based'. The ability of indicators to demonstrate adequate quality by meeting these criteria was discussed. The conclusion is that all SMART criteria must be met for a safety performance indicator to show acceptable quality and be considered useful in supporting barrier management decision making. However, it was also observed that the inclusion of criterion M in the quality assessment is not necessary. If all the other criteria are met, the conclusions should not be misleading because of measurability or manageability considerations.

Therefore, for the quality of safety performance indicators, it is sufficient to assess only four criteria and it was suggested that the acronym should be abbreviated to "STAR".

The European Union's road safety policy is based on the European Directive 2019/1936/EC. Among the safety management procedures and strategies, road safety audits are an effective tool to prevent the risk of accidents and to reduce the frequency and severity of accidents on existing road networks. The European Road Safety Council encourages the extension of these measures to major urban and rural roads through the 5th Road Safety Action Programme. Vaiana et al. carried out a safety benchmarking exercise to identify all road infrastructure features with poor safety conditions [38]. Significant correlation was found between accident frequency/total number of injuries and pavement markings deficiencies.

A demonstrable link between management commitment to health and safety at work and employee satisfaction and safety performance [39]. The results suggest that management commitment to occupational health and safety has a positive impact on employee satisfaction. Employee satisfaction directly and positively affects safety performance. However, no direct relationship was found between management commitment to OSH and safety performance.

Tappura and colleagues found that a commitment to performance measurement promotes its effective use [40]. The use of performance information requires appropriate measurement systems.

However, in day-to-day operations, the management of safety at work is usually sidelined to the operational management. This division between the two areas can be explained by conflicts between the risk-oriented logic of OSH management and the effectiveness of operational management [41]. These conflicts are manifested in differences in objectives, in the rationale behind practices, and in the organization of OHS and operational tasks. The future of safety science requires research into the relationship between the two fields to increase the impact of the OSH field.

Accou and Carpinelli explored the possibility of combining human and organizational factors, combining human and system analysis, to safely and sustainably manage the performance of socio-technical systems [42].

The results of an investigation into the relationship between organizational factors and management performance in occupational safety and health show that organizational factors applied at the firm level have a stronger influence on workers' behavior than organizational factors applied at the individual level [4]. Thus, safety management at the corporate level can be an important practical tool for developing safe behavior and attitudes towards workplace risks in the organization.

Each organization is unique in the way it operates, the training of its employees, its relationships with other organizations, its history, its organizational culture, its relations with regulators. Accordingly, each organization’s workplace safety management has its own strengths and weaknesses. There is therefore no one-size-fits-all approach to improving companies' OSH performance. It must be based on a thorough analysis of the organization concerned, leading to tailor-made solutions. To support such analysis and customization, Stroeve et al. developed the Occupational Health and Safety Management System Maturity Assessment approach in combination with a review of methods for improving the people-related soft aspects of safety management [43].

Homann and colleagues identified the factors that determine and influence the commitment of factory workers to OSH [44]. The main drivers of engagement were:

(a) The safety focus of the company in its organizational and social aspects;
(b) The quality and consistency of safety communication; and
(c) The psychological environment, which includes the relationship between workers and managers.

Of these, the trusting relationship between OSH managers and workers appeared to be the most influential factor in terms of committed safety behavior. The safety focus - communication - environment are closely interrelated and should be considered as a whole, rather than as separate and distinct domains.

Turner and colleagues have examined the extent to which human resource management practices - selection, training, performance appraisal, compensation and empowerment - predict subsequent injury rates at the organizational level [45]. They found that only empowerment predicted subsequent organizational-level injuries. Organizations promoting empowered working had lower injury rates. They conclude that it is worth looking beyond traditional occupational health and safety management systems to understand how more general human resource management practices can help improve workplace safety.

Boczkowska and colleagues proposed a measure of workers' active involvement in OSH, considering the depth and extent of involvement [46].

The direct impact of organizational culture on occupational safety and health has also been identified by other researchers [47]. This finding highlights the key role of organizational culture in shaping and influencing safety and health management practices within an organization. A positive organizational culture can contribute to a safer working environment by promoting a safety culture, encouraging employee involvement and promoting leadership in occupational safety and health. The direct impact of organizational culture on business performance has also been confirmed. This highlights the critical role of organizational culture in shaping overall business performance. The study found that OHS management

has a direct impact on business performance. This finding suggests that effective safety and health management practices can positively impact business performance by reducing workplace accidents, improving employee well-being and optimizing resource utilization.

OSH training and competence has a significant positive impact on worker participation and involvement; while worker participation and involvement have a significant positive impact on worker satisfaction; and safety performance has a significant positive impact on worker satisfaction [48]. Furthermore, it has also been found that employee satisfaction is indirectly affected by safety training and competence through employee participation and involvement.

