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New integrated system with "circle economy" impact

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Abstract: *The current study is focused on the development of integrated system for safety production and storage of hydrogen with a potential impact to the "Circle Economy". The possibility of methanol production from diverse waste sources determines its key role in the integrated scheme. The originality of the proposed system is the conversion of the waste sources (different agricultural residues, coal tar pitch from low-rank coals, waste motor oils and polyolefin wax) to activated carbons by suitable technologies. Further, these activated carbons are modified with finely dispersed zinc ferrite nanoparticles. The obtained composites are used as catalysts for hydrogen release from methanol by decomposition. The phase composition, surface functionality, texture and structure features of the catalysts are characterized by X-ray diffraction, Low-temperature nitrogen physisorption, Moessbauer spectroscopy and Boehm method. The possibility for the regulation of the catalyst efficiency by simple selection of the activated carbon waste precursor is demonstrated.*
Keywords*: HYDROGEN PRODUCTION; CIRCLE ECONOMY; WASTE UTILIZATION, ACTIVATED CARBON, CATALYSTS*

1. Introduction

The recent worldwide conventions for development of sustainable and environment-friendly economy clearly declare the need of the replacement of the conventional energy sources by clean and renewable ones with a simultaneous increase of the efficiency of the waste management. Nowadays, both "Hydrogen Economy" and "Circle Economy" reveal great potential in this aspect.

Hydrogen is the most efficient energy vector with zero pollutant emissions [1]. The development of cheap and safety systems for hydrogen storage, transportation and supply is the main challenge for its wide application in the industrial and mobile installations. Hydrogen storage in the form of different liquid compounds seems to be an appropriate way to avoid these troubles. Due to the high H/C ratio, methanol has been considered as the most suitable molecule [2]. Besides, methanol could be produced from different waste, including renewable, sources by well-developed technologies and easily release hydrogen in case of need *via* simple catalytic decomposition [3]. Obviously, the efficiency of this process strongly depends on the activity, selectivity and the price of the catalysts used.

Recently, many efforts have been done to replace the expensive noble metals by alternative transition metal-based catalysts. The development of nanoscale bi-component metal containing systems has been assumed as appropriate approach to increase their catalytic activity not only due to the improved dispersion and enhanced electron transfer between different components, but also, *via* the generation of synergistic effects. Here, ferrite materials with a common formula MFe_2O_4 gain a considerable attention. These compounds possess spinel structure, where the metal ions are in tetrahedral and octahedral coordination by the oxygen ions. The catalytic behaviour of the ferrites could be controlled by variation of the nature and the position of the metal ions in the spinel structure [4]. Among them, $ZnFe_2O_4$ is a normal spinel, where Zn^{2+} ions occupy mainly the tetrahedral sub-lattice, while the Fe^{3+} ions are located in the octahedral positions.

"Circle Economy" is a novel strategy for the elimination of wastes. Its feature potential strongly depends on the development of cost-effective technologies for waste recycling and transformation to valuable functional materials for diverse applications. The production of activated carbon (AC) from waste and low-cost precursors is a reliable way for their utilization. Nowadays, a permanently increasing number of publications related to the development of energy-effective technologies for AC production from various waste precursors are available [5]. Due to the unusual texture porous characteristics and tunable surface functionality, activated carbon has been considered as an appropriate catalyst support. However, nowadays only a few reports on the application of AC from waste sources for catalysts preparation are known.

This paper is aimed at the demonstration of integrated methanol based catalytic system for hydrogen production. Here, both methanol and the catalysts needed for the hydrogen release from it could be produced from waste sources. Particularly, the manuscript is focused on the production of activated carbons with tunable textural and surface characteristics from different waste precursors (agriculture residues, spent motor oil, polyolefin wax, coal tar pitch). Further, they were modified with $ZnFe_2O_4$ and thus obtained composites were tested as catalysts in methanol decomposition to syngas. Different physicochemical techniques such as Nitrogen physisorption, X-ray diffraction, Moessbauer spectroscopy and Boehm method were used for the characterization of the phase composition, texture and surface properties of the obtained AC and their ferrite modifications. The relation between waste precursor composition, activated carbon features and catalytic behavior of its ferrite modification were discussed in details.

2. Experimental

2.1. Activated carbons and catalysts preparation

Activated carbons denoted as ACCS and ACWN were prepared from canning industry residues such as cherry stones and walnut shells, respectively, by one-step hydropyrolysis in a vertical steel reactor (30 g of the precursor, size of 1-3 nm) at 973 K for 1 h.

The activated carbon denoted as ACCF was prepared from a mixture of low-rank coal tar pitch and furfural (1:1) by treatment with concentrated HNO_3. The obtained solid product was heated at 873 K under nitrogen atmosphere. The obtained carbonized material was further submitted to steam activation at 1073 K for 1 h.

Activated carbons denoted as ACPS and ACAR were produced from peach stones and dry aronia residues (both of them waste products from the canning industry), respectively, by two-step procedure of carbonization in nitrogen atmosphere at 823 K for 30 min and further activation with water vapour at 1023 K for 1h.

Activated carbon denoted as ACWP was obtained from a mixture of 60% sawdust (waste product from the wood pellets production) and 40% polymer waste by heating at 600 K and next drop-wise addition of concentrated H_2SO_4. The obtained solid granular product was carbonized by treatment in nitrogen at 873 K for 30 min and then, activated with water vapour at 1123 K for 30 min. Similar procedure was applied for the preparation of ACMF activated carbon, starting from a mixture of spent motor oil and furfural (1:1 wt. ratio).

The activated carbon, denoted as ACPO, was obtained from polyolefin wax (waste product from ethylene production) by heating up to 400 K until melting and further treatment with concentrated H_2SO_4 until solidification. The obtained solid was carbonized at 823 K and then, subjected to water steam activation at 1073 K for 1 h.

The reference KIT-6 mesoporous silica was prepared according to the procedure described in [6].

Thus obtained activated carbons and mesoporous silica were modified by incipient wetness impregnation with methanol solution of $Fe(NO_3)_3.9H_2O$ and $Zn(NO_3)_2.6H_2O$ (total metal content of 8 wt.% and Zn:Fe mol ratio of 1:2) followed by treatment in nitrogen at 773 K for 2 h. The obtained carbon modifications were noted as ZnFe/AC, where AC was the corresponding activated carbon.

2.2. Methods of investigation

The agriculture precursor was subjected to chemical analyses by extraction with toluene-ethanol mixture and sulfuric acid with different concentrations according to the procedure described in [7].

The texture of the obtained materials was studied by low-temperature nitrogen adsorption in a Quantachrome Instruments NOVA 1200e (USA) apparatus. The specific surface area was determined from Brunauer Emmett Teller (BET) equation, the total pore volume was obtained at a relative pressure of 0.99, the micropores volume was elucidated by V-t-method. The mesopore size distribution was made by Non Localized Density Functional Theory (NLDFT) method, using proper models and the micropore size distribution was calculated by the Dubinin-Astakhov method.

The amount of surface oxygen-containing acidic functional groups was determined by Boehm method as was described in [8]. The basic groups were determined by titration with HCl.

Powder X-ray diffraction (XRD) study was performed on a Bruker D8 Advance diffractometer (Bruker AXS GmbH, Germany) with Cu Kα radiation and a LynxEye detector with constant step of 0.02° 2θ and counting time of 17.5 s per step. Mean crystallite size were determined by the Topas-4.2 software.

The Mössbauer spectra at room temperature (RT) and liquid nitrogen temperature (LNT) were recorded by Wissel (Wissenschaftliche Elektronik GmbH, Germany) electromechanical spectrometer working in a constant acceleration mode. A 57Co/Rh (activity ≈ 10 mCi) source and α Fe standard were used. The spectra were fitted using CONFIT2000 software.

The catalytic tests were carried out in a flow type fixed-bed reactor (55 mg of catalyst). Methanol (1.57 kPa) was introduced into the reactor from a saturator, thermo-stated at 273 K using argon as a carrier gas (50 $cm^3.min^{-1}$). On-line gas chromatographic analyses were performed on a SCION 456-GC apparatus equipped with flame ionization and thermoconductivity detectors using PORAPAC-Q column.

3. Results and Discussion

3.1. AC precursor characterization

The chemical analyses of agriculture precursors revealed predominantly presence of lignin, cellulose and holocelulose in different proportions. The cherry stones and walnut shells consisted of significantly high amount of lignin (40-43%), 25-28% of cellulose and 51-55% of holocellulose. The peach stones had slightly lower amount of lignin (37%) and higher portion of cellulose (33%) and holocellulose (59%). The aronia and sawdust residues contained relatively lower portion of lignin (29-30%) and higher amount of cellulose (38-39%) and holocellulose (57-58%). The precursors of ACCF and ACMF represented a mixture of furfural and predominantly condensed aromatic or paraffin hydrocarbons, respectively, while the ACPO precursor was polyethylene with low degree of polymerization.

3.2. Low-Temperature Nitrogen Physisorption

Data for the texture characteristics of the AC and their ferrite modifications, obtained by low-temperature nitrogen physisorption, are listed in Table 1. The nitrogen physisorption isotherms for selected materials are presented in Figure 1a.

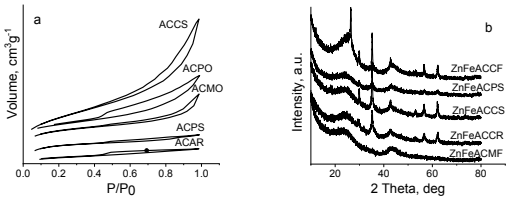

Figure 1 *Nitrogen physisorption isotherms (a) and XRD patterns (b) of selected samples*.

The isotherms of parent carbon materials possessed steep slope at low relative pressure and well-defined hysteresis loop above 0.4 P/P_0, which according to IUPAC classification, indicates mixed I-IV type of porous texture. Co-existence of micro- and mesopores, which proportion varied with the variation in the AC precursor, was observed (Table 1). Extremely high specific surface area and well-developed porosity was achieved when cherry (ACCS) and peach stones (ACPS), walnut shells (ACWN), spent motor oil (ACMO) and polyolefin wax (ACPO) were used as a precursor.

Table 1. *Nitrogen physisorption and XRD data for the parent and ferrite modified activated carbons and reference KIT-6 silica*

Sample	**S_{BET} m^2/g**	**V_t cm^3/g**	**V_{mi} cm^3/g**	**V_{mes}/V_{mic}**	**ΔV_t %**	**ΔS %**	**Phase composition**	**Particle size, nm**
ACCS	1083	1,40	0,16	7,75				
ZnFe/ACCS	569	0,28	0.21	0,33	80	47	spinel	10
ACPS	1258	0,61	0,45	0,36				
ZnFe/ACPS	965	0,46	0,35	0,31	25	23	spinel	7
ACWN	552	0,31	0,18	0,72				
ZnFe/ ACWN	492	0,30	0,20	0,50	3.	11	spinel	15
ACAR	561	0,37	0,23	0,61				
ZnFe/ACAR	447	0,29	0,18	0,61	22	20	spinel	11
ACWP	963	0,71	0,20	2,55				
ZnFe/ACWP	719	0,50	0,18	1,77	25	42	amorphous	-
ACCF	509	0,28	0,22	0,27				
$ZnFe_2O_4$/ACCF	395	0,22	0,18	0,22	21	22	spinel	29
ACMO	1212	0,84	0,39	1,15				
FeZn/ACMO	1118	0,90	0,37	1,43	<0	8	amorphous	-
ACPO	972	0,83	0,26	2,19				
FeZn/ACPO	637	0,35	0,26	0,35	58	34	spinel	12
KIT-6	931	1,29	0,11	10,72				
ZnFe/KIT-6	748	1,04	0,09	10,55	19	20	$Zn_xFe_{3-x}O_4$; α -Fe_2O_3 ZnO	13 11 4-5

With the exception of ACPS, all these activated carbons possessed also significant portion of mesopores. Obviously, the presence of larger portion of lignin in the agriculture precursor facilitates the formation of mesopores, while the micropores are

predominantly developed using a precursor with higher amount of cellulose and holocelulose (ACAR, ACPS). The formation of mesopores was also promoted if polyolefins (ACPO, ACWP) and paraffins were present in the precursor (ACMO), while mainly microporous texture was detected when a precursor consisted of condensed aromatic compounds, such as coal tar pitch (ACCF).

The reference KIT-6 silica sample represented (not shown) well-defined porous texture of well-organized cylindrical mesopores. For this material, negligible amount of micropores were also detected.

After the modification, for most of the activated carbons a significant drop in the specific surface area and total pore volume was found (Table 1). The preservation of the shape of the isotherms reveals absence of significant structural collapse of the activated carbon support. The observed textural changes could be assigned to pore blocking due to the deposition of small metal-containing particles within the pores or nearby their entrances. For the ACCS, ACWP and ACPO based materials this was also combined with significant decrease in the V_{mes}/V_{mic} ratio, indicating predominant deposition of metal particles within the mesopores or nearby their entrances. Just the opposite, the slight variations in the V_{mes}/V_{mic} ratio with a simultaneous significant decrease in the total pore volume and BET surface area for the ACPS and ACCF modifications proposes almost random deposition of the metal phase into the micro- and mesopores of the activated carbon. Note the negligible changes in the textural characteristics of ACWN during the modification, which could be assigned to predominant deposition of particles on the external carbon surface. The observed simultaneous slight increase in the total pore volume and V_{mes}/V_{mic} ratio for the ACMO based sample proposes that the modification procedure initiates formation of additional, predominantly micropores.

For the reference ZnFe/KIT-6, the significant decrease in the total pore volume and BET surface area combined with a negligible change of the V_{mes}/V_{mic} ratio indicate that the modification procedure provides almost random blocking of the micro- and mesopores of the silica support.

3.3. Surface functionality of the activated carbons

Table 2 presents data for the surface functional groups of the activated carbons, elucidated on the base of the Boehm method [8] and by titration with HCl, respectively.

Table 2. *Surface functional groups of pristine activated carbons*

Sample	Surface functional groups, mmol/g					
	Carboxyl	**Lactone**	**Phenol hydroxyl**	**Carbonyl**	**Total acidic groups**	**Total basic groups**
ACCS	BDL	0.18	0,55	0,44	1,17	1,65
ACPS	BDL	BDL	0,29	1,07	1,36	1,04
ACWN	BDL	BDL	BDL	0,54	0,54	0,22
ACAR	BDL	BDL	0,03	0,45	0,48	1,65
ACWP	BDL	BDL	0,40	2,90	3,30	0,70
ACCF	0,01	0,06	0,21	1,36	1,64	0,98
ACMO	0,15	0,80	0,18	0,98	1,96	0,47
ACPO	BDL	BDL	2,25	2,59	4,84	0,78

Surface hydroxyl and carbonyl groups were mainly registered for all AC. Their amount was significant for the carbons obtained from polyolefin wax (ACPO) and sawdust (ACWP). Almost similar portion of these acidic groups was registered for the former material, while carbonyl groups dominated in the latter. The carbonyl groups were mainly detected also in the other activated carbons with the exception of ACCS, where a significant amount of hydroxyl groups was observed. For the carbon obtained from spent motor oil (ACMO) the carbonyl groups co-existed with almost similar portion of lactone groups. The surface acidic functional groups were extremely low for the AC obtained from walnut (ACWN) and aronia (ACAR) residues. For ACWN and ACMO relatively small amount of surface basic groups was also registered.

3.4. X-ray diffraction

The XRD patterns of selected materials are shown in Figure 1b. The broad diffraction peaks at around 22.4º and 43.2º could be assigned to (002) and (101) planes of carbon turbostratic structure. The slightly narrow (002) reflection for ACCF indicates that the condensed aromatic structure of the coal tar pitch precursor provides the formation of AC with higher crystallinity.

The additional reflections at about 30º, 36º, 43º, 53º, 57º, 62º and 74º 2Θ for most of the AC modifications correspond to (220), (311), (222), (400), (422), (511) and (440) planes of $ZnFe_2O_4$ spinel phase with average crystallite size of 10-30 nm (Table 1). These reflections were not observed for the ZnFe/ACWP and ZnFe/ACMO indicating presence of highly dispersed ferrite phase. In the case of the reference ZnFe/KIT-6 small reflections of Fe_2O_3 and ZnO with average crystallite size of 11 and 5 nm, respectively, were also detected, indicating that the long mesopores of the KIT-6 support renders difficult the formation of ferrite phase.

3.5. Moessbauer spectroscopy

The room temperature Moessbauer spectra for all modifications are recorded (not shown) and the values of the isomer shift (IS), quadruple splitting (Δ), hyperfine magnetic field ($B_{hf,}$), line width (G_{exp}) and relative weight of each component (G) are listed in Table 3. The spectra of ZnFe/ACCS, ZnFe/ACAR, ZnFe/ACCF were well fitted with doublets and sextets. The parameters of the sextets, which relative part represented about 15-17 %, could be assigned to Zn-substituted magnetite phase with average particle size above 10-12 nm. This indicates the reduction activity of the AC support during the formation of the ferrite phase. The interpretation of the doublet part in the spectra is more complicated. The Moessbauer spectra collected under the temperature of liquid nitrogen (LNT) indicated that they could be partially assigned to the particles with average size bellow 12 nm, but also to the spinel phase with relatively high amount of Zn-substitution in it. Note, that the spectra of ZnFe/ACPS, ZnFe/ACWP and ZnFe/ACMO contained only doublets, indicating high dispersion of metal oxide phase in them. In case of ZnFe/ACPO, additional sextet with relative weight of 9% and parameters typical of Fe_2O_3 was observed. Obviously, the dispersion and phase composition of the loaded metal oxides depend in a complex way both from the texture and surface characteristics of the AC support. The well-developed microporosity of ACPS and the formation of additional pores during the modification procedure in ACMO promote the production of very finely dispersed spinel particles. The high amount of surface carbonyl groups in ACWP probably regulates the growth of spinel particles into the mesopores by blocking of the micropore entrances. We can propose that the strong interaction of the distinct metal oxide entities with the surface hydroxyl groups of the ACPO renders difficult the interaction between them and provides the formation of separate hematite and ZnO phases.

Table 3. *Parameters of room temperature Moessbauer spectra for Zn-ferrite modified activated carbons and KIT-6 silica. Parameters of Moessbauer spectra collected at liquid nitrogen temperature (LNT) and after the catalytic test (c) for selected samples are also presented.*

Sample	Components	δ, mm/s	Δ,mm/s	B_{hf}, T	Γ_{exp}, mm/s	G, %
ZnFe/ACCS	Sx1-Fe^{3+}_{octa}- $Zn_xFe_{3-x}O_4$	0.33	0.00	39.0	1.00	15
	Db1-Fe^{3+}_{octa}	0.34	0.38	-	0.34	44
	Db2-Fe^{3+}_{octa}	0.34	0.84	-	0.55	41
ZnFe /ACPS	Db - Fe^{3+}_{octa} – $Zn_xFe_{3-x}O_4$	0.35	0.74	-	0.58	100
ZnFe /ACPS (LNT)	Db - Fe^{3+}_{octa} – $Zn_xFe_{3-x}O_4$	0.34	0.74	-	0.55	100
ZnFe/ACWN	Db1-Fe^{3+}_{octa}- $Zn_xFe_{3-x}O_4$	0.35	0.40	-	0.43	52
	Db2-Fe^{3+}	0.33	0.96		0.59	48
ZnFe/ACWN(c)	Sx –Fe_3C	0.13	0.04	20.9	0.45	26
	Db-Fe^{3+}	0.27	0.73	-	0.68	61
	Sn- FeO	1.08	-	-	1.27	13
ZnFe /ACAR	Sx1-Fe^{3+}_{octa}- $Zn_xFe_{3-x}O_4$	0.33	0.00	36.1	1.00	17
	Db1-Fe^{3+}_{octa}	0.34	0.37	-	0.34	43
	Db2-Fe^{3+}_{octa}	0.38	0.79	-	0.75	41
ZnFe /ACWP	Db1-Fe^{3+}_{octa}	0.33	0.54	-	0.36	34
	Db2-Fe^{3+}_{octa}	0.33	0.97	-	0.47	66
ZnFe/ACCF	Sx1- Fe^{3+}_{octa}- $Zn_xFe_{3-x}O_4$	0.32	0.00	47.5	0.41	17
	Db1-Fe^{3+}_{octa}	0.34	0.41	-	0.36	42
	Db2-Fe^{3+}_{octa}	0.33	0.92	-	0.49	41
ZnFe/ACCF (LNT)	Sx1-Fe^{3+}_{tetra} - $ZnxFe_{3-x}O_4$	0.41	0.04	50.5	1.10	14
	Sx2-$Fe^{2,5+}_{octa}$ - $ZnxFe_{3-x}O_4$	0.81	0.04	46.1	0.82	12
	Db1-Fe^{3+}_{octa}	0.34	0.45	-	0.36	33
	Db2-Fe^{3+}_{octa}	0.34	0.83	-	0.52	41
ZnFe/ACMO	Db-Fe^{3+}_{octa}- $Zn_xFe_{3-x}O_4$	0.34	0.80	-	0.54	100
ZnFe /ACPO	Sx1 - Fe3+octa - α-Fe2O3	0.34	-0.10	50.6	0.60	9
	Sx2 - Fe3+tetra - $Zn_xFe_{3-x}O_4$	0.29	0.00	47.9	0.90	13
	Sx3 - Fe2,5+octa -$Zn_xFe_{3-x}O_4$	0.61	0.00	42.6	1.50	18
	Db - Fe3+octa – $Zn_xFe_{3-x}O_4$	0.35	0.67	-	0.68	60
ZnFe /KIT-6	Sx1 - Fe^{3+}_{octa} - α-Fe_2O_3	0.33	0.11	50.4	0.50	15
	Sx2 - Fe^{3+}_{tetra} - $Zn_xFe_{3-x}O_4$	0.30	0.00	46.6	1.00	21
	Sx3 - $Fe^{2,5+}_{octa}$ - $Zn_xFe_{3-x}O_4$	0.64	0.00	43.5	1.20	10
	Db – Fe^{3+}_{octa}	0.34	0.67	-	0.51	54

3.6. Methanol decomposition

All carbon modifications demonstrated catalytic activity in methanol decomposition above 570-600 K, which exceeded about 70-100% at 670-720 K. The highest catalytic activity (Figure 2a) was detected for ZnFe/ACWP and ZnFe/ACMO, followed by ZnFe/ACCS and ZnFe/ACWN.

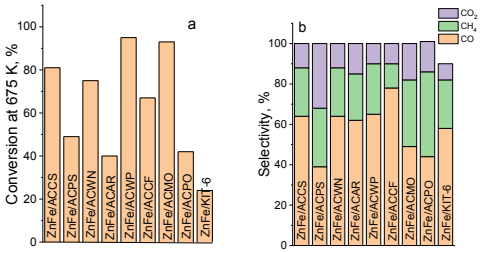

Figure 2. *Methanol conversion at 675K (a) and products distribution at 50% conversion (b).*

For these samples about 50-65 % selectivity to CO and hydrogen was achieved at 50% methanol conversion (Figure 2b). Methane and CO_2 were also detected as by-products. The lowest catalytic activity was observed for ZnFe/ACAR and ZnFe/ACPO as well as for the reference ZnFe/KIT-6. The Moessbauer analyses of the samples after the catalytic test clearly demonstrated reduction transformations of the spinel phase with the formation of FeO and Fe_3C. Considering the data from the physicochemical characterization, the positive impact of the mesopores in the ACWN, ACCS and ACWP could be assumed. This effect is enhanced with the increase of the lignin component in the agriculture precursor (ACCS, ACWN) or by the addition of polymer to the cellulose- and holocellulose-rich one (ACWP). The presence of paraffins and furfural in ACMO precursor promotes the formation of additional pores during the modification, which facilitates the formation of accessible and highly active spinel particles. The domination of micropores in the ACPS, ACAR and ACCF renders difficult the diffusion of the reactants to the blocked in them active spinel species, leading to lower catalytic activity. Similar effect is achieved by the presence of high amount of surface OH groups (ACPO) or long mesopores of KIT-6, which promotes segregation of low-active individual Fe_2O_3 and ZnO phases.

4. Conclusion

Activated carbons produced from diverse waste precursors demonstrate good potential for the development of integrated catalytic system for hydrogen production from waste. The efficiency of the catalysts strongly depends on the texture and surface characteristics of the carbon supports as well as on the reductive phase transformations of the loaded spinel phase under the reaction medium. All these features could be easily controlled by the regulation of the AC waste precursor composition.

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RFID practices as a prerequisite for smart warehousing

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Abstract: *The emergence of Industry 4.0 has led to the development of high-tech solutions that influence a number of related activities. In the field of warehousing management, as an important element of logistics systems, there is also an impact that follows a certain model. Warehousing 4.0 and related developments have to be supported by a number of basic technologies for automatic identification, and technologies that represent intelligent connections to the real world. One of these is the Internet of Things (IoT), which is essentially based on many other solutions, including radiofrequency identification (RFID). The report presents some aspects of the application of RFID in the management of warehousing processes, and also reveals some basic practices of trade and manufacturing enterprises in that field. The study represents the results of a survey focused on warehousing management practices in Bulgaria. The results reveal some fundamental aspects of radiofrequency identification practices as a prerequisite for smart warehousing. The general findings are related to the relatively low and insufficient level of RFID technology usage in the field of warehousing.*

Keywords*: WAREHOUSING 4.0, RFID, IoT*

1. Introduction

Warehousing is an important part of any logistics system. Related activities ensure the efficient movement of material flows in the supply chain. In modern views and under the pressure of strong competition, warehouses seen as an important managerial aspect, and not only as a carrier of costs. An integral element of their successful management is the use of modern information systems and technologies, especially in the context of Industry 4.0, which is associated with a number of technologies based on autonomy, robotics, the Internet of Things (IoT) and cloud technologies [1], and forces for that change are general social, economic, and political changes and technology-push [2]. The technological solutions here are highly connected and they are intelligent to the real world [3]. The development of this topic also reflects and leads to the emergence of the term Logistics 4.0 [4,5] and the same views are inherent. Some aspects of the definition of Logistics 4.0 indicate that it is focused on customer satisfaction with using digital technologies [6].

According to [7], recently terms have appeared such as 'Digital Supply chain', 'Supply Chain 4.0', 'Digital logistics', 'Smart logistics' in theory and practice. Logistics is a dynamic system and consists of many subsystems. Warehouses are one of them [8] and in the context of Logistics 4.0 they are a potential research area [9]. In accordance with the requirements of Industry 4.0, logistics processes are reorganized [10]. This problem has a significant impact on the science and there is growing appearance of research papers for the last several years in scientific research databases. Because of the interrelation between Industry 4.0, Logistics 4.0 and the appearance of Warehousing 4.0 it is possible to confirm the findings of [11] that smart warehousing is related to automated vehicles, augmented reality, and IoT for performing different warehousing processes. Now there is also the appearance of terms focused on single warehousing processes such as Order picking 4.0 [12]. The importance of IoT technology for modern logistics management and supply chain management is pointed out by authors like [11,13–15] as can be seen by reviewing their article reviews. IoT technology encompasses many other technologies and in the literature is presented in different ways. Nevertheless, it is important to note that RFID as automated identification technology is very basic. RFID tags for facilitating routing, inventory management and loss prevention represent an important element of the technology roadmap of IoT [16]. RFID is in the perception layer of the architecture of IoT applications [17]. RFID is also defined as an important part of the intelligent warehouse management system (i-WMS) [18] and also could be used in several energy efficient warehousing practices that are classified by [19], human resources management [20] and omnichannel specifics [21].

2. RFID technology in warehousing

RFID technology has a future in a variety of specific applications. It is hardly possible to list them all because the technology and practice is so vast that its application depends solely on the creativity of its users. It is applicable wherever there are separate material units that may be marked with tags - in procurement, operations and distribution.

Tracking units passing through and their movement [22] is the most well-known and widespread application of the technology. When a unit is tagged, its movement can be tracked. For example, if a pallet has an RFID tag and it is moved from one warehouse area to another, the readers located between the two zones reflect the movement and submit information about it to the information system. The variations of this application are endless - identifying exactly which goods are unloaded from a vehicle to a warehouse, how many and what goods have left the warehouse, at which dock in the warehouse they is located, etc.

In the previous applications the identifications system/reader was stationary, and only the tagged unit was moved. In practice, there are other solutions that use moving identification systems, such as warehousing material handling machines. They have also a real-time data connection with the main server, and this is an opportunity for a more advanced application. Through fast research on the internet for practical solutions it is possible to conclude that the market is growing. The summarized vision for the main elements of an RFID-enabled warehouse are shown in Fig. 1.

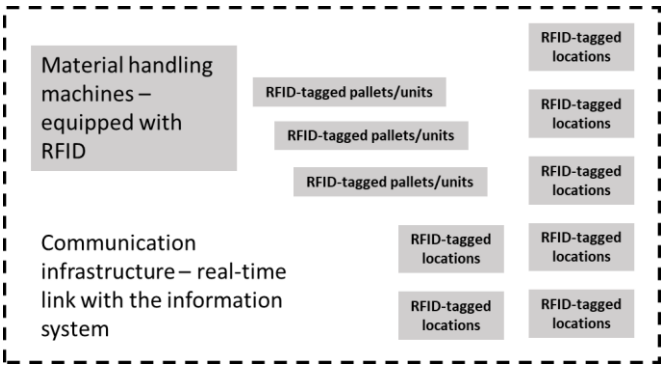

Fig. 1 *Fundamental RFID technology components in warehousing*

Material handling machines are equipped with different RFID readers. Pallets and handling units are tagged, as well as the warehouse locations. There are some solutions on the market where the machines are tagged also. When the operator is receiving a task for moving a certain unit from one place to another he is controlled by the system. The system automatically identifies the loaded units and sends the data to the information system. At this point, if there is a mistake the system takes action and warns the operator to stop,

but if the right unit is taken, the operator receives confirmation to move on. When machine reaches the appropriate rack and unloads the unit, the system identifies the place where the unit was unloaded and if there is an error, sends a warning signal. Using this technology, many mistakes can be avoided.

Stock-taking and asset tracking - This is another application of RFID technology that with a single scan allows the physical location of units in a selected area to be detected. When the electronic tag of a unit in the area of the respective antenna is read, it means that the marked unit is also physically located there. When units have to be located – tags that are in the warehouse area are located that they are within the range of every antenna. The information system then knows the area in which the searched tag is located. This application can also have many variations according to specific warehousing needs. One of the most common is asset tracking. Now these ideas are more developed and there are solutions for RFID inventory control that use drones (unmanned aerial vehicles - UAVs) and their usage is much faster than human operators [23].

3. Some warehousing RFID usage practices in Bulgarian enterprises

The presented research data is a selection from a research project focused on the warehousing practices in Bulgaria. In the current article, only a few aspects of the usage of RFID are included. The research scope is Bulgarian trade and manufacturing enterprises. Data was collected with an electronic questionnaire in 2020. Over 130 responses were received - 58.2% trade and 41.8% manufacturing enterprises that were managing warehousing systems. 28.4% of the respondents were executives in company management/including logistics, 7.5% were in manufacturing departments, 15.7% in marketing-related departments and 23% in logistics. A prerequisite for inclusion in the research sample is that the company should have and manage a warehouse. Outsourcing of warehousing activities to logistics service providers is not covered. Answering all questions in the questionnaire sections was mandatory.

Generally, the usage of information systems and technologies in warehousing was relatively low, and that was expected. Several previous research projects that focused on logistics and supply chain management in Bulgaria revealed that the level of usage of information systems and technologies was low and not adequate for the modern trends and forms of competition. The overall usage of RFID (means 1-5 from Likert scales) – statements related to warehouse employees use RFID scanners, warehouse locations are marked with RFID tags, pallets are marked with RFID tags, warehousing machines are equipped with RFID scanners are presented in Fig. 2.

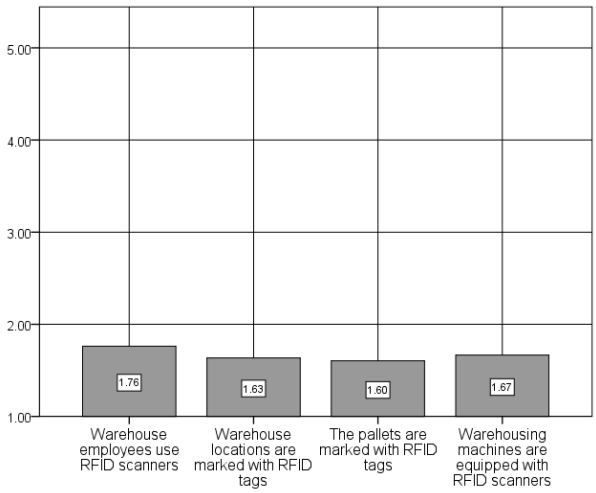

Fig. 2 *Mean scores for statement for usage of RFID in warehousing*

The average results were very low and this means that the usage of RFID in the field of warehousing is unsatisfactory. There is no adequate warehousing infrastructure, and this reflects the low usage of automatic identification alternatives. Maybe the traditional approaches like using barcodes will continue in the coming years until a trigger for innovation appears.

Another overall descriptive indicator is the average self-assessment for RFID usage in warehousing. Answers to the question on the level of implementation of different information systems and technologies such as RFID in the warehouse reveal that at present their average usage is 2.10. The future results for the next three years are more positive and the average results are only 2.84 but the standard deviation in the answers is more than 1.40. When respondents' answers are analyzed by type of business – trade or manufacturing – it is revealed that the trade organizations are more proactive now as regards warehousing innovations, and this is likely to continue in the future. This could be explained by the specifics of their businesses and the intensity of the competition.

Each warehousing process and related activities have significant roles in the efficiency of the whole warehousing system and they are associated with certain costs. The relative importance of each of the processes depends on the specific case, as well as on the specific functions of the warehousing systems in the whole logistics system. The processes for order preparation including unit collection from the warehouse can vary significantly and depend on the specific warehouse needs. The importance of these types of activities is great because they are time-consuming, generate many costs and directly affect the competitiveness of the warehousing system. Depending on the specific warehousing functions, variations in the management of the warehousing processes are observed. However, it is possible to conclude that organization of the warehousing processes follows the movement of material flows, from their entry into the warehouse to their departure. This includes receiving and incoming control; preparation for storage, putting away and storage; preparation of orders; packaging and labeling; departure.

From the logistics management point of view it is more important to focus on the potential processes that can lead to improvement of warehousing systems. In most cases these are the processes related to the preparation of orders, process often called "picking" in English or "kommissionieren" from German. In essence, these are activities related to the collection of products and the preparation of orders, which generate significant part of the total warehousing costs according to [24]. That is why they are an important research and practice topic. They are also a complex of managing process for which there is no defined universal solution. These activities are a consolidating result of other solutions in warehousing and [24] define some of them, like information systems and technologies, the layout design of the warehouse, and storage equipment etc. The organization of these processes is associated with the definition of concepts such as "picking strategies" and "picking methods". Picking strategies define the process in general principles and rules, and the methods are related to the specific methods solution used for picking – paper picking, using labels, barcode scanners, RFID scanners, voice picking, picking guided by light and etc. [24]

That is the reason the picking process is focused on the usage of RFID systems. Research data for the used order picking methods in the warehouses reveals that only 6.2% of all methods are RFID-based and they are usually combined with other solutions. This is a serious difference to global trends. Positive side of the problem is the right focus of the respondents for their future plans for the next 3 years for development for faster order picking the warehouse. More than 27% of them have plans for greater usage of technologies for automatic identification - barcodes or RFID. In more than 50% of cases they have plans for greater usage of material handling machines, software systems upgrade, human resource motivation, and higher wages. In 40.2% of the cases there are plans for partial automation of warehousing processes.

There is no difference between the types of organization (trade or manufacturing) for their answer for the current time. For future plans, there is a difference. Most significant are the more ambitious plans of the trade organizations for process automation, more human resource and a higher level of usage of RFID. For the last the technology share of the trade organizations is 29.5% and only 24.1% for the manufacturing organizations.

3. Conclusions

In conclusion, it can be confirmed that there is insufficient use of information technologies in the field of warehousing in Bulgarian enterprises, especially of the technologies such as RFID that will be so important in the future for logistics. With the appearance of Logistics 4.0 and Warehousing 4.0 concepts, it is clear the future will see modern and highly technological competition. That is why it is necessary for Bulgarian companies to look for fast development in that field and to follow the global practices – a high level of use of information systems and technologies leading to automation of warehousing processes. The initial focus should be on the IoT concept and the related components, especially on RFID systems as a prerequisite for the successful future of smart warehousing.

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Approaches to support learning in today´s workplace

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Abstract: *Workplace learning supports acquiring knowledge and practical skills also to use up-to-date equipment by formal or informal methods and means and occurs mostly in the workplace. It contributes to learning of employees, employers and the organization as a whole. As a response to COVID-19 disease, workplace learning had to be changed. Companies need to consider Industry 4.0 to stay competitive in the market. Among the challenges regarding the transformation towards Industry 4.0 are requirements to re-skill the staff for the new work environment by using digital technologies. The staff has to adapt to the workplace transformation brought by digitalization, automation and robotic. So, learning at the workplace should be changed supporting cost-effective delivery modes, easy to access leaning resources, and flexible learning environments. This paper aims to present first some existing forms, benefits and requirements of workplace learning as well as factors that are impacting the workplace and can support to drive a new approach to workplace learning. Second, some learning methods like interdisciplinary experiential ones, reflection as well lifelong learning (LLL) supported by digital technologies are proposed which can be applied within workplace learning.*
Results about existing approaches in published papers, including the author ones, as well as of projects in this field have been used. Recherche has been done by the Study Group Lifelong Learning of the IAT, coordinated by the author. Finally, the methods described in this paper for workplace learning have been tested within an Erasmus+ project with participation of the author. The results should help managers, education responsible, employees to rethink their whole approach to workplace learning: the culture, tools, methods by adopting a new, modern understanding of what it means to learn at work by using digital technologies. The results should be tested also within other projects because due to changed situation during the Covid-19 and after it not all proposed approaches have been applied in optimal conditions. The factors driving workplace learning and the combination of described learning forms described in the paper have not been applied in this form until now.
Keywords: *WORKPLACE LEARNING, DIGITALIZATION, INDUSTRY 4.0, INTERDISCIPLINARY EXPERIENTIAL LEARNING, REFLECTION, LIFELONG LEARNING*

1. Introduction

Workplace is an important source of learning and workplace learning supports the acquisition of knowledge or skills by different methods and means that occur in the workplace. Due to rapid changes in companies, particularly in connection with COVID-19, digital technologies that have to be used and the need for reskilling people to achieve new knowledge and skills to cope with change; working should be increasingly interconnected with learning.