An examination of the relationship between the maturity of corporate safety culture and employee satisfaction found that overall employee satisfaction with the safety culture is primarily influenced by employee engagement. [49] Employee engagement, in turn, is highly dependent on the commitment of top management, mediated by supervisor commitment and safety training. The correlations identified suggest that the dimensions of individual safety culture should not be developed in isolation, as they are all interrelated. It is also important that mature communication can explicitly support workers' commitment to safety at work without the commitment of supervisors.

Aven emphasizes the importance of integrating safety and risk sciences to further develop concepts, approaches, principles, methods and models for understanding, assessing, communicating and managing system performance [50]. It argues that there is potential to further develop these safety aspects through the integration of risk science knowledge.

Safety and safety management is a key factor in the safety of an organization, and safety management studies have received a lot of attention recently. An analysis has been made of the status and trends in safety management research [51].

Sawhney examined the impact of different safety leadership behaviors on safety motivation [52]. He pointed out that positive leadership behaviors have an impact on safety motivation. In addition, safety attitudes and safety norms mediated the relationship between active safety leadership behaviors and safety motivation. Perceived safety control did not mediate the leadership attitudes-safety motivation relationship in any of the five leadership behaviors.

A similar conclusion was reached by Peker, who with his co-authors examined the motivational effects of the behavior of occupational health and safety officers and managers [53]. Their research results draw attention to the importance of managerial behavior, both in relation to safety motivation and safety results at the organizational level.

A number of security measures, such as security-related rules and security management procedures, are applied to ensure security-related behavior in risky operations. It is reasonable to assume that all these lead to compliance with the rules, but the question is how do they interact? Experiments have shown that some combinations of measures, the interaction of several measures, can have a strong detrimental effect on safety, although overall they have been assumed to reduce risks [54]. In practice, this means that the effects of safety measures depend on their combination and may lead to undesirable effects. It can be argued that unintended adverse effects of a combination of several safety measures may distort the outcome of efforts to reduce workplace incidents and accidents. The definition of OSH management measures should consider the complexity and diversity of safety-related measures at different organizational levels.

Safety mistakes at work can lead to organizational learning. The role of error severity (error attribute) and negative affectivity of a personal trait (personal attribute) in learning from error was examined. [55] The view that fault traits must be severe enough to attract attention was undermined. The severity of error contexts increased both affective learning and cognitive learning. The results suggest that some errors in the workplace, at least those with minor consequences, may not receive much attention and can be easily forgotten. To fully exploit the learning potential and to be effective in preventive safety management, organizations need to pay attention to all errors and take them seriously, regardless of the severity of the immediate consequences of the error.

Incorporating human factors into decision making is a difficult challenge for manufacturing companies because human factors data is difficult to perceive and incorporate into decision making processes. A review of the relevant literature has provided guidance on different methods of measuring human factors, solutions to reduce occupational stress on workers, and the technical options for integrating these measures into a complex industrial decision system. [56] The analysis has shown the main differences between approaches to short-term fatigue, long-term physical strain and psychosocial risks. Long-term physical exertion is the topic that has focused most research efforts, mainly using physical and simulation techniques to highlight physical limitations in the workplace. Short-term fatigue and psychosocial limitations are a growing concern in industry due to new technologies that increase the demands on workers' cognitive activities.

A similar result was confirmed by Norwegian researchers [57]. During the analysis of accidents in the European process industry, it was found that accidents were caused by human factors in addition to process and design errors, mainly deficiencies in the technical and non-technical skills of the workers.

Based on the analysis of the causes of unsafe behaviors leading to serious accidents, a comprehensive approach to improving occupational health and safety performance is that OSH managers

and employers should devote more resources to studying and preventing adverse working conditions and unsafe behaviors among workers, regardless of age group [58].

IV. CONCLUSION

Most of the literature on measuring safety performance focuses on the technical issues of measurement, the effectiveness of the application of an occupational health and safety management system, or the differences between the use of leading and lagging indicators. Limited attention has been paid to the use of information from OSH performance measurement and the factors that influence management decisions leading to improvements in OSH performance. [59], [60]

The literature suggests that the effective use of information can lead to improved organizational performance. OSH experts agree that the OSH performance of companies is related to how well they track, manage and use the information provided by leading indicators. [61] Companies often have a lot of information about safety performance, but how and how effectively they use this data to make decisions is still a question.

The effective use of information from process measurement into tasks can be problematic. This problem is a "knowledge-action" problem, but it can also be described as an information-action problem, i.e. the difficulty of moving from performance measurement to performance management.

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