In the last months, work has changed, and it is not clear how it will return to the way before, in particular if remote working by using digital technologies will be more used in organizations. Digitalization will support this necessity. In this year about 40-50% of staff returned to their work offices and remote training and work will still need to take place. This situation is a great opportunity for companies to re-think their whole approach to learning and development to build and sustain a continuous company learning culture [26]. However, such changes will not happen tonight, and a number of steps are necessary to build this new world of workplace learning. Designing and delivering modern content and learning experiences in line with new ways of digital learning, working with managers to help them to support everyday learning individually and in work teams and groups are necessary [23]. Individuals should be helped to take responsibility for their own continuous self-development also by using lifelong learning supported by digital platforms, aligned with organizational objectives, adapted to the Industry 4.0 requirements and sharing their experiences so that the organization can benefit from it too.

In this presentation, first some existing forms, benefits and requirements of workplace learning are described as well as factors that are impacting the workplace and can support to drive a new approach to workplace learning. Second, some learning methods like interdisciplinary experiential ones, reflection as well lifelong learning, supported by digital technologies suitable to Industry 4.0 are proposed, which can be applied within workplace learning. Some of them have been tested by the Study Group Lifelong Learning of the IAT within a European project.

2. Workplace learning

Workplace learning takes place often within work-related interactions contributing to the learning of employees, employers and the organization as a whole [6]. Michael M. Lombardo and Robert W. Eichinger model of learning shows that 70% of own learning comes from working on-the-job or from own experiences at the workplace, 20% of learning comes from observing, being coached and mentored by others, while 10% of learning comes from attending classes or formal learning programs (https://trainingindustry.com/wiki/content-development/the-702010-model-for-learning-and-development/).

Workplace learning is most informal and is often incorporated into workplace social interactions and everyday practices, but it can include also formal elements [25]. Formally qualifications can be acquired within learning structure organized for employees, in educational and training institutions and various communities within organizations. Both formal and informal learning may benefit either the organization or the individual or both [7, 23].

Workplace learning has also a ‘culturally bound’, meaning that the skills that an employee learns correspond to the requirements of tasks within the organization [25]. People learn from each other and through finding solutions for their day-to-day problems at the workplace [13, 17, 31]. In-house training organized in companies involve planned learning activities that take place near the job or outside work. Short training courses are organized at the workplace or information and communication approaches that have a learning element. Trainers are usually from the organization itself or from external entities. Taking different learning opportunities at work is a business imperative in order to improve and minimize time for business operations. Self-directed learning, networking, coaching and mentoring are some used forms [32]. Workplace learning takes place also within in-house training sessions and within lifelong learning (LLL) processes.

Lifelong learning is an educational philosophy changing rapidly particularly within digitalization in organizations. People believe that it is not too early or too late to learn, to change attitudes and to be open to new ideas and decisions. In order to survive/be successful due to many technological changes as well as disruptions like this due Covid-19, the existing and future workforce must be engaged, independently or with organizations in which they work, on continuous expansion and deepening of their own knowledge. LLL should be a part of daily life, helping i.e., employees to solve immediate problems, gain an understanding, or practice some specific skills [14]. Younger employees have a different relationship to learning than older generations, instead of asking they google and so they have access to an unlimited knowledge

base. The internet, then, acts as a form of lifelong learning. Companies, who recognize the benefits of training employees continuously, use digital technologies to provide employee lifelong training and make learning in the workplace accessible. Today, many employees no longer want to simply execute. They want to contribute to company development, want to learn. Beyond creating innovative products, many employees see corporations improving people's lives. These are some reasons why lifelong training is so important in workplace learning (https://learning.linkedin.com/resources/workplace-learning-report-2018).

Mentoring is an old approach supporting professional development and is associated with a specific goal in learning or working context aimed at improving performance to do a task in shorter time [8]. Kram [22] gives a theoretical foundation for understanding of mentoring relationships at work. Mentoring could be initiated formally or informally. Baugh and Fagenson-Eland [1] underlines that due to the characteristics of formal programs long term relationships are occur in such programs than in informal mentoring relationships. Scandura and Pellegrini [30] define e-mentoring as "the process of mentoring a protégé (mentee) over the Internet by a mentor usually not physically present at the protégés site or location". This is particularly important during and after the Covid-16 as well as to support the use of digital approaches. Mentoring relationships can be different during different phases of the relationship and evolve through phases that reflect different experiences and patterns of interactions. Both mentor and mentee should feel safe to express their feelings, to take risks and fulfill some requirements. Mentoring offers a number of benefits for workplace learning in companies. Research has shown a positive influence on mentee performance [18, 22]. Mentoring can address i.e., needs for timely, relevant training content, does not require significant personal and cost resources. Some benefits for companies are a quick introduction of new employees and support of integration of staff with special needs. Mentors can help to carry out an analysis in the company including existing knowledge gaps and staff reskills needs. Often companies need to strengthen their current market position before entering international markets with new products or strategies and need help in this transition; mentors can help companies to prepare a new workplace learning plan and guide them in implementing this.

3. Factors driving workplace learning

As a response to COVID-19 disease, workplace learning had to be changed and many usual activities in this context have been postponed or canceled. Taking into consideration the needs for employee's reskilling in order to assure social distancing but also to cope with digital transformation, a new approach to workplace learning is necessary [18, 20]. One factor impacting the workplace learning in this context is digitalization. Microsoft explains "The exponential growth of digital connectivity, devices and information is driving profound changes in the way we work, all around all the world …" (https://www.microsoft.com/en-us/worklab/).

Referring workplace learning terms, it means not only converting classroom training into e-learning – as Microsoft explains. "In order to survive in this world, companies need to rethink everything from culture to tools and environments." Managers and employees need to rethink its whole approach to workplace learning by adopting also a new, modern understanding of what it means to learn at work by using digital technologies under following requirements (https://modernworkplacelearning.com/magazine/5-factors-driving-modern-workplace-learning/):

Changing learning habits

It is known that individuals do not longer rely on being trained as the only way to learn for work, but they learn as they do their work as well through their interactions with colleagues, clients, their manager, a coach or mentor. They use the Web not only to access online courses, but also for resources in different formats, i.e., videos, as well as by building their professional networks of connections from around the world on social networks (like Twitter, LinkedIn). Maturity Learner's Voice report showed that employees like to be in charge of how they learn, with 91% wanting to learn at their own pace and 82% knowing what they need to learn in order to do their job (https://emeraldworks.com/research-and-reports/workplace-learning/learner-voice-part-3). It requires from manager to support employees by using lifelong learning approaches and actively encouraging them to find their other own solutions to their learning and performance problems in the ways that suit them best. This is particularly important also due to:

Multi-generational workplace

Different attitudes to work and learning of each of these generations are already known in particular their use of new technologies. It is not possible to create resources in multiple formats to meet everyone's preferences, but it is necessary to support flexibility and autonomy so that individuals can build their own learning experiences in the way that suits them best. This is important also because of

Exponential information growth

Huge amounts of data are being created every day. Knowledge should be updated, and skills are quickly going out of date. In the past, individuals were trained once to do their jobs and their whole careers. Nowadays job roles became more sophisticated, new technology or procedures were introduced so that training became a continuous requirement to improve people knowledge, skills, and competences. It means not always adopting a new approach for training but recognizing that everyone needs to keep themselves up to date learning and develop new skills and expertise in the ways that best suit them, encouraged and supported by own manager.

Necessity for a Social Ecological Perspective in learning

The social ecological perspective is based on the assumption that many factors from environment come together to create the unique circumstances that shape who people are, seeking to promote the idea that they all are interdependent but must handle society's issues in ways that consider all parts of a functional system (https://courses.lumenlearning.com/sociology/chapter/theoretical-perspectives-on-education/).

Social ecology looks at the changing relationship between different parts of society, the role to play in keeping the system healthy and stable. Applying these principles in workplace learning means people, particularly social workers; they get a better picture of how the system and new digital developments affect different groups of people, particularly these with special needs. So, people are in a better position to change and do their job well.

Understand the significance of lifelong learning

LinkedIn's 2018 Workplace Learning Report showed that continuous learning in the workplace has never been so important for today's workforce (https://learning.linkedin.com/resources/workplace-learning-report-2018). Particularly younger employees are interested in lifelong learning and seek development opportunities at work. They look for jobs that can help them pursue professional growth and development. That is why companies who acknowledge the benefits of training employees and support their individual learning attract them.

4. Some learning approaches in workplace learning and support of digital technologies

Interdisciplinary and experiential approaches are two innovative learning formats, which can be used also in workplace learning. Interdisciplinary approach to education combines two or more disciplines while experiential education provides opportunity to

apply theoretical concepts into practice. The combination of these two learning methods can improve also the workplace learning.

Geertz [15], identifies the boundaries between the two approaches and notes the "more and more we see ourselves surrounded by a vast, almost continuous field of variously intended and diversely constructed works we can order only practically, relationally and as our purposes prompt us". Life is complex and multidimensional so that educational approaches should reflect and respond to this reality. Interdisciplinary approaches to teaching are used within higher education [10, 16], but not much within projects in workplace learning. In an interdisciplinary project, learners from different departments could integrate information from different subject areas; it provides learners with a deeper understanding or solutions from different perspectives. Learners develop an interdisciplinary understanding and try to integrate own work expertise and discipline-specific ways of thinking, which increase cognitive abilities and critical thinking [3].

Experiential learning takes place when a person is involved in an activity, looks back, reflect and evaluates it, determines what was useful or important to remember, uses this information to perform another activity [9, 21]. This process involves learners in experiments and encourages shared experiences, allowing learners to apply acquired knowledge in particular situations. The adaptation and integration of the experiential approach led to an effective learning of participants in different fields including management and entrepreneurship [2]. The four stages of experiential learning theory concrete learning, reflective observation, abstract conceptualization, and active experimentation could be used in workplace learning. The first two stages of the cycle involve achieving experience, the second two focus on transforming an experience. Experiential learning can be digital supported i.e., through a combination of synchronous tools such as a web conference, asynchronous tools such as discussion forums and/or social media for group work, and e-portfolios and multimedia for reporting. Combining traditional training methods and experiential ones engages students and helps them to apply knowledge acquired in the interdisciplinary learning process to real-world situations. Some requirements for efficient experiential learning process are the followings (https://www.abacademies.org/articles/experiential-interdisciplinary-approach-to-teaching-a-case-of-collaboration-between-entrepreneuship-and-media-production-7006.html):

It is necessary that instructor has experience to support the learner doing or performing an activity [11]. This allows the student to apply and practice the knowledge achieved from instructor through an experience i.e., a management project.

Learners must be engaged in a reflection stage, allowing them to process the experience through discussion and analysis, sharing observations about their conclusions [12, 28]. Reflection on the experience is an important exercise in determining what went well, what it needs improvement. The reflection stage provides a basis for the application or conceptualization phase [4, 27].

Learners should have the opportunity to expand their understanding of the applied concepts enforcing their experience through generalizations and applications to other potential experiences [5].

These requirements will allow students to learn during the process to solve problems in the workplace and to experience synthesizing information from multiple perspectives; an interdisciplinary approach and experiential learning should be used together.

5. Digital support of lifelong learning

Digital developments, social distance due to Covid-19 and disruption of education methods encourage the use of digital platforms for lifelong learning – digital lifelong learning. Some important factors at the development of learning materials for digital LL are:

- advantages and problems with digital technologies,
- the attitude and motivation of students towards learning a specific topic,
- digital skills of educators in the use of technology,
- structure of content that need to be adopted, the interaction that occurs between students and teachers, as well as among students [24].

In order to promote the use of digital learning, emphasis should be on technology and also on "experience while using," "inclusion," and other general important factors for the successful acquisition of knowledge. In order to use the benefits of lifelong learning within workplace, it is important not only to connect it with different forms of learning – formal, informal, not formal and to apply digital technologies but to assure for it a practical content easily applied in practice [29].

Digital lifelong learning requires, besides motivation and needs of learners, the right technology i.e., platforms like Learnworlds, Kajabi, Teachable and Thinkific that offer integrative solutions. There are tutorials available for how to create and use online learning platforms effectively for lifelong learning engaging students for technical, marketing and selling aspects. Some lessons while creating an own lifelong digital platform are the following (https://www.forbes.com/sites/jeroenkraaijenbrink/2020/09/04/using-covid-19-as-catalyst-for-lifelong-e-learning/?sh=559043b77e42):

- Focus on an area of expertise
- Facilitate the emergence of an active community
- Assume directed need-driven learning and undirected curiosity-driven learning.
- Facilitate one-time learning and continuous applications.

One value of lifelong learning in workplace learning is the possibility to apply what is learned when it is needed and exploit it when there is an opportunity within work or life. This requires access of employees to useful digital tools, materials and a community that learners can use when they need. Needs, means, environments are important for digital lifelong learning. Covid-19 serves as a strong catalyst for the necessary global reskilling within workplace by using digital lifelong learning. Unfortunately, due to closed education institutions and of some companies as well lack of corresponding research results, the digital lifelong learning could not be used efficiently within the workplace until now. Due to the Covid-19 crisis, this being a recent and ongoing event, future research on digital lifelong learning within workplace learning is necessary. More studies are also needed on teaching and learning innovations that have resulted from the Covid-19 crisis. This includes focusing on different ways employers, instructors have fostered an inclusive digital learning environment and digital tools within workplace learning.

5. Example

Within a European Erasmus+ project, a digital program supported by an interactive digital platform for workplace learning within small and medium sized companies (SMEs), particularly to achieve work necessary research skills and motivate learners to involve in lifelong learning, has been developed and tested [19, 20]. The proposed model involved an interplay between inter organizational, organizational and individual learning at each stage of the project. Interdisciplinary, experiential learning should be tested. It was planned to involve employees working with their peers and external business partners to actively seek business opportunities, actively plan and implement solutions, actively investigate these and actively reflect on the impact of these in professional, social, cultural and economic contexts. Interdisciplinary small teams (3-4 people from different departments of each participant company) had to develop and test an own research project connected with their work and including social ecological aspects. The topics for the projects have been chosen to benefit also the company because SMEs have no

resources for research. Participants should reflect on the findings and learn from these by identifying future opportunities for their own workplace. A mentor from each Erasmus+ partner country having knowledge in experiential learning helped employees in their projects. Discussion forums have been developed for each learning module, supported by mentors. Participants have been helped to use LLL for completing their projects.

A short time after starting the program, some companies have been closed due to the COVID-19 pandemic and experiential planned methods and cooperation established at the beginning have to be adapted. Some of the groups did not continue their work. Five groups from German SMEs (each of 4 people) finished their small projects. Two of the groups considered socio ecological aspects in their projects, employees from all groups were between 25 and 64 years old. Finally, each group developed an e-portfolio of work to allow them to progress own individual careers based on the learnings identified in the Evaluation Map and a Future Research Plan. The Evaluation Map included a detailed assessment of the issue, the drivers for change, input from internal and external stakeholders, key implementation steps taken, and outcomes achieved. Included in this portfolio is a Reflective Learning Journal that is an account of the learning journey through the program. Reflective learning journals provide a place for learners to record observations of occurrences that happen to and around them, as well as the surroundings in which these events occur. Journals enable learners to identify key aspects that are important to them and help learners to use previous learned material. The final stage of reflective cycle, the Action plan, examines anything need to be known and to improve for next time. The e-portfolio, which students developed, is an on-line compilation of materials that exemplifies beliefs, skills, qualifications, education, training and experiences during the project.

The participants appreciated the importance of reflection on research impact and of portfolio development, they could better integrate learnings and work with improved awareness and confidence. They affirmed that reflective practice also helped them to develop lifelong skills like creative thinking skills, cooperation and decision making, encouraged and motivated them in using lifelong learning to finish their research projects.

6. Conclusions

Workplace learning is a mean of improving the skills of employees and enhancing their knowledge formal or informal. Managers, education responsible, employees need to rethink their whole approach to workplace learning by adopting a new, modern understanding to learn at work by using digital technologies. Active learning in the form of experiential interdisciplinary projects make the workplace learning more engaging for instructor, learners, mentors and contribute to develop learners' communication skills, teamwork ability, creativity and critical thinking. The interdisciplinary experiential model implies that learning becomes a process whereby knowledge is created through the transformation of various experiences acquired by learners, instructors, mentors, through the interaction between various parties involved in the educational process. Reflection provides learners with motivation and enjoy the process of learning because they reflect on their thoughts, feelings and emotions Continuous learning in the workplace i.e., within digital lifelong learning has never been so important for today's workforce as now.

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ДИГИТАЛИЗАЦИЯ НА СЧЕТОВОДНАТА ОТЧЕТНОСТ В БЮДЖЕТНИТЕ ПРЕДПРИЯТИЯ В БЪЛГАРИЯ

DIGITALISATION OF PUBLIC SECTOR ACCOUNTING IN BULGARIA

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Abstract: *The aim of this paper is to evaluate the pivotal factors for the digitalisation of public sector accounting in Bulgaria. An academic research regarding the challenges before digitalisation in accounting is observed in the paper. The analysis is concentrated on the specifications of public sector accounting organisation. Several key factors, which hinder the digitalisation of public sector accounting in Bulgaria, have been identified.*
Keywords*: PUBLIC SECTOR ACCOUNTING, DIGITALISATION, PROBLEMS*

1. Увод

Бурното развитие на дигитализацията доведе до трансформация в много индустрии и обществени организации. Използването новите технологии в счетоводната методология променя формата на нейната организация, поставя изисквания към нивото на професионална компетентност и извежда системата за счетоводно-информационно осигуряване на управлението на качествено ново ниво на прозрачност, сигурност, актуалност и ефективност.

Предприятията от публичния сектор[1] също не са извън дигиталната вълна. В бюджетните организации в нашата страна широко навлезе компютърното оборудване и прилагането на различни компютърни счетоводни програми, с помощта на които се създава, извлича и преобразува отчетна информация. Дигитализацията обаче съвсем не се изчерпва със счетоводните програмни продукти. Все още не се използват възможностите на новите дигитални технологии като блокчейн, облачни технологии, изкуствен интелект, големи масиви от данни и др.

Целта на настоящата статия е да се изследват основните проблеми, съпровождащи счетоводната дигитализация в предприятията от публичния сектор (ПС). За тази цел работата е разделена на три основни секции: първата е посветена на особеностите на дигитализацията на счетоводството. Във втората част се извеждат основните специфики в организацията на счетоводството в ПС в България. В последната, трета част се очертават някои проблеми пред дигитализацията на счетоводството в бюджетните предприятия.

2. Дигитализация на счетоводството

Най-често дигитализацията на счетоводството се свързва с въвеждането на широк спектър от технологии и системи за създаване, представяне и предаване на счетоводна информация в електронен формат. [1] [2] Компютрите и счетоводният софтуер трансформираха счетоводната работа. В исторически план, счетоводителите са едни от първите специалисти, които внедряват електронните таблици в практиките си, и адаптират работата си към новите технологии. [3] Технологичният напредък подобри способността на счетоводителя не само да отчита, но и интерпретира информацията по-бързо и по-ефективно от всякога [4]. В резултат на това се повиши качеството на счетоводно- информационното осигуряване на управлението на всички нива, обединени от единна цифрова платформа.

Проучване на KPMG сред главните счетоводители на 146 немски дружества показва кои дигитални решения вече са въведени в счетоводната работа или предстои въвеждането им в близко бъдеще: водена на счетоводство без хартия, т.е. дигитализация на всички документи; връзка на информационните системи на компанията с външни такива; управление на качеството на данните – периодично валидиране на данните; автоматизация на процесите – внедряване на най-новите технологии за автоматизиране на рутинните процеси; еднаквост на системите –счетоводните системи са уеднаквени; разработена и прилагана консолидационна система, която осигурява пряк достъп към всички подразделения; отчетност в реално време; прозрачност; анализ на големи бази от данни; визуализация –графично онагледяване на резултатите от анализ на данни; облачни технологии. [5]

Изброените възможности за дигитализация на счетоводството позволяват обобщаване събиране, групиране и подреждане на информационните потоци в реално време. Увеличаване на начините за обмен на информация, както и интегрирането на всички видове отчетност за създаване на единна информационна база, което спомага за постигането на по-голяма аналитичност. Бързият достъп до информация, съкращаването на интервала между получаването и въвеждането ѝ в базата данни дават възможност за постигане на гъвкавост. Намаляването на рисковете от грешки при създаването на счетоводната информация спомага за повишаване на качеството на информацията във финансовите отчети, прецизността в процесите на вземане на решения и ефективен контрол.

Дигитализацията на счетоводството е възможна при синергия на новите концепции за обработка и предаване на информация и новите компетенции, знания и умения на счетоводителите. Статия на Международната федерация на счетоводителите (International Federation of Accountants, IFAC) посочва, че цифровизацията на счетоводството изисква от служителите да развиват специфични знания и умения, които редовно трябва да бъдат обновявани в хода на развитие на дигиталните технологии. [6]

Според Института на професионалните счетоводители на Канада (Chartered Professional Accountants) и IFAC в компанията трябва да съществува верига на стойността в управлението на информацията, която включва пътя от първоначалното създаване на данните, преминава към тяхното преобразуване, анализ и представяне и завършва с нейното безопасно съхранение. Авторите подчертават, че е анализа и представянето на информацията трябва да позволява на потребителите да я осмислят и да могат да вземат информирани решения на нейна основа. В тази връзка се открояват четири важни роли на счетоводителите, а именно – инженер на данните, контролиращ данните, изследовател на данните и стратегически съветник. [7]

Следователно, дигитализацията изисква от счетоводителите днес не само знания и умения за работа с новите технологии и системи, но също и способност да оценяват и преобразуват счетоводната информация, да интегрират към нея нефинансова информация, за да могат да мотивират алтернативни възможности за използването на ресурсите, както и стратегически предложения. В този смисъл дигитализацията на

[1] За целта на настоящата статия понятията „бюджетни предприятия“, „бюджетни организации“ и „предприятия от публичния сектор“ се възприемат като синоними.

счетоводството е комбинацията от технологични иновации и счетоводни компетенции.

3. Специфики в организацията на счетоводството в бюджетните предприятия

Промените в областта на счетоводното отчитане в бюджетните предприятия в България, започнали от началото на новото хилядолетие, са един от важните елементи на реформите в публичното управление. Началото е положено през 1999 г., в отговор на поетите от България ангажименти, в хода на преговорния процес за присъединяване към Европейския съюз (ЕС), за подобряване управлението на бюджетните ресурси, укрепване на бюджетната дисциплина и увеличаване на прозрачността при планирането, изпълнението и отчитането на държавния бюджет.

Основната специфика в счетоводното отчитане на дейността на бюджетните предприятия се определя от информационните потребности на основните групи ползватели на тази информация. На първо място, счетоводната информация се използва за целите на макроикономическия и фискалния анализ, като е необходимо съгласуване на счетоводните данни и показатели с тези на системата от национални сметки, паричния отчет на банковата система и платежния баланс. От друга страна все повече внимание се насочва от обществеността към дейността на бюджетните компании и разходването от тях на публични средства. Последното предопределя и нарастващата роля на отчетността на тези предприятия за задоволяване информационните потребности на обществото. Не на последно място, информацията се използва и за задоволяване на информационните потребности на управлението на бюджетното предприятие. За ръководителите на тези организации не е достатъчно да следват утвърдения бюджет и да се стремят да не излизат от неговите рамки. В условията на новия публичен мениджмънт, чиято основна цел е „преобразуване на държавните органи и тяхната администрация в гъвкави, адаптивни и самообучаващи се организации, използващи ефективно публичните ресурси, с оглед генерирането на повече ползи за обществото“ [8], ръководителите на бюджетните предприятия имат потребност от уместна информация за целите на вземане на конкретни решения, свързани с управлението на отделни проекти и изпълнението на конкретни политики.

Счетоводното отчитане на дейността на бюджетните предприятия се базира на Закона за счетоводството (ЗС) и Закона за публичните финанси (ЗПФ). Съгласно чл. 164. ал. 1. от ЗПФ, министърът на финансите утвърждава счетоводни стандарти и сметкоплан и издава указания, свързани с отчетността, които следва да са в съответствие със: 1. изискванията на ЕС за отчетността, статистиката и бюджетирането на ПС; 2. счетоводната рамка, принципите и концепциите на Методическото ръководство за държавна финансова статистика, издадено от Международния валутен фонд; 3. международните счетоводни стандарти за публичния сектор (МПСС) на Международната федерация на счетоводителите; 4. изискванията на българското законодателство по отношение на бюджетирането, отчитането на изпълнението на консолидираната фискална програма и управлението и контрола на средствата и разходите на бюджетните организации.

Бюджетните предприятия прилагат сметкоплан, който е задължителен. Те не могат да добавят сметки, извън посочените в сметкоплана. Могат да създават аналитични сметки, според информационните потребности на управлението. Нови синтетични сметки, нови подгрупи, групи и раздели се откриват само с указания от Министерство на финансите (МФ). Сметкопланът на бюджетните организации съдържа повече от 600 сметки.

Съгласно Концептуалната рамка на МССПС, финансовата отчетност с общо предназначение за предприятията от ПС се основава на принципа на начисляването [9]. В същото време съгл. чл. 14, ал. 3 от ЗПФ планирането, изпълнението и отчитането на показателите по консолидираната фискална програма се извършва на касова основа. За целта се прилага Единна бюджетна класификация, която представлява система от принципи, методи и форми на групиране и подреждане на приходите, разходите и източниците на финансиране на бюджетния дефицит по консолидираната фискална програма. [10] Ежегодно министърът на финансите утвърждава единната бюджетна класификация.

През 2004 г. се изготвят указания за прилагането от бюджетните предприятия на Националните счетоводни стандарти, приети с ПМС № 37/2002 г. [11].С указанието се цели приспособяване на съществуващите стандарти към спецификите на бюджетните организации. С указание от 2005 г. министърът на финансите определя, че разпоредбите на ДДС № 20 от 2004 г. продължават да се прилагат за бюджетните предприятия, независимо, че въпросните НСС вече са отменени и сега действат нови счетоводни стандарти. На практика законово установените изисквания за приемането на счетоводни стандарти за ПС не е изпълнено до момента. Липсата им води от една страна до отклонения в редица от фундаменталните счетоводни принципи, залегнали в ЗС и друга – до различно третиране на определени обекти и сделки през различните отчетни периоди. [12] Това поставя под въпрос надеждността на информацията от финансовите отчети на предприятията от ПС. Така потребителите трудно се ориентират в „голямата картина“ показваща целите и стратегиите на бюджетното предприятие и как последното използва ресурсите, получени от данъкоплатците за да ги постигне.

Важна специфика на отчетността в бюджетните предприятия е организирането й в три обособени отчетни групи (*стопански области)* – “Бюджети”, “Сметки за средства от ЕС” и “Други сметки и дейности”. Тези групи от отчетна гледна точка се разглеждат като независими една от друга, въпреки, че идентифицираните по тях активи, пасиви, приходи и разходи са в рамките на едно юридическо лице – бюджетното предприятие. [13]

Това, че бюджетните предприятия трябва да създават информация както на начислена основа за приходите и разходите, така и на касова основа за движението на паричните средства определя и основните компоненти на финансовите им отчети. Бюджетните организации съставят месечни, тримесечни и годишни отчети. Дирекция „Дълг и държавно съкровище“ издава указания с които определя редът, сроковете, процедурите и обхвата на отчетната информация, която да бъде представена в МФ.

На месечна и тримесечна основа изготвят отчети за касовото изпълнение на бюджета, на сметките за средства от Европейския съюз и отчет за операциите и наличностите по сметките за чужди средства, които се представят по параграфите и подпараграфите от ЕБК, както и по агрегирани показатели. На тримесечна основа се представят още отчет за салдата (наличностите) по банкови сметки, оборотните ведомости, както и друга информация, посочена в указанията. Съгласно Заповед ЗМФ-1338/22,12,2015 г. Годишните финансови отчети на бюджетните организации включват: Баланс; Отчет за приходите и разходите; Отчет за касовото изпълнение на бюджета, сметките за средства от ЕС и сметките за чужди средства; Приложение. [14]

Отчетната информация се представя като се използват специални отчетни форми, разработени с помощта на MS Exel. Всяко бюджетно предприятие попълва тези форми и ги изпраща в МФ. От тях се извлича и преобразува информацията, която е необходима за макроикономическата статистика и фискалния анализ. На интернет страниците на бюджетните организации се публикува информация, предназначена за задоволяване информационните потребности на широк кръг потребители. Тя включва освен компонентите на годишния

финансов отчет, посочени в Заповед ЗМФ-1338/22,12,2015 г. още и одитния доклад на Сметната палата.

4. Проблеми пред дигитазлизацията на счетоводството в бюджетните предприятия

Според Dunleavy, за да се случи дигитализацията в ПС е необходимо много повече от технологии, системи и програмни продукти. Необходима е още правителствена стратегия, съсредоточена върху целта за подобряване на ПС. [15] В нашата страна са приети редица документи, с които се цели ускоряване на дигитализацията в икономиката.

С националния стратегически документ „Цифрова трансформация на България за периода 2020-2030 г.“ се определят визията и целите на политиката за цифрова трансформация за периода до 2030 г., като обобщена политическа рамка, в която намират място Националната програма „Цифрова България 2025”, приоритетите на „Националната програма за развитие БЪЛГАРИЯ 2030”, както и редица други национални стратегически документи с технологична компонента, обхващащи периода 2020-2030. [16]

В същото време Според Индекса за навлизане на цифровите технологии в икономиката и обществото (DESI) България се нарежда на последното 28 място за 2020 г. [17] Основните предизвикателства пред България са свързани с много ниското ниво на умения в областта на цифровите технологии у населението и ниското ниво на внедряване на такива технологии в стопанската дейност, включително и в бюджетните предприятия.

В областта на счетоводството в ПС, дигитализацията се свежда до използване на счетоводен софтуер и MS Exel за представяне на изискуемата информация към МФ. Направен преглед на по-широко прилаганите програмни продукти в сферата на бюджетното счетоводство разкрива, че повечето от тях не отговарят на нуждите на бюджетните предприятия за изготвяне на специфичните им отчети и допълнителната информация, която се изисква от МФ. [18] Тъй като повечето от тях не са специално разработени за бюджетните организации те не предлагат и необходимата гъвкавост за информационно осигуряване на управлението на самото предприятия. Както беше подчертано по-горе през последните години нараства значението и интересът от страна на обществото към дейността, отчетността и управлението на бюджетните предприятия. Ясно е, че само счетоводният софтуер не може да доведе до задоволяване на такъв широк кръг от информационни потребности. Проучване на PWC ясно показва, че ерата на Excel в счетоводството и финансите бързо приключва. [19] Дигитализацията позволява внедряване на инструменти за комплексно информационно осигуряване. И не само. Тя позволява свързаност между отделните бюджетни предприятия и МФ, данъчните служби, сметната палата и други важни структури в реално време. За да се постигне това обаче е необходима стратегия на национално ниво за въвеждане на подходящи дигитални решения в ПС, които разбира се засягат и счетоводните процеси. Посочените по-горе документи са твърде общи.

Отсъствието на държавна стратегия относно конкретното дигитално решение е само едната страна на монетата. Като причина за забавянето във въвеждането на дигитализацията в счетоводството в ПС виждаме и незавършилата, по наше мнение, реформа в областта на счетоводното отчитане. Липсата на стандартизация е сериозен недостатък на сега съществуващия модел, което силно влияе върху качеството на създаваната счетоводна информация. Практиката, счетоводното отчитане на дейността на бюджетните предприятия да се базира на указания, издавани от МФ е изключително неуместна. Получаваните готови схеми могат да се прилагат само при конкретни условия и обстоятелства. В случай, че последните се променят, трябва да се чакат нови указания. Ефектите от това са както върху качеството на финансовите отчети, така и върху възможностите за адекватно информационно осигуряване на управлението на конкретното бюджетно предприятие. Считаме, че така се създават условия, компрометиращи ПС в способността му да създаде сигурност, че ограничените ресурси се използват икономично, ефективно и ефикасно.

Друго съществено предизвикателство пред дигитализацията в ПС е липсата на разбиране за това как могат да се използват съвременните дигитални технологии в помощ на счетоводната работа. Институтът по публична администрация публикува през 2016 г. „Сборник с добри практики от дейността на администрациите“, в който са описани примери за оптимизиране на работните процеси на различни публични институции. [20] За съжаление нито един пример не засяга счетоводни процеси. Много от последните могат лесно да бъдат напълно дигитализирани, като на пазара съществуват решения за постигането им.

Голямо предизвикателство също е нивото на цифрови умения на работещите в публичната сфера. Цитираният по-горе документ DESI показва, че лицата, които притежават поне основни цифрови умения възлизат на 29% от възрастното население в сравнение със средно 58% за ЕС, докато само 11% притежават умения над средното равнище (малко под една трета от средната стойност за ЕС). Според Световния Доклад за Конкуренция 2017-2018 на Световния Икономически Форум, България е на 39-то място (от общо 137 държави) в перо *Технологична готовност*. Що се отнася до обученията на служители, България е на 118-то място. [21] Данните красноречиво показват, че България е изправена пред сериозни предизвикателства по отношение на използването на дигиталните технологии.

Наред с ниското равнище на цифрови умения, средно за страната в публичния сектор кандидатстват по-малко млади хора, в сравнение с частния сектор. Това е много осезаемо в по-малките общини. Това е предпоставка счетоводителите да предпочитат традиционните софтуерни решения, с които вече са свикнали да работят и не са склонни към нововъведения.

Проблем пред дигитализацията е сложната организация на ПС. Това води до повишена организационна комплицираност, съчетана с голям брой потребители при въвеждането на дигитални решения. Също така риск има и по отношение на властовата система, което затруднява последователното лидерство. В ПС мениджърите от висше ниво, т.е. политически назначени лица, са по-малко склонни към въвеждането на нови информационни технологии, отколкото мениджърите на средно ниво. [22]

Като сериозно предизвикателство отбелязваме липсата на достатъчно средства за започване на една такава широкомащабна реформа в областта на публичното управление. Планирането на инвестициите в дигитални технологии в ПС често се подчинява на политическата ориентация към конкретния момент и затова е ориентирано предимно в краткосрочен план. Ръководителите на отделните бюджетни предприятия също са твърде ограничени от средствата с които разполагат, за да започнат по-сериозна автоматизация на счетоводните процеси. Осигуряването на достатъчно финансови ресурси вероятно ще е факт с приемането на стратегия за реформа и дигитализация.

С изброеното не се изчерпват проблемите пред дигитализацията на счетоводството в ПС. Светът обаче става все по-дигитален и дигитализацията навлиза все повече в ежедневието. Така и счетоводството в ПС в нашата страна не може да остане дълго време извън тези процеси. Дигитализацията в счетоводството ще нараства в бъдеще, тъй като използването на новите технологии позволява решаване на нови проблеми, модернизиране на концепциите за обработка и предаване на информация и допринася за повишаване на ефективността на счетоводните процеси.

5. Заключение

Дигиталните технологии коренно трансформират начина, по който работят организациите, както в публичния, така и в частния сектор. Дигитализацията на счетоводството в ПС в България се свежда основно до използването на счетоводен софтуер. Не се използват съвременните нови дигитални решения, които са в състояние да променят коренно както работата на счетоводителя, така и да подобрят счетоводно информационното осигуряване на всички управленски нива и на обществото. Основните предизвикателства пред дигитализацията на счетоводството са резултат от липсата на държавна стратегия, която засяга не само технологичните и организационни аспекти на процеса, но също така и развитието на отчетността в публичния сектор. Сред другите важни предизвикателства се нареждат непознаването на възможностите, които предоставят новите информационни технологии, ниската степен на цифрови умения у работещите и липсата на достатъчно финансов ресурс.

6. Литература

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Влияние на електромагнитното поле, генерирано от смартфон, върху мозъчната активност на човек

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Резюме: *По време на работа мобилните телефони излъчват енергия под формата на електромагнитни полета, които взаимодействат с органите в главата на потребителя. Съществуват множество изследвания, даващи противоречиви резултати за ефектите на този вид електромагнитна енергия върху здравето на човек. Настоящата статия има за цел да определи дали радиочестотните импулсни експозиции от мобилни телефони могат да повлияят на мозъчната активност на човек. За тази цел е изследвано влиянието на експозицията на работещ мобилен телефон върху нервната реакция на човек чрез анализ на електрофизиологични измервания на активността на мозъчните вълни. Тестовите измервания на електроенцефалограмата (ЕЕГ) на участниците в експеримента са проведени при наличие и при липса на работещ мобилен телефон.*

Ключови думи: *електромагнитно поле, електроенцефалограма, физиология на човека*

1. Въведение

Хората живеят и работят в среда от естествени и изкуствени електромагнитни полета [1]. Човешкото тяло може да се разглежда като електромагнитна система на клетъчно ниво. То се е приспособило към въздействието на естествените електромагнитни полета на Земята, Луната и Слънцето. През последните десетилетия броят на източниците на изкуствени електромагнитни полета нараства [2]. Увеличава се и честотният диапазон на работа на тези устройства. Влиянието на всички заобикалящи ни електромагнитни полета зависи от честотния диапазон на излъчваните сигнали, времето на облъчване и мощността на сигнала. Дистанцията от предавателя до човека е от съществено значение за мощността на електромагнитното поле. От всички източници на електромагнитна радиация като че ли най-опасни за здравето на човека са мобилните телефони, които са неразделна част от нашия живот [3-5]. Ако преди няколко десетилетия този вид устройства се използваха предимно от възрастните хора по няколко минути на ден, в днешно време ситуацията е доста различна. Съвременните деца притежават мобилни смарт апарати, които използват часове наред както за комуникация, така и за забавления или за учене по време на пандемията от COVID-19 [6]. Притеснителното в този вид устройства е, че те са много близо до тялото на човек и честотата на употреба е ежедневна и продължителна. Мобилният телефон е генератор на електромагнитни полета, които денонощно облъчват най-важните органи като мозъка, сърцето или интимните части на тялото.

Все още не е определено дали експозицията на мобилен телефон може да причини някакви биологични промени и ефекти, които да доведат до неблагоприятни последици за здравето при хората. На разстояние 1 см от главата на потребителя мобилните телефони могат да излъчват радиочестотни импулсни сигнали в обхвата от 410 MHz до 52 600 MHz при специфична скорост на абсорбция на енергия (SARs) неповече от 2 W/kg, което е общоприето обществено ограничение. В момента честотният диапазон на мобилните телефони е твърде висок, за да предизвика възбуждане на клетките (срещащи се при честоти <100 KHz) и съответно нивата на SAR са сравнително ниски, за да се получи значително нагряване на тъканите, които могат да причинят временна мозъчна дисфункция, като например намалена производителност или решаване на ежедневни задачи. Понастоящем не е изяснено или не се дава ясна и точна информация дали експозициите на мобилни телефони причиняват биологични ефекти [7]. Производителите на смарт устройства обикновено споменават, че нивото на генерираните електромагнитни полета от техните устройства са ниски и това по никакъв начин не засяга човека, използващ устройството. За потвърждаване на тези твърдения устройствата на компаниите се сертифицират и стандартизират.

Едни от най-вредните за човешкото тяло електромагнитни излъчвания, от гледна точка на организма, са високочестотните излъчвания от сантиметровия диапазон. Мобилните комуникации са в самото начало на този диапазон, но той непрекъснато се увеличава. Съществуват много и различни проучвания за установяване на влиянието на излъчваното електромагнитно поле от заобикалящите ни смарт устройства върху различни биологични функции на човешкото тяло. Електромагнитните полета от радиочестотния диапазон могат да причинят неблагоприятни състояния на централната нервна система и сърдечно-съдовата система [8-10]. Установени са ефекти от преумора и превъзбуда на човек от прекомерното използване на безжични смарт устройства [11-13].

Микровълновото лъчение, генерирано от мобилните телефони, предизвиква загряване на човешкото тяло, което може да се охлади от кръвоносната система [14, 15]. Проблем съществува, когато даден орган като лещата на окото, не съдържа кръвоносни съдове и не може да се охлади, което може да доведе до увреждане на лещата. Тези промени са необратими.

Съществуват много и различни изследвания на влиянието на електромагнитните вълни върху биологичното състояние на човека. Част от изследванията се провеждат от телекомуникационни компании, които имат корпоративни интереси, което поставя под съмнение достоверността на резултатите. Настоящото изследване не е обвързано с телекомуникационни компании и претендира за научна обективност.

Последните статистически данни показват, че броят на потребителите на мобилни телефони в световен мащаб непрекъснато се увеличава и цялостната оценка на риска за здравето от използването на мобилни устройства е от решаващо значение.

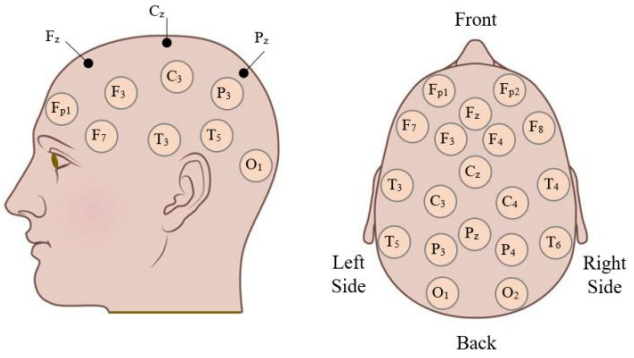
Един от основните въпроси, предмет на настоящия анализ, е изследване на влиянието на електромагнитните полета (ЕМП), генерирани от мобилни телефони, върху мозъчната активност на човек по време на използването на мобилен телефон. Направено е сравнение между резултати, получени по време на използване на мобилен телефон и преди използването му.

Получените записи на ЕЕГ сигнали са обработени във времевата и честотна област и са анализирани с помощта на t-тест за свързани извадки (paired sample t-test).

2. Енцефалография

Изследването на активността на мозъка на човек се осъществява с помощта на енцефалография [8]. Този метод се основава на регистрацията на сумарната електрическа активност на главния мозък, отведена до повърхността на главата – електроенцефалограма (ЕЕГ). Енцефалограмата позволява да се прави както качествен, така и количествен анализ на функционирането на главния мозък на човек. Записите на ЕЕГ сигналите се използват широко в диагностиката и лечението на хората (най-често при епилепсия), в анестезиологията, също при изучаване на дейностите на мозъка като възприятие, памет, адаптация и др.

Регистрацията на ЕЕГ се осъществява с помощта на електроди, закрепени за повърхността на кожата на главата, които чрез проводник пренасят в усилвателя биопотенциалите – електроенцефалограма (фиг. 1).



Фиг. 1 *Позиция и име на електродите, използвани при енцефалограма от международната система 10-20*

За получаването на качествен запис на ЕЕГ без наличието на артефакти (шумове и смущения) е необходимо в хода на изследването пациентът да се намира в удобно кресло с намалена възможност за движение на главата и тялото. Също така е необходимо да се минимизира влиянието на външни светлинни или звукови дразнители. При попадане на артефакти в електроенцефалограмата е необходимо те да се филтрират [16].

ЕЕГ активността на мозъка представлява съвкупност от вълни с приблизително постоянни честоти, наречени *ритми*.

Преобладаващите ЕЕГ ритми се наричат *доминиращи*. Намаляването на амплитудата на колебанията без изменение на честотата на сигнала се нарича *депресия* на ритмите. Процесът на формиране на регулярна ритмична активност и увеличаването на амплитудното колебание се нарича *синхронизация* на ритъма. Нарушаването на ритмичността на вълновите процеси на ЕЕГ сигналите с промяна на амплитудата и промяна на честотата се нарича *десинхронизация*.

Обикновено ритмите се разделят на няколко вида според честотния диапазон, в който се намират. Те биват: делта-ритми, тета-ритми, алфа-ритми, бета-ритми и гама-ритми [17-19].

Делта-ритмите се характеризират с честотен диапазон 0.5-4 Hz. В ЕЕГ на здрав възрастен човек в състояние на бодърстване делта-ритмите може да присъстват в много малки количества. Тяхната амплитуда не превишава 40 μV (обикновено е около 20 μV). Делта-ритмите се явяват основен ритъм при сън, когато неговата амплитуда достига до 300 μV и нагоре.

По данни от различни изследвания границите на *тета-ритъма* се различават, но средно се приема с честоти от 4 до 8 Hz. Амплитудата на тези вълни в нормално състояние не превишава 40 μV. Увеличаването на амплитудата на тета-ритъма, от една страна, може да означава патология, а от друга страна – може да е отражение на определено функционално състояние, свързано или с намаляване на активността на мозъка, или с увеличаване на концентрацията, когнитивната и емоционална активност.

Към *алфа-ритмите* се отнася добре модулирана, висока амплитуда (средната амплитуда е 60-80 μV), ритмична активност с честоти в диапазона от 7.5 до 13 Hz. Тези ритми се регистрират в повече от 85% от здравите хора. Преди всичко алфа-ритъмът се отнася за здрави възрастни хора, намиращи се в състояние на спокойно бодърстване при затворени очи, преимуществено в теменно-тилната област на главата.

Депресията на алфа-ритмите свидетелства за обща активация на кората на главния мозък. Отварянето на очите или при умствена активност на човек се съпровожда от депресия на алфа-ритъма. Важна особеност на алфа-активността се явява нейната функционална асиметрия при различни когнитивни и емоционални натоварвания.

Бета-ритъмът има честотен диапазон 13-35 Hz, амплитуда до 15 μV (разделят се на нискочестотни – 13-25 Hz и високочестотни бета-ритми – 25-35 Hz). Тези ритми са добре изразени в челната и темпоралната област. Както синхронизацията, така и десинхронизацията на бета-активността се свързва от много автори с различни видове емоции и когнитивни процеси. Синхронизацията на бета-ритъма в челната област се свързва с процеса на концентрация.

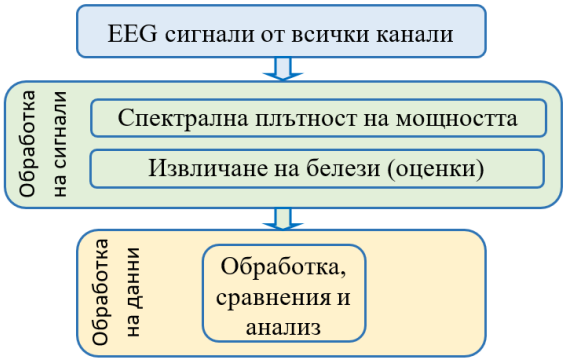
Гама-ритъмът засяга главно честоти над 35 Hz. Този ритъм се определя до честоти около 80 Hz или 100 Hz. Той е свързан с различни когнитивни и двигателни функции. Гама-вълните са важни за ученето, паметта и обработката на информация.

Известно е, че ЕЕГ сигналите се променят според задачата, изпълнявана от човек, и неговите емоционални състояния. Различни честотни диапазони на мозъчния спектър като делта, тета, алфа, бета и гама са носители на информация за текущото състояние на индивида. Анализът на промените в спектъра на човешкия мозък дава полезна информация за принципа на функциониране на мозъка [20-22].

3. Обработка на ЕЕГ сигнали и данни

Поради много ниска амплитуда ЕЕГ сигналите често пъти са зашумени, като е възможно да съдържат и различни артефакти [16]. Шумът може да бъде електроден шум или да се генерира от самото тяло на човека. Видовете шум, които могат да замърсят ЕЕГ сигналите по време на записите, са шумът от електрода, от движението на тялото, движенията на очите, мигането на очите и понякога ЕКГ смущения. Шумовете в ЕЕГ сигналите се наричат *артефакти* и те трябва да бъдат премахнати от първоначалния ЕЕГ сигнал, тъй като шумът/артефактите затрудняват обработката и анализа на ЕЕГ сигналите.

Алгоритъмът за обработка на ЕЕГ сигнали, използван в настоящата статия, е показан на фигура 2.



Фиг. 2 *Алгоритъм за обработка на ЕЕГ сигналите и данните*

Алгоритъмът се състои от две части. Първата част обработва сигналите от всички сензорни канали, като ги филтрира и разделя по ритми и за всеки ритъм се оценяват неговите параметри. За получаване на спектъра на сигналите в ЕЕГ каналите се използва алгоритъм на преобразование на сигналите в честотната област. Оценката на параметрите на сигналите в честотната област на сигналите се извършва в спектралната област на сигнала. Получавайки набор от данни от времевата и честотна област на ЕЕГ сигналите или т.нар. „*feature extraction*“, се преминава към обработка и анализ на тези данни.

За провеждане на статистически анализ с цел установяване на някакви значими разлики между усреднената мощност в получените данни преди и по време на експозицията е използван t-тест за свързани извадки за сравняване на спектралната мощност на ЕЕГ сигналите [7].

Важно е да се отбележи, че границите на фигура 2 между спектралната плътност на мощността, извличането на белези и сравнителният анализ не са твърдо фиксирани и тези граници могат дори да не съществуват. По този начин компонентите за предварителна обработка и извличане на белези от ЕЕГ сигналите понякога се обединяват в един алгоритъм, докато алгоритъмът за сравнение може да липсва или да се редуцира до най-простата му форма, т.е. до праг за вземане на решения и определяне на стойностите на различните характеристики.

4. Резултати

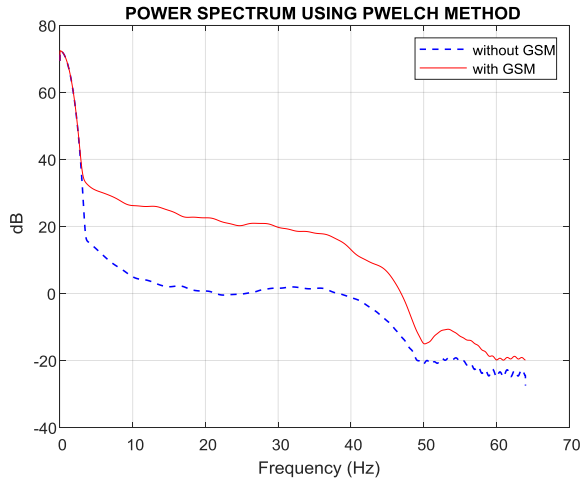
За установяване на евентуални ефекти от въздействието на електромагнитните полета, генерирани от мобилен телефон, върху активността на човешкия мозък са проведени серия от експерименти в Университета по библиотекознание и информационни технологии, УниБИТ – гр. София, Университета „Проф. д-р Асен Златаров“ – гр. Бургас и Многопрофилната болница за активно лечение – гр. Шумен. Експерименталната постановка е обсъдена от биоетична група и е установено, че изследването не застрашава здравето на пациентите. Изследваните лица декларират в писмен вид своето съгласие за участие в експеримента, както и че са физически здрави и че не са приемали лекарства през последния месец преди изпитателния период. Всеки от експериментите стартира със стандартно изследване на ЕЕГ ритмите на човек и установяване на добро физическо и психическо здраве на участника. По време на експеримента участникът седи на удобен стол със затворени очи, но в будно състояние (фиг. 3).

Фиг. 3 *Участник по време на експеримента*

Първоначално се прави запис на ЕЕГ ритмите без използване на мобилен телефон, а впоследствие – с неговото използване. Тези записи са необходими, за да се направи сравнителен анализ между дейността на мозъка преди и по време на използването на мобилен телефон. За установяване на зависимости между електромагнитните излъчвания на GSM по време на разговор върху мозъчната активност на човек е пресъздадена ситуация, максимално близка до реалната за провеждане на телефонен разговор. За тази цел участникът в експеримента държи мобилен телефон на разстояние около 1 см от лявата страна на главата си, както е показано на фиг. 3. Експериментът е проведен с апарат Samsung Galaxy S9+, който има Specific Absorption Rate (SAR) от 0.36 W/kg. По време на ЕЕГ записите участникът държи очите си затворени, трябва да е буден в отпуснато състояние и слуша тих разговор по телефона. Звукът в телефона съдържа равномерно и спокойно броене от едно до сто, което се подава от друг участник, намиращ се в съседна стая. Записът на ЕЕГ сигналите, без използване на мобилен телефон и с неговото използване, е с обща продължителност около 30 минути. Получените ЕЕГ сигнали се филтрират в средата на МАТЛАБ по подходящ начин, като се анализират четирите клинично значими ЕЕГ ленти, а именно делта (1-4 Hz), тета (4-8 Hz), алфа (8-13 Hz) и бета (13-32 Hz). Записите на ЕЕГ сигналите са обработени при липса на работещ мобилен телефон и по време на разговор с мобилен телефон.

Тъй като ЕЕГ сигналите се записват във времевата област, се прилага техника за преобразуване на сигнала за време в честотна област. Спектрите на сигнали, получени от Pwelch спектъра на сигналите преди и след подаване към мобилен телефон, се използват за сравнителен анализ, изготвяне на заключения и даване на препоръки.

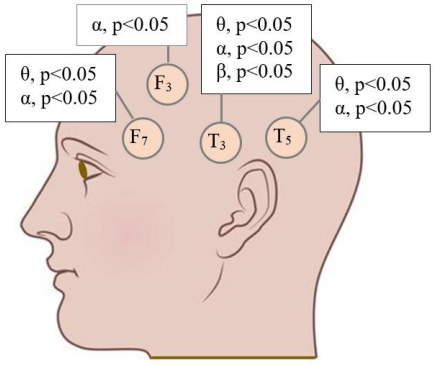
Изследвани са всички ЕЕГ канали, обхващащи и двете мозъчни полукълба. От получените резултати бе установено, че в точките T3, T5, F3 и F7, които са най-близко до лявото ухо, се получава промяна в спектъра на ЕЕГ сигнала. Най-голямо е увеличението на спектралната мощност на ЕЕГ сигнала в точка T3, която се намира най-близко до мобилния телефон и съответно е подложена на най-високи нива на облъчване (фиг. 4). В точка T3 се забелязва увеличаване на спектралната мощност в почти целия честотен диапазон, докато при останалите точки T5, F3 и F7 това увеличение е предимно в тета- и алфа-диапазона. Промяната на спектралната мощност на ЕЕГ сигнала е преди всичко в средната челна контралатерална страна, което може да се обясни с близостта на мобилния телефон до тази страна.



Фиг. 4 *Спектър на ЕЕГ сигнал от точка T3*

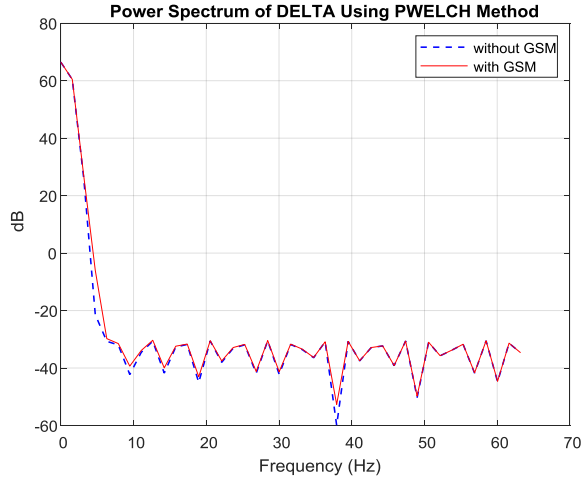
Изследвани са 30 лица (16 мъже и 14 жени на средна възраст 45.2 г.), като в бъдеще се планира увеличаване на техния брой. За потвърждаване на достоверността на получените резултати са използвани три измервателни уреда: Emotiv EPOC+, SIGMA PLpro и Sienna EEG. За тази цел изследванията са проведени в три организации – УниБИТ, Университета „Проф. д-р Асен Златаров“ в гр. Бургас и Многопрофилната болница за активно лечение в гр. Шумен. В бъдещи изследвания се предвижда да се използват различни мобилни апарати при различна продължителност на експеримента.

За сравняване на средната спектрална експозиция с и без GSM за диапазоните на делта (1-4 Hz), тета (4-8 Hz), алфа (8-13 Hz) и бета (13-32 Hz) е приложен t-тест за свързани извадки. Получените статистически нива във всичките четири ленти показват p-стойности по-големи от 0.05, което означава, че няма значима разлика между средната фалшива експозиция и данните за експозицията (p-стойностите се считат за значими при $p<0.05$). Статистически значимите различия са визуализирани на фиг. 5.

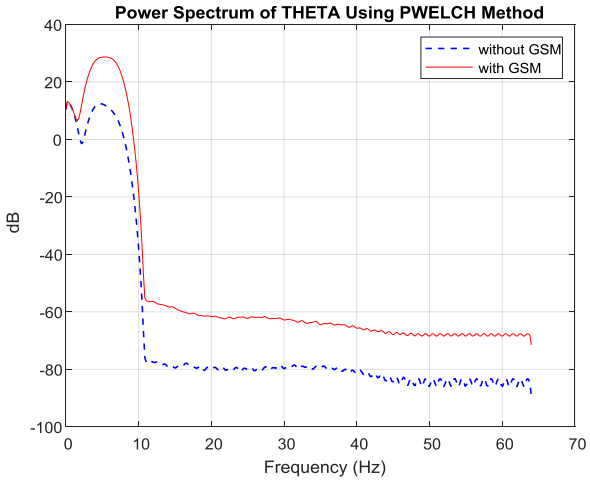


Фиг. 5 *Разлики в спектъра по диапазони*

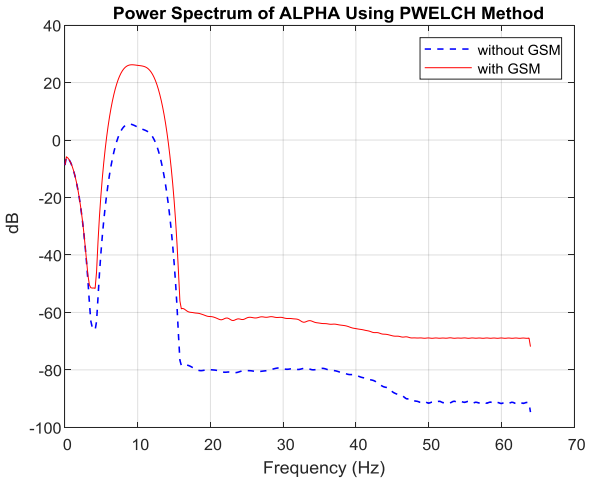
Най-големите промени в спектъра на сигнала се забелязват в точка T3, затова за тази точка е направено специално изследване на спектъра на ЕЕГ сигнала в делта, тета, алфа и бета-диапазона.



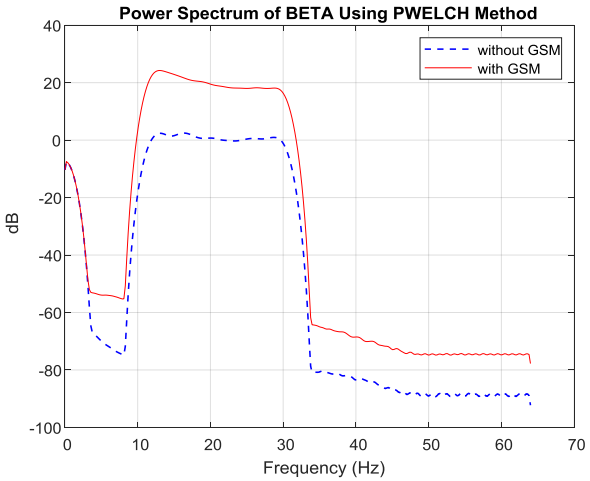
Фиг. 6 *Спектър на ЕЕГ сигнал от точка T3 в делта-диапазона*



Фиг. 7 *Спектър на ЕЕГ сигнал от точка T3 в тета-диапазона*



Фиг. 8 *Спектър на ЕЕГ сигнал от точка T3 в алфа-диапазона*



Фиг. 9 *Спектър на ЕЕГ сигнал от точка T3 в бета-диапазона*

Приносът на изследването се изразява в провеждане на задълбочен спектрален анализ в различните мозъчни диапазони с цел установяване на най-съществените разлики в промяната на спектралната мощност. Това би обяснило някои биологични състояния на човешкото тяло.

5. Изводи

Настоящото изследване установи краткосрочни ефекти в активността на мозъчните вълни, предизвикани от радиочестотните сигнали, излъчени от мобилен телефон. Относително по-високите нива на експозиция на SAR предизвикват значително увеличаване на спектралната мощност на ЕЕГ на човек в средночелната контралатерална страна на главата по време на използване на мобилен телефон. Тъй като механизмите, предизвикващи тези радиочестотни ефекти, в момента не са проучени в дълбочина, то е жизненоважно в бъдеще да се повторят и доразвият подобни изследвания с цел изясняване на биофизичните причини за регистрираните ефекти.

На базата на получените резултати могат да се направят следните по-важни препоръки: по възможност да се ограничи броят на разговорите по мобилен телефон; по време на разговор мобилният телефон трябва да се държи на известна дистанция от главата; желателно е по време на дълъг телефонен разговор мобилният телефон периодично да се премества от двете страни на главата.

В заключение, що се отнася до бъдещата работа, се планират различни експериментални сценарии като проучване на по-дълги периоди на продължителни експозиции на

мобилни телефони върху участниците в теста. Също така би било интересно да се видят ефектите на експозицията на мобилни телефони върху мозъчната дейност при продължителност до един час или повече с различни марки устройства. Изследването на децата за такива ефекти е от решаващо значение, тъй като е възможно човешкият мозък в по-ранна възраст да бъде по-податлив на неблагоприятни последици за здравето.

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Higher Education and COVID 19 in Conditions of Education 4.0

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Abstract: *In general, Education 4.0 is an institute of believed that promotes intelligent and smart thinking in education. Education 4.0 promotes education differently, mainly by consuming technology-based tools and resources. This is the most important goal of Education 4.0 for all educational institutions: to encourage students and improve students' learning outcomes. Higher education in the Fourth Industrial Revolution is an open, rational and dynamic door that can change the thinking of society and upgrade the living standard of the people.*

The epidemic outbreak of the novel coronavirus (COVID-19) has disrupted virtually all aspects of human life, including the tragic loss of many lives around the globe. COVID-19 provides the right opportunity for all universities to try to change the how of learning.
KEY WORDS: *HIGHER EDUCATION, EDUCATION 4.0, COVID – 19, TEACHING*

1. Introduction

Education 4.0 was recognized as a respond to Industry 4.0, greatly increasing the use of Internet technologies and cross-communication tools. In fact, Education 4.0 uses intelligent school management systems, learning management software, communication tools, and other teaching and learning tools.

The epidemic outbreak of the novel coronavirus (COVID-19) has disrupted virtually all aspects of human life, including the tragic loss of many lives around the globe. It has broken rhythms and routines, shattered patterns and norms, and exposed the best and worst of humanity and human institutions. Yet, even these great challenges and great difficulties offer opportunities to question time-honored norms and routines, so we may reimagine and recreate human institutions. Among these institutions, schools and universities are built to serve the purpose of education. COVID- 19 has certainly disrupted the operations of millions of schools, often forcing their closure.

While these closures have prompted innovation and institutional self-examination, the chance of large-scale, long-term changes is largely dependent on how we treat COVID-19 in education. If we treat COVID-19 as a short-term crisis, then whatever we do to help extend learning when universities are closed will be only temporary. As soon as schools are reopened, the status quo will be restored. This seems to be the mindset and behaviors of most schools around the world [10].

Globally speaking, virtually all schools and universities have been paused: some stopped temporarily for a few weeks, some for much longer. Individual schools have tried a variety of ways to ensure that schooling continues. Some replicated schooling using online tools; some tried to broadcast content to students; some gave out schoolwork without requiring all students to check in online; some tried to let students decide what they wished to do; and some enabled teachers to reorganize student learning. Meanwhile, higher education, which many schools work to prepare students for, has also been paused, as have many accompanying entities that provide colleges the test scores for admissions. More important, the pauses give schools a very rare and possibly very short window of opportunity to recreate educational institutions.

2. Education 4.0

Personalized learning with Education 4.0 promotes understanding and allows students to reach really interested, more professional and memorable materials. It also means that students can become interested professionals. General education 4.0 allows students to achieve better learning outcomes based on real scientific or professional interests. This is the most important goal of Education 4.0 for all educational institutions: to encourage students and improve students' learning outcomes. Students are the main stakeholders of the educational ecosystem and are the main beneficiaries of the educational ecosystem.

Education 4.0 treats students as beneficiaries as before. Using technology, students can connect in a better way with many other stakeholders in the system, better communication with teachers, parents and management. Student learning outcomes are directly proportional to the level of implementation of Education 4.0. Higher education in the Fourth Industrial Revolution (HE 4.0) is an open, rational and dynamic door that can change the thinking of society and upgrade the living standard of the people. The fourth industrial revolution was triggered by counterfeiting and altered the working environment in the central workplace. Peter Drucker said in 1997 that the university would not survive and higher education is in serious danger. The university campus as an institution will not survive. The current dormitory is completely inappropriate and completely redundant [9].

The current innovative and leadership-based learning objectives introduced by Education 4.0 have made the transformation obligatory from traditional classrooms of the industrial society to creation of digital classrooms. This transformation will embrace digital curriculum that might impact learning outcomes and reduce in-class management. The characteristics of education systems can be outlined in the Table 1 [8].

1,5 смThe characteristics of education systems

MEANING IS…….	
"Download" Education 1.0	Dictated
"Open Access" Education 2.0	Socially constructed, usually with aid of Internet access
Knowledge Producing Education 3.0	Socially constructed and contextually reinvented knowledge
Innovation Producing Education 4.0	Built through selective individual and team-driven focused innovations practices
TECHNOLOGY IS……	
"Download" Education 1.0	Confiscated at the classroom door (digital refugees)
"Open Access" Education 2.0	Cautiously adopted open access (digital immigrants)
Knowledge Producing Education 3.0	Everywhere (digital natives in a digital universe) for ubiquitous knowledge construction and transmission
Innovation Producing Education 4.0	Always changing with the direct input of learners acting as a major source of tech evolution in the service of innovation production

TEACHING IS DONE…….	
"Download" Education 1.0	Teacher to student
"Open Access" Education 2.0	Teacher to student and student to student (progressivism); Internet resources are a normal part of learning activities
Knowledge Producing Education 3.0	Teacher to student, student to student, student to teacher, people – technology people (co-construction of knowledge)
Innovation Producing Education 4.0	Amplified by positive innovation feedback loops; ubiquitously and creatively 24/7 in all phases of living, learning, and working
SCHOOLS ARE LOCATED IN	
"Download" Education 1.0	In a building (brick)
"Open Access" Education 2.0	In a building or online (brick and click), but increasingly on the Web through hybrid and full internet courses
Knowledge Producing Education 3.0	Everywhere in the "creative society" (thoroughly infused into society: cafes, bowling alleys, bars, etc.)
Innovation Producing Education 4.0	In the globally networked human body, a continuously evolving instrument innovatively supplementing

Source: Thi Lan Anh Vu, Building CDIO Approach Training Programmes against Challenges of Industrial Revolution 4.0 for Engineering and Technology Development and Author

Education 4.0 is a response to the needs of IR4.0 where human and technology are aligned to enable new possibilities. Fisk [4] explains that the new vision of learning promotes learners to learn not only skills and knowledge that are needed but also to identify the source to learn these skills and knowledge. There are nine trends related to Education 4.0 [4].

- ✓ First, learning can be taken place anytime anywhere. e-Learning tools offer great opportunities for remote, self-paced learning. Flipped classroom approach also plays a huge role as it allows interactive learning to be done in class, while the theoretical parts to be learned outside the class time.
- ✓ Second, learning will be personalized to individual students. More practices will be provided. Positive reinforcements are used to promote positive learning experience and boost students' confidence about their own academic abilities.
- ✓ Third, students have a choice in determining how they want to learn.
- ✓ Fourth, students will be exposed to more project-based learning. Students are required to apply their knowledge and skills in completing a couple of short term projects. By involving in the projects, they are practicing their organizational, collaborative and time management skills which are useful in their future academic careers.
- ✓ Fifth, students will be exposed to more hands-on learning through field experience such as internships, mentoring projects and collaborative projects.
- ✓ Sixth, students will be exposed to data interpretation in which they are required to apply their theoretical knowledge to numbers and use their reasoning skills to make inferences based on logic and trends from given sets of data.
- ✓ Seventh, students will be assessed differently and the conventional platforms to assess students may become irrelevant or insufficient. Students' factual knowledge can be assessed during the learning process, while the application of the knowledge can be tested when they are working on their projects in the field.
- ✓ Eighth, students' opinion will be considered in designing and updating the curriculum.
- ✓ Lastly, students will become more independent in their own learning, thus forcing teachers to assume a new role as facilitators who will guide the students through their learning process.

3. *Higher Education and COVID -19*

Today, very little is known about the COVID-19 effects on the higher education industry. The issue of the COVID-19 and its impact on the higher education industry is a growing topic of discussion worldwide [3]. Closing universities and cancelling classes have become a COVID-19 reality in many parts of the country, leading to enormous anxiety and uncertainty. At the same time, the COVID-19 crisis has revealed the severe inequality and inequity that exists in higher education worldwide. For example, issues surrounding access to distance education and the enrollment of international students and scholars in developing and transitional economies have taken on heightened importance. The Institute of International Education (IIE) (2020) [5] cautioned that "The COVID-19 health crisis will affect international student mobility in this academic year and possibly for years to come….including decreasing number of students studying abroad, as well as inbound international students and global partnerships with universities" (p. 10). As a result, cancellations of events, postponed and cancelled study abroad programs, and moving teaching and operations virtually have disparate impacts on the internationalization and globalization of higher education [2]. The top three themes found were students, education, and COVID-19 are present on Figure 1.

Figure 1. *Word Cloud: Top 100 Frequently Used Words from Coronavirus (COVID-19) and Global Higher Education: Opportunities and Challenges.*

Source: Chan, R. (2020). Studying Coronavirus (COVID-19) and Global Higher Education: Evidence for Future Research and Practice

Before the pandemic, many campuses were facing declining enrollment of traditional college-age students, potentially leading to increased competition for students and tuition revenue. For public

universities particularly, these challenges had been exacerbated by long-declining state funding. One bright spot has been the growth of online learning, accelerated by the stay-at-home shutdown in March 2020. Yet contrary to popular belief, emergency remote learning is not the same as online learning. Emergency remote learning provides temporary access to courses during a crisis, while online learning intentionally plans and designs courses to be delivered online from the start. A growing number of higher education institutions have been considering how online learning could assist in overcoming enrollment and financial shortfalls. After the 2019-2020 school year, online learning has clearly become an important part of making higher education accessible, equitable, and affordable.

When the university closed and teaching shifted online, there was still a need to inform the learning with awareness of affect in practice. This requires strategies to continue with the reflexive work on affective embodiment. Research into implementation science indicates that teaching for student wellbeing and other social emotional learning is most effective when embedded in collaborative learning [1]. Therefore, the best activities for this subject were debates, guided discussions, games, role-plays and micro-teaching as these allow university students to experience and practice collaboratively. This work often requires scaffolding skills for students who may be unfamiliar or uncomfortable with these teaching techniques. Reading the bodies and words of the students, the lecturer is assisted in identifying when students may require further support and this work in turn, allows teachers to gain more skill and familiarity with these important teaching approaches for their own practice.

The available choices for asynchronous activities included annotated videos, questions, systems models (another popular choice using a free online tool) and different reading group discussions. Students were asked to do two, but several did all the activities. Just over 90% of students chose a simulation activity each week. Online discussions developed into deep systemic analysis. Despite being given the choice of whether or not to respond to the reflections of others, almost all the students did.

Students benefit from a university education in two main dimensions – self growth and professional development. For the first, the on-campus experience is the key – in fact a good deal of the self-growth happens outside of the formal curriculum through the social and other engagements in an on-campus model. Any good university provides a rich campus environment for such a growth. Professional development is the focus of the formal curriculum. Here, online mode is useful for some types of learning. But even for professional development, online mode is of limited value in developing graduate attributes like team work, communication ability, consensus building, etc. So we can say that face-to-face, campus-based education has a role in the overall education of the student which cannot be replaced by online teaching, though online models can indeed be useful for some aspects of the learning a university provides.

Given the experience during covid lockdowns, Post-covid, universities will want to be prepared for online delivery of courses. However, given the limitations of online approaches, universities are likely to opt for blended approach for education, keeping in mind the learning goals as well as value perceptions. The blending will happen in a few ways:

- Students will still be enrolled in a brick and mortal university, but some of the courses they take in a semester may be offered online, while the others will remain face-to-face.
- Even with online courses, a blended model is likely to be used – some Massive Open Online Courses (MOOC) style asynchronous lecturing, complemented with some weekly synchronous interaction (face-to-face or online) – this maybe discussion like in a flipped classroom, or may be summarizing the lectures for the week, etc. Some aspects of assessment will also be face-to-face, like projects, major exams, etc.
- For courses being offered in classroom mode, some students may be allowed to attend them online (i.e. the lecture and presentation will be streamed live) [6].

This means that universities have to gear up to provide, in addition to regular education, online education also – MOOC-style lectures, synchronous online teaching, and streaming of live lectures. We view the third option as straightforward use of technology to have a distributed class, which reduces the need for classroom infrastructure, and do not discuss it further.

This means that universities have to gear up to provide, in addition to regular education, online education also – MOOC-style lectures, synchronous online teaching, and streaming of live lectures. We view the third option as straightforward use of technology to have a distributed class, which reduces the need for classroom infrastructure, and do not discuss it further.

Once universities adopt a blended model where some courses may be offered online, then the entire repository of online courses available becomes a resource – the university does not have to necessarily create its own courses. Using externally created courses may not be used by the top universities of the world who may want to offer their own courses to their students, they will be useful for many universities, particularly those which have limited faculty resources.

Institutional rules do not permit me to share their contributions, but from my teaching notes, in synchronous sessions students referenced their learning from the simulations and continued their online discussions. Students were able to talk about the limitations of the 'characters' they played in the simulation. They were able to draw relevant insight into understanding some of the challenges they were experiencing with disadvantaged families, and observations about the differences that would likely exist in the different safety nets in schools in their countries [7].

4. Conclusion

Despite the Education 4.0 paradigm, universities are characterized by a plurality of learners with different profiles, interests, and learning rhythms, which makes it extremely difficult to implement certain resource-intensive techniques to provide each learner with personalized follow-up. The need to integrate resources and actors to allow the design of intelligent and self-adaptive cyber-physical systems capable of managing learning processes also slows down the perfect application of the education 4.0 paradigm.

Digitization and virtualization in education are motivating, inspiring and potentially broad challenges for individuals and societies. Smart and intelligent educational tools and resources should allow individuals to develop more complete expertise, knowledge and skills and unleash their innovative prospective.
Universities have the possibility to emerge from this pandemic as places of compassion, of wisdom and worthiness. They were far from that before the pandemic, where neoliberal interests influenced not just the structure of the curriculum, the economics of scale in teaching and in the profitability of its colonized expansion and exploitation, but also in the self-deceit of its academics, their administrators and their marketing professionals. The possibilities

are for universities to speak to the truth as they can know it, provide truth based on facts, argument and spirituality.

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An assessment of energy efficiency measures in a public building in Albania in the prospect of cost and emissions reduction

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Abstract: *The building sector in our country has an important share of energy consumption. According to Eurostat data, final energy consumption in the residential sector was estimated about 35 % of the total consumption. On the other hand about 75% of the electricity consumption takes place in the building sector. It should be noted that currently this sector faces many challenge, as the quality of energy supply (heating) in public buildings and the residential sector remains at low rates. Nevertheless, reducing energy consumption is one of the main targets set in the National Energy Strategy 2018-2030. By 2030 this target suggests 15.5 % of the energy reduction. This study has at its core the assessment of energy consumption in a public building placed in the city of Durres. Determining the typology and thermo-physical characteristics of the building is of primary importance. The evaluation of the energy performance of the building in the dynamic regime was carried out through the Hourly Energy Analysis (HAP) software. The implementation of energy efficiency measures is carried out taking into account the energy and cost criteria. A cost analysis of EE measures was performed using the dynamic Net Present Value method.*

Keywords*: PUPBLIC BUILDINGS, ENERGY EFFICIENCY, COST, EMISSION*

1. Introduction

Energy consumption in building represents more than 38 % of the total energy in Europe [1]. On the other hand, buildings are responsible for approximately 35 % of greenhouse gas emissions. Albania is part of this energy consumption trend. According to INSTAT (Institute of Statistics) energy consumption of non-residential building is approximately 20.6 % of the total energy consumption [2]. In the recent years a number of initiatives in the Albanian energy sector have been recorded. The Energy Efficiency Directive established a set of binding measures to achieve the 20% target in Energy Efficiency (EE) [3]. On the other hand Albania has made a significant progress in preparation of the National Energy and Climate Action Plan (NEACP). In order to maintain a high economic growth rate, Albania has to provide power supply, which is long-term, reliable and within the means to pay for it [4]. On the other hand, the country needs to use energy in an efficient way and to diversify its energy sources. Energy demand in the residential sector represents a permanent challenge. The general classification of climatic zones in Albania according to heating degree days is divided into three main categories: zone A, B and C. Most of area of public buildings, which makes up 57%, is located in climate zone A. It is followed by the area climate B with 26% of the area and finally the area climate C with 17% of the surface. Public buildings with all the sub-categories have a significant contribution on energy demand in buildings. For this reason this study is focused on the A climatic zone. In absolute values the climatic zone A results the largest percentage of energy savings. This paper discusses the energy performance of a public building situated in climatic zone A.

2. Energy consumption in buildings

Electricity is often the main energy source for space heating, especially in urban areas. Share of electricity consumption in Albanian households according to Eurostat [5] is 31.7 % for space heating, 29.8 % goes for cooking, whereas 21.4 % and 11.7 % for domestic hot water and lighting/electrical equipment respectively. Recently Albania introduced changes to the law of energy efficiency in country, in order to insert mandatory energy efficient targets for public, private and large consumers of energy. Therefore, from September 2021 the public sector is obliged to renovate a minimum of 3 % of the overall stock of public buildings [6]. This should be realized annually to meet the minimum requirements of energy performance. The law obligates municipalities to prepare local action plans for energy efficiency that includes policies and measures to save energy. In general, Albanian dwellings are partially heated, and only for a few hours a day. The continued use of old firewood stoves brings many problems to the environment and health of citizens. Findings on the final energy consumption need for thermal energy services in the residential sector in 2015 speak of 4.9 billion kWh, of which 54% were met by electricity, 37% by wood consumption, and 9% from liquid gas. The sector emitted 96,000 tons of CO2 associated with the consumption of liquid gas. The final consumed energy calculated on the basis of the geometric and thermal properties of buildings, as well as the features of the installed energy systems, differ substantially from the energy balance. A view of energy sources share for space heating is given below in Figure 1.

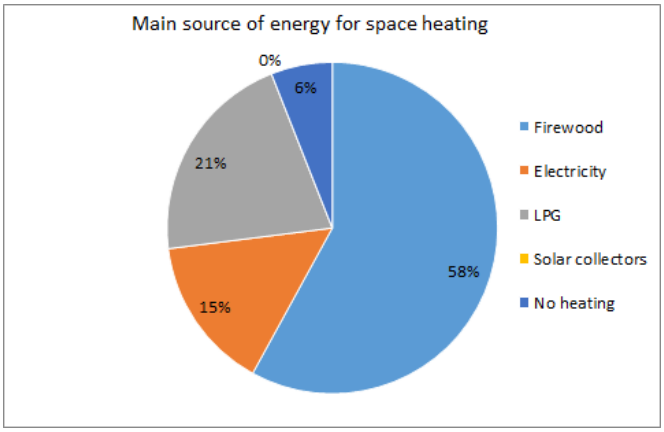

Fig. 1 Main energy sources used for space heating purposes

3. Case Study

An administrative office building was considered for this study. The building is placed in the port city of Durres. The gross floor area of the building is approximately 925.9 m^2 which is organized in two floors. Total window area is estimated 137 m^2, whereas wall transmission area results 442 m^2. The roof transmission area according to the plan is 438 m^2. The building serves as an administrative and office space running 8 hours per day and 6 days a week. The actual energy flows in the building, include lighting, office equipment, HVAC system. Electricity is the main energy source in the building. As for the time of this study no other fuel source supplied the building facilities. It is obvious that electrical equipment consists in the largest energy consumer in the investigated building. However, the first attempt was to highlight the current energy performance of the building. Overall heat transfer coefficient prior the energy efficiency measures was estimated U=1.023 W/m^2K, whereas for windows this value was U=3.147 W/(m^2k). For the roof the estimated value was U=2.05 W/(m^2K). In Figure 2 is given the front view of the building studied in this paper. Before estimating the energy performance a thermal

imaging of the building was performed using infrared Testo camera. The result is shown in detail in Figure 3.

Fig. 2 *Front view of the office building [8]*

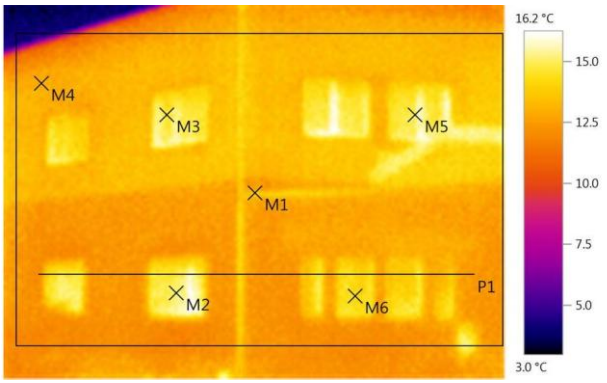

Fig. 3 *Temperature distribution of the measured building side*

In this case study thermal insulation was considered as the first energy efficiency measure. For this a 50 mm polystyrene XPS was predicted as an effective energy efficiency measure. It was obvious from the beginning that the share of heating and cooling in the total energy consumption is not very high due to geographic location of the city in the west part of the country. However we expect large consumption in cooling during summer season in both cases. It is a fact that in this study the no intervention on windows replacement was introduced, due to the relatively good condition observed during the investigation of the building. On the other hand, window replacement would require extra financial sources that were not predicted by the administrative staff of the building.

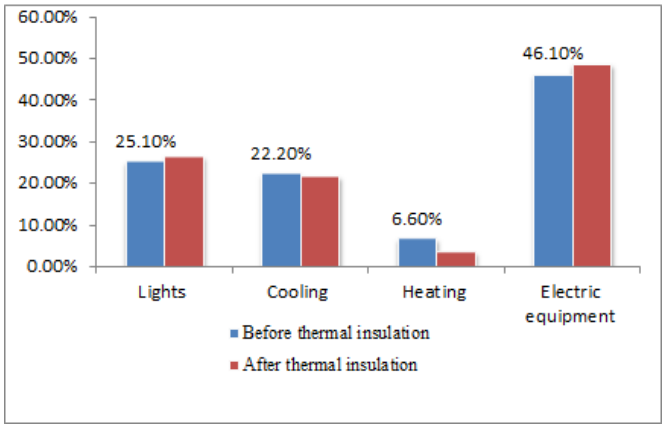

Fig. 4 *Distribution of energy consumption in the building before and after EE measures*

A view of energy consumption in the building is presented in Figure 4. The graph shows the real distribution of energy flows in building before and after thermal insulation assumed. The results suggest that introduction of such an EE measure could have a considerable impact on heating, by a reduction by half. On the contrary, a slight impact is observed in cooling where this reduction is less than in heating. In Hourly Analysis Programme (HAP) is performed the monthly energy consumption by each consumer in the building inserting all the input data, such as lighting load, HVAC load, equipment load, working hours, technical description of energy consumers, employees etc. The results are presented in the Figure 5 to Figure 7.

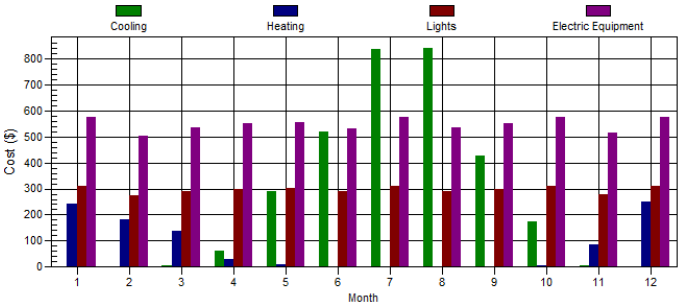

Fig.5 *Monthly component cost estimated in USD in HAP software.*

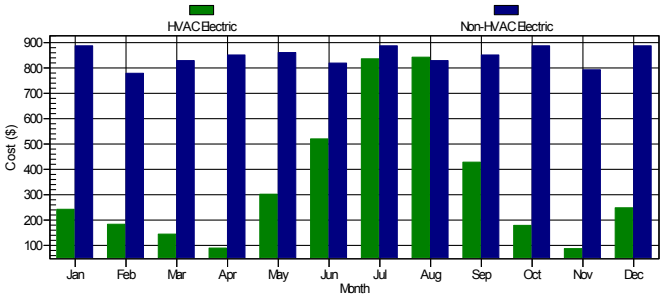

Fig.6 *Monthly energy cost for HVAC and non-HVAC components prior introducing thermal insulation*

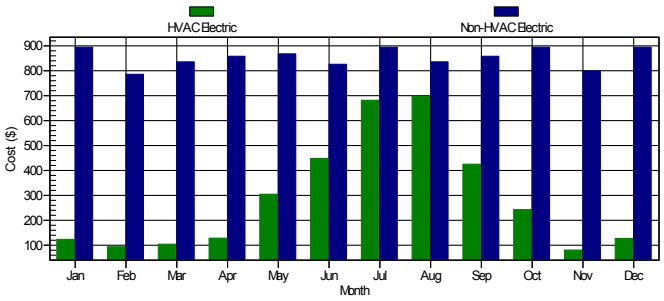

Fig.7 *Monthly energy cost for HVAC and non-HVAC components after applying thermal insulation*

What we can observe from the results taken from simulations is the dominant energy consumption by non HVAC equipment, such as lighting and electric appliances for office purposes. However this trend sharply changes during summer days where solar irradiance is higher. As a consequence the energy cost for cooling would increase during summer season. As mentioned above the application of thermal insulation of the walls would only slightly decrease the cooling load during summer. It is clear that the highest influence is on the windows, since their U-value is higher than in opaque structures. Nevertheless, observing the Figure 7, a new discussion can be made. Since the share of lighting and electrical equipment is approximately equal throughout the year with minimal variation and the demand for electricity is constant over the year it was estimated appropriate introducing a photovoltaic PV system on the rooftop of the building.

3.1 PV System generating electricity

A grid connected photovoltaic system made of Si polycrystalline cell was simulated using PVSol software. The PV generator surface estimated at 181 m2 covered by 88 PV modules arranged on the roof of the building. Numbers of inverters were four and total PV output is assessed 34.32 kWp. The inclination was taken 30^o and orientation South 172^o. The simulated results are listed below in Figure 8.

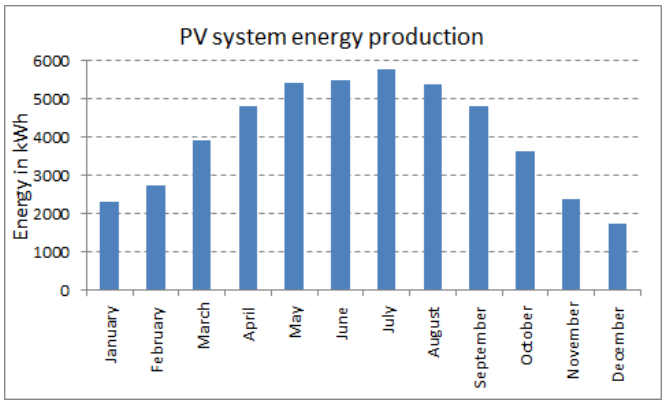

Fig. 8 *Energy production by PV system on rooftop of the building*

From the simulations we are able to determine the specific annual yield which results 1418.74 kWh/kWp and annual contribution of PV system on the grid results 48,691 kWh/year. The stand-by consumption evaluated about 64 kWh/year. On the other hand generating electricity using solar energy will directly contribute on the reduction of CO_2 emissions. The avoided CO_2 emissions result in 29,215 kg/year. Furthermore an economic analysis was performed using the simple payback method. For the financial analysis specific investment cost was selected 750 Euro/kWp, which is accordance with the nowadays market price of PV modules. The assessment period was chosen 20 years and amortization period 5.9 years. Total investment cost resulted 25,740 Euro. No bank loan was predicted for the investment during the simulations. The results are given in Figure 9.

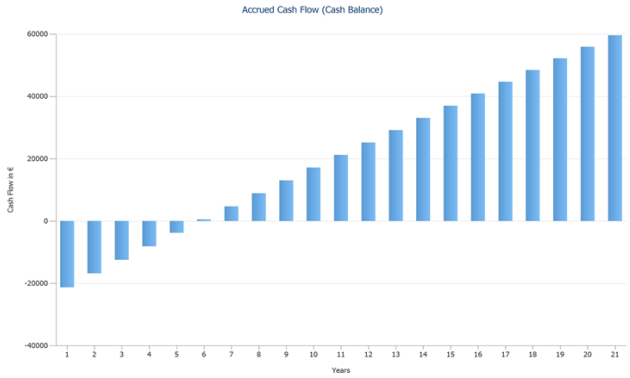

Fig. 9 *Accrued cash flow balance*

4. Conclusions

In this research paper a typical public building placed in the city of Durres was considered. Durres city is part of the A climatic zone, in which the public buildings dominate with more than 57 % located in this area. The building is a two floor structure which is firstly investigated using infrared thermal camera. From the investigation carried out in the building four main energy consumers are lighting, cooling, and heating purposes. Energy consumption of electric equipment result on approximately 46 % of the total electricity consumption. First attempt to include energy efficiency measures was to introduce the thermal insulation. Due to this EE measure the impact on energy reduction in heating is significant, whereas for other energy consumers this measure has a slight effect. The second EE measure applied in this study was the introduction of a grid connected PV energy system applied on the roof of the building. Total PV capacity assessed was34.32 kWp with an annual yield about 48,691 kWh of electricity. This figure will significantly contribute on the CO_2 emission reduction estimated at 29,215 kg of CO_2 per year. Energy consumption in public buildings requires more accurate data which can be supplied at sight. The analysis needs to deepen thoroughly in order to improve the energy performance in building by introducing effective energy efficiency measures with low cost ensuring greenhouse gas emission reduction and increasing the energy performance of the building in generally.

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Changes in the need for digitization during the covid-19 pandemic

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Abstract: *The digitization and automation of production and logistics technology as part of Industry 4.0 bring many positive aspects. They create the conditions for expanding production capacities, enforcing in a competitive environment by increasing productivity and quality of produced products, new opportunities and new customers, replacing people in dangerous operations and events. This paper deals with the changing perception of the need for digitization brought about by the COVID-19 pandemic.*

Keywords: DIGITALIZATION, PANDEMIC, SAFETY AND SECURITY, INDUSTRY 4.0

1. Introduction

In a modern enterprise operating in the conditions of digital transformation, the main priority of business development is to create and exploit the potential of available digitalization opportunities. The COVID-19 pandemic has changed the situation considerably and there has been an increasing emphasis on digital transformation. The pandemic has had the opposite effect on digitalisation and intelligent automation, as it is new technologies that provide the solution to a crisis situation. Digital transformation and the adaptation of new technologies, closely linked to the revision of internal and external processes, is becoming a question of survival for many enterprises [1].

2. Digitization within the EU

Digitalization is one of the European Union's top priorities. The Digitalization should also help in the transition to a greener economy and in achieving climate neutrality by 2050. The EU wants to improve the digital skills of its population, provide training for workers and move towards digitalization in public services that respects fundamental rights and values. The European Commission launched the Digitising European Industry (DEI) initiative back in April 2016. As part of the Digital Single Market Strategy, the DEI aims to strengthen the EU's digital competitiveness and ensure that every business in Europe can benefit from digital innovation [2].

Based on the various initiatives to digitise industry and the economy at national level, the activities of DEI are structured into five main pillars:

Pillar 1 - A European platform for national initiatives to digitise industry.

Pillar 2 - Digital innovation centres.

Pillar 3 - Strengthening leadership through partnerships and industry platforms.

Pillar 4 - Regulatory framework for digital technologies.

Pillar 5 - Preparing Europe's citizens for the digital future.

In April 2021, the European Parliament approved the Digital Europe Programme. It is the first ever Union financial instrument to bring technology closer to citizens and businesses. The programme should fund digital infrastructure and strategic technologies to improve Europe's competitiveness, help the transition to a greener economy and ensure technological sovereignty. In total, it should invest almost €7.6 billion in five areas: supercomputers (€2.2 billion), artificial intelligence (€2.1 billion), cybersecurity (€1.6 billion), advanced digital skills (€577 million) and mainstreaming digital technologies (€1.1 billion) [2].

3. Digitalization in enterprises

The digitalization and automation of production and logistics technologies as part of Industry 4.0 bring a number of positive aspects to enterprises. They create conditions for expanding production capacities, asserting themselves in the competitive environment by increasing productivity and quality of manufactured products, new opportunities, and new customers, replacing humans in hazardous operations and events [5]. The different stages of digitalization in enterprises can be summarized in 5 basic stages:

Stage 1 - Basic level of digitalization: The enterprise does not address Industry 4.0, requirements are not met or only partially met.

Stage 2 - Interdepartmental digitization: The enterprise is actively engaged in elements of Industry 4.0. Digitalization is being implemented in various departments and the first Industry 4.0 requirements are being implemented across the enterprise.

Stage 3 - Horizontal and vertical digitalization: The enterprise is digitalized horizontally and vertically. Industry 4.0 requirements have been implemented within the enterprise and information flows have been automated.

Stage 4 - Complete digitalization: The enterprise is completely digitalized even beyond the enterprise boundaries and integrated into value networks. Industry 4.0 approaches are actively pursued and embedded within the corporate strategy.

Stage 5 - Optimizing complete digitalization: The enterprise is a model for Industry 4.0 activities. It works closely with its business partners and therefore optimises its value networks, Fig. 1.

4. Digitalization and risks

Risks in the context of digitalization begin with an assessment of all the impacts (risks, opportunities, and changes) that may affect the organization in a given environment, Fig. 2.

On the one hand, it is necessary to identify the requirements imposed by customers and stakeholders and, on the other hand, the inherent requirements ensured by the operation of the enterprise. Subsequently, it is necessary to consider all the activities carried out within the set processes and their impact on the fulfilment or non-fulfilment of these requirements. These activities are based on specific sources, e.g., the political situation in the organisation's location, and may represent threats arising from the dissatisfaction of certain social groups. The degree of dissatisfaction, i.e., the magnitude of the impact of this parameter, depends on a closer examination of its characteristics (e.g., political orientation, religion, etc.). Financial threats depend on the possibility of losing an important customer.

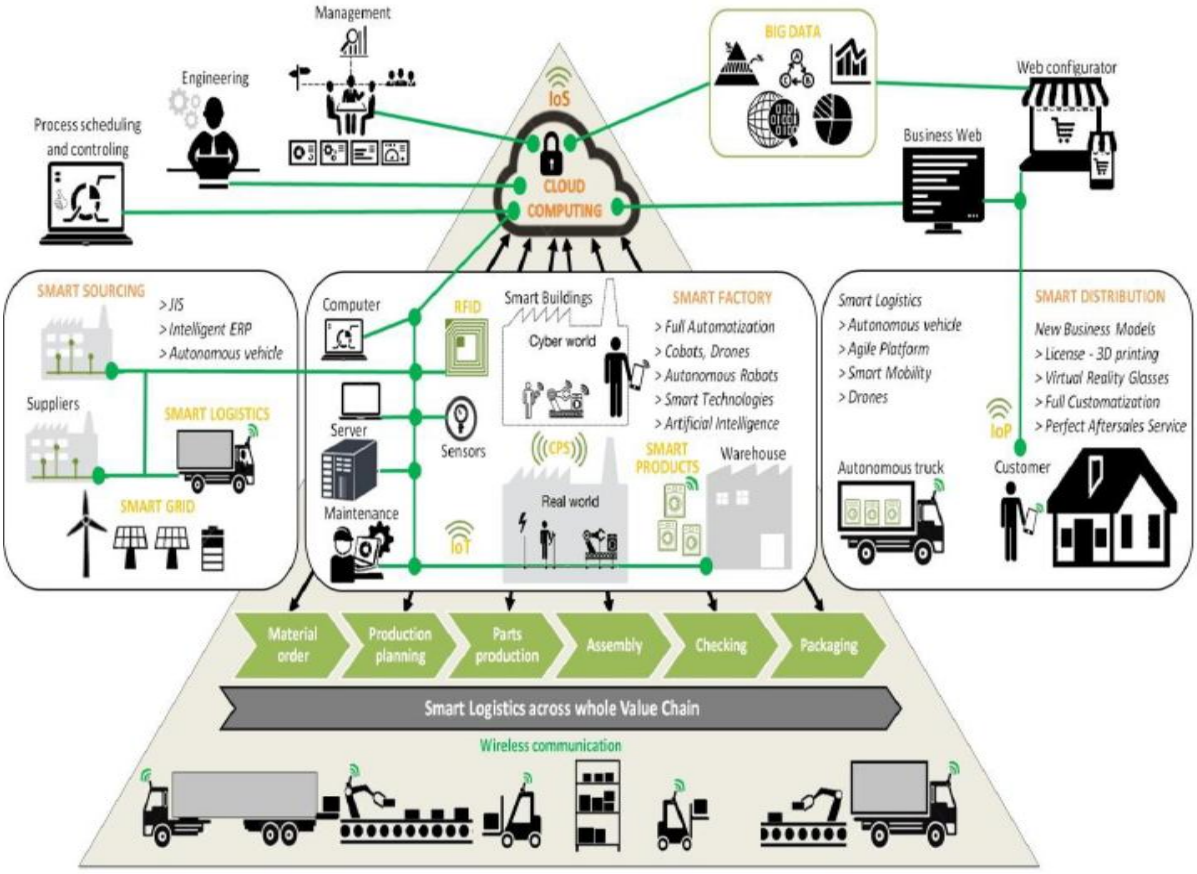

Fig. 1 *Example of Stage 5 of digitalization in the enterprise [3]*

It cannot be assumed that there are fewer risks in a company with a lower level of digitalization, but the nature of the risks is changing and so is the way they are managed. The implementation of the different phases of digitalization will improve and humanize the work in the production lines. Simple manual tasks will disappear. Employees will be coordinators who ensure smooth production and will only intervene when a machine calls them to action. It can be concluded that areas where Industry 4.0 elements are not implemented will be more Safety-oriented, while areas where Industry 4.0 elements are more actively used will be more Security-oriented.

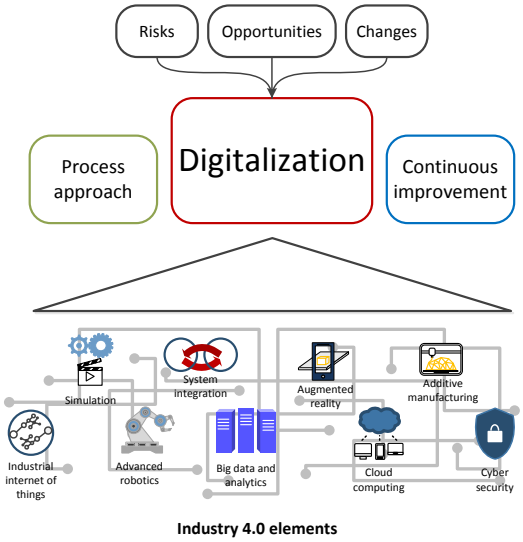

Fig. 2 *Risks in the context of digitalization*

5. Change of perception of the need for digitalization in enterprises

Before the pandemic, a survey [4] was conducted in enterprises of the Slovak Republic, one part of which was devoted to the analysis of the current state of digitalization in relation to safety and security. This part consisted of 24 questions. The results came out interestingly, namely that 34% of the respondents were aware of the need to implement digitalization in the enterprise but considered it to be little known in the enterprise. 32% of the respondents perceived that digitalization in relation to safety and security is only marginally reflected in the management of the enterprise. The estimate of the degree of digitalization in 18.9% of enterprises came out to be around 51%-60%, Fig. 3.

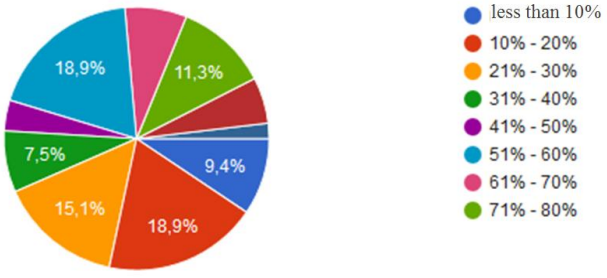

Fig. 3 *Perception of the need for digitalization in enterprises before the pandemic*

The global spread of COVID-19 infection and the deployment of strict precautionary and safety measures has led in many cases to the paralysis of production facilities. Thanks to digitalization, some enterprises have had sufficiently flexible and agile processes to be able to implement and continue their business activities without downtime, disruption, and unnecessary financial costs.

The crisis caused by the pandemic has significantly changed the previous plans in many companies. If digitalization has not been a priority so far, enterprises will have to rethink their strategic plans if they want to continue operating after the crisis. The same is true for automation, where, as a result of the current crisis, a similar scenario is expected in this area as for digitalization [1].

It is the current pandemic that has highlighted the gaps and reserves in business processes at different levels that could provide digital transformation solutions. In this case, it is a matter of trivial signing of legally binding documents by statutory officers remotely up to more complex solutions for dynamic management of production lines or supply.

This situation has revealed the need for digitalization for:

1. crisis management,
2. access to accurate, correct and up-to-date information.

The crisis has divided enterprises into two groups. The first group includes companies whose operations are currently shut down. These enterprises belong to the endangered group and their priorities will focus on the survival of the enterprise, consolidation after the crisis and rehabilitation of the enterprise. The crisis will help them to identify weaknesses and they will also need to focus on increasing the flexibility of processes so that the operation is able to respond to extreme market fluctuations, such as in the case of a pandemic. The second group includes companies that are managing their business activities during the crisis thanks to digitalization.

6. Conclusion

Evidence of the need for digitization and a change in perception is the existence of at least partial digitization in almost every company, at least in the form of a basic in-house digital system related to financial-administrative processes. Deploying new technologies, process optimization, continuous innovation and setting up new operating as well as business models will be a new strategic challenge for most companies.

This contribution is the result of the projects implementation: APVV No. 19-0367 Integrated Process Safety Management Approach Framework for the Smart Enterprise

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Improvement of the production processes based on the lean methodology

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Abstract: *The project for improvement of the production process based on the Lean methodology in SMELT-ING DOO was implemented in four phases (mini projects). The detailed analysis of the work orders in the period of 9 months provided clear picture of the current situation. With the defined methodology and through mutual meetings with the upper management and the employees of the company, the project team managed to introduce and implement the following mini projects: improved visualisation, digital work order, implementation of 5S and portable tools trolley. All these mini projects have improved the organization of the production process and helped the process of waste elimination in the company.*
Keywords*: IMPROVEMENT, PRODUCTION, LEAN, PROJECT, WORK ORDER, VISUAL MANAGEMENT, 5S, MANUFACTURING.*

1. Introduction

Lean is an approach to manufacturing that focuses on eliminating waste and improving workflow. It is particularly associated with the production system established at Toyota, with its twin pillars of just-in-time inventory management and automated quality control. In recent decades the principles of 'lean thinking' have been increasingly applied within the various industries to banish waste and create value [1].

The authors were part of an international project Increasing the Competitiveness of the Domestic SMEs in Order to Improve Their Cooperation with Foreign Investors' Companies [InComSMEs] where 6 SMEs from North Macedonia were selected and industrial projects were carried out, www.mf.edu.mk/incomsmes. This case presents one of the projects, implemented in SMELT-ING DOO.

SMELT-ING DOO was founded in 1996 as a company for trade of electrical materials. Since then, the company is constantly growing and investing in various other businesses in North Macedonia and the region. SMELT-ING DOO is famous for its flexibility and the individual approach to each of its clients. They produce electrical cabinets, complex metal assemblies and production of welding machines. SMELT-ING DOO team has provided significant support during the entire InComSMEs project. They were included in all training sessions organized by the Faculty of Mechanical Engineering – Skopje and the Technical University of Vienna. After they were selected as one of the companies for implementing this industrial project, the employees strongly engaged in the process and proposed many improvement ideas for their organization. The project plan for implementation of the project is shown in Figure 1.

	Project name	Improvement of the production processes based on the lean methodology								
	Phases	MONTH								
		Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.
1	Preparatory activities										
2	Collecting data and analysis										
3	Identifying and prioritizing problems										
4	Development of solutions										
5	Implementation of the solutions										
5	Monitoring of the solutions										
7	Standardization of the processes										
8	Preparation of documentation										
9	Preparation of the final report										
	Project leader	Assoc. prof. Bojan Jovanoski (Faculty of Mechanical Engineering – Skopje, UKIM)									

Fig. 1 *Project plan*

2. Prerequisites and means for solving the problem

One of the first tasks that were completed in the phase of the project was an analysis of the layout i.e., the material flow on the shop floor of SMELT-ING DOO. Figure 2 is presenting the material flow analysis for three specific products. The flow in the production area is chaotic and this is understandable because they have a heterogeneous product line. But there are no overlapping lines, as seen in Figure 2, which means that the current machine layout is acceptable. This means that the efforts of the project team shouldn't be directed towards the improvement of the transportation paths and reorganization of the production shop floor (redesign of the layout).

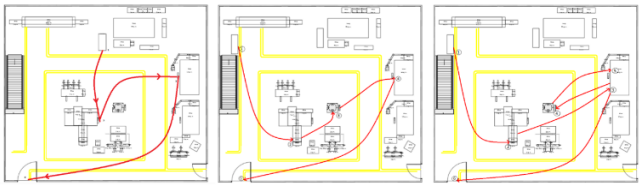


Fig. 2 *Analyzed layouts and flow paths for the products (red lines)*

After this, as shown in the project plan, in a six-month time span, a detailed analysis of one of their main client's programs was performed, according to the real manufacturing demand and work orders. The goal of this analysis was to determine the distribution of time for each product (and batch) and based on these findings, the team to propose future improvements (Figure 3).

NEEDED PROCESS CAPACITY

Name of the process	Part number	Requirement	Monitored by
Metal processing	GEH-0656	30	Aleksandar
		Net Operating Time in sec (I)	Date
		25.200	20-Mar-19

			Basic time in sec.			Total changeover time in sec.			Summary in sec.	
#	Operation	Machine	Manual work A	Automatic work B	Machine work C = A+B	Changeover time D	Quantity during changeover	Time/part F=D/E	Total time for one part G=C+F	Process capacity H=I/G
1	Trail		30	110	140	765	30	25,5	165,5	152
2	Cut through		165	920	1085	5	30	0,166667	1085,1	23
3	Ginding		605	0	650	5	30	0,166667	605,1	42
		Total	800	1030					Max. output	23

Standard Work Combination Sheet

Name of the process	Part number	Net Operating Time in sec.	Legend
Monitored by		Date	Motion, Manual work, Automatic work, Waiting

#	Operation	Operator	Automatic work	Motion	Operational time in sec. 10	20	30	40	50
1	Taking material	5							
2	Set on the machine	65							
3	Positioning	8							
4	Positioning		20						
5	Cutting		900						
6	Taking out and control	87							
7	Grinding	605							

Fig. 3 *Detailed analysis for specific products*

From all these observations, a table containing all the products that SMELT-ING DOO is manufacturing for KEMET was generated, with the time needed for manufacturing (T_i) and setup time (T_{pz}) for each machine separately. In the period when this observation was performed, there was no demand for all products. Therefore, for those products (that were not observed), the project team adopted the times for the most similar product that was observed during the project (if needed, some of the times were modified based on past experiences), Figure 4.

After processing the collected data, the project team analysed the work orders from the past year, to provide reliable analysis for

the utilization of the capacities. After this detailed analysis, a presentation in SMELT-ING DOO summarized the conclusions from the observations of the manufacturing process in the past months.

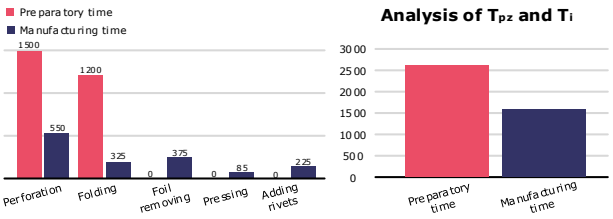


Fig. 4 *T_{pz} and T_i analysis*

Besides the fact that this analysis provided many various results such as the utilization of every machine for the selected production program, the team was especially interested in the setup time data – which are times that are not adding any value to the process. The results are shown in Figure 5.

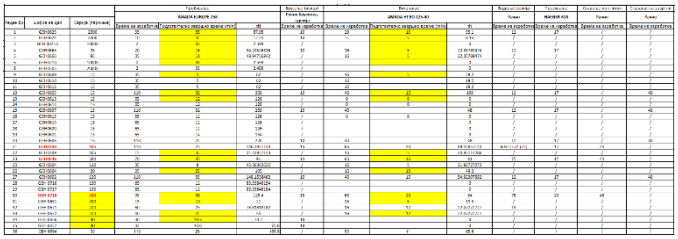


Fig. 5 *Detailed analysis of T_{pz} per product*

3. Challenges

Right after the analysis of the production system, the upper management of the company organized several workshops including all employees from the manufacturing department. The project team was leading the process according to a previously set methodology. Before the application of each new tool or method, the team explained the tool/method and ensured that all employees are aware of its meaning and application. During the process, many ideas were proposed and through filling of CIP cards [2, 5] (Continuous Improvement Process) shown in Figure 6 the team prepared KAIZEN board, specially designed for SMELT-ING DOO, as shown in Figure 7.

The ideas were classified as mini projects and were assigned to a responsible team member:

- Improved visualisation (Bojan Nestorovski),
- Digital work order (Bojan Jovanoski),
- Implementation of 5S (Aleksandar Neveselov),
- Portable tool trolley (Zarko Angeleski).

Name		Date	
☐Safety	☐Quality	☐Productivity	☐Costs
Description of the problem			
5 Why analysis		Suggested countermeasures	

Fig. 6 *CIP card template*

KAIZEN is an approach that continuously improve operations and involve all employees [2, 4]. It is a business philosophy or system that is based on making positive changes on a regular basis, as to improve productivity [6]. For this project, a KAIZEN board was implemented where the team and the company employees can generate and monitor all the ideas for a particular topic. From total of 12 ideas, in accordance with the timeframe for this project, the project team decided to prioritize 4 ideas for further development and implementation.

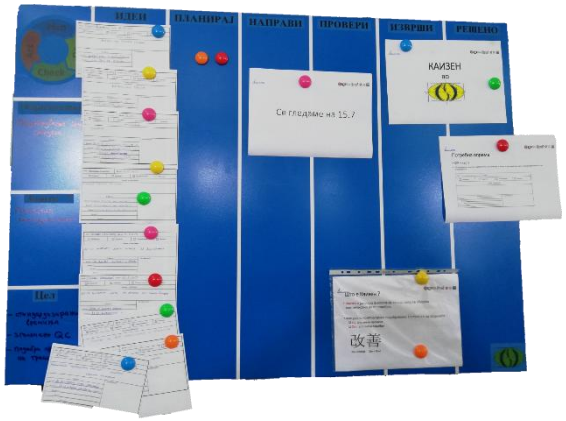


Fig. 7 *KAIZEN board*

4. Results and effects

It is very important to mention that from the start of the entire project and during the initial visits of SMELT-ING DOO, the project team could recognize a well-organized company and successfully set systems. All mini projects that are subject to this study, are simply improvements of the currently well-organized shop floor. All these projects were directed towards the elimination of the waste time (the non-value adding time).

4.1.Improved visualisation

The goal of this mini project was to enhance the visualisation of the manufacturing shop floor. During the project, many crucial positions were labelled such as the movement paths, the machines and most importantly, labels were placed on the tools needed in the manufacturing process (Figure 8).

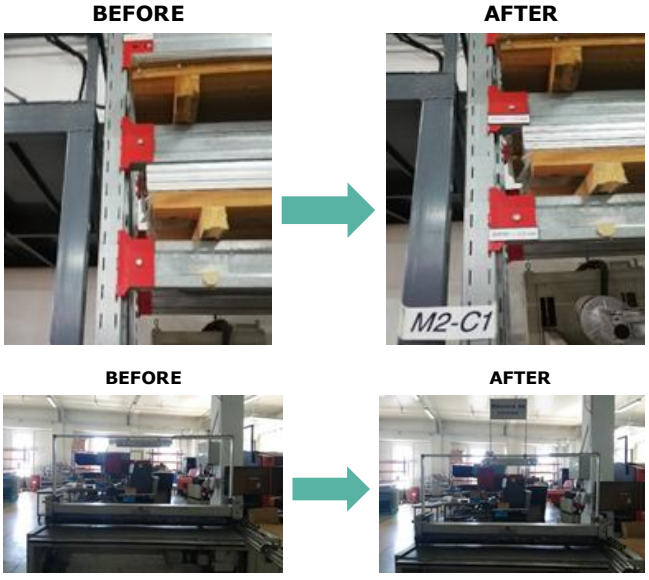


Fig. 8 *Part of the improvements of the visualization on the shop floor*

4.2. Digital work-order

SMELT-ING DOO had ideas for the introduction of ERP system. But considering that this company is connected to many other organizations that still don't use this ERP system, in this timeframe, implementation of such a system was ruled out. Instead, the project team prepared a solution that will still fulfil the requirements of the company for digital work order until the ERP system is implemented. Based on the observed times in the previous phase, a digital work order template was prepared in Microsoft Excel (Figure 9). This enabled flexibility for the employees, but also it was a system for better planning and control of the production.

Work order number ________________

SMELT-ING.DOO

Contract number	
Product	
Delivery date	

Order number	
Quantity	
Completion date	

Client	
Materials	
Starting date	

Notes

#	Activity	Machine/tool	Time $t_{ʀ}$ (sec.)	Batch time (min.)	Control	Responsible	Notes
0	Taking material						
1	Cut trough						
2	Grind						
3	Fold						
4	Removing foil						
5	Press						
			Total	(min)	or	(h)	work

Finishing date	

Control of the finished product

Date	
Responsible	

Corrective measures

Fig. 9 *Digital work order with previously defined technology and times*

4.3. Implementation of 5S

5S is an approach to organize, order, clean, standardize and continuously improve a work area. 5S is not just about housekeeping, it is one of the most efficiently working tools of Lean manufacturing [3]. This approach was introduced to SMELT-ING DOO's workplace to enhance the effectiveness of the production and eliminate unnecessary objects (devices, machines, documents, etc.). The steps to implement 5S are **sort**, **set**, **shine**, **standardize** and **sustain**.

The 5S activities usually seem very simple and easy, but the project team spent most of the time and energy on this mini project as they are time consuming. Sometimes, full implementation of 5S can take up to 3 years, but the project team had only 2 to 3 months. Considering the time constrains, the team focused only on the most frequently used machine, but also the machine where the T_{pz} values were the highest (as identified in the observations at the beginning of the project). The goal was to empower the employees to be involved in this process on a daily basis and therefore sustain the solutions set up with this project. Considering one of the most important goals of the project – to connect the output control of SMELT-ING DOO and the input control of their client, it was suggested to use the client's 5S checklist for audits and adapt it accordingly (Figure 7).

Fig. 10 *5S checklist*

	Чек - листа				Област				Внеси име на оддел	Добиена вредност	Максимална вредност	Процент
	Безбедност	0	1	2	3	4	5	NA	Забелешка			
1	Дали пешачките патеки, патеките до ППА и патеките за излез се одржуваат						X		Да, пешачките патеки и патеките за излез се одржуваат.			
2	Дали "СТОП" копчето е во функција и истото е на достапно место за работникот						X		Во функција е и истото се наоѓа на достапно место каде вработениот може лесно да го притисне, доколку има потреба.			
3	Дали шкафчињата за електрика (ормарите) се чуваат затворени?						X		Да, секогаш се чуваат затворени.			
4	Средства за лична безбедност се достапени и се во употреба						X		Да			
5	Кога е возможно, се користат транспортни средства за пренесување тежок товар						X		Да			
	Вредност	0	0	0	0	0	25	0		25	25	100%
	Сортирај	0	1	2	3	4	5	NA	Забелешка			
6	Дали има лични предмети на работното место				X				Има понекогаш (најчесто телефон). За да дојдеме до оцена 5 потребно е сите лични предмети да се отстранат од работното место и да стојат само оние работи кои се потребни.			
7	Постојат инструменти или машини кои не се користат или се оштетени / расипани, кои не се користат во процесот				X				Постојат, една машина се наоѓа во погонот но не се користи. Визуелизацијата би била едно од најдобрите решенија на која просторот/машините кои што не се користат ќе биде обележани.			
8	Материјалите/ остатоците /неусогласените делови се чуваат одделно на соодветен начин и се управуваат во соодветна област				X				Недостасува документирање на сортирањето.			
9	Материјалите / алатите кои се во лоша состојба правилно се идентификувани? Се користат?					X			Не се користат и истите се идентификуват.			
10	Дали некој материјали или производ што не е поврзан со чекорите на процесот се анализира?						X		Не. Се анализираат само оние чекори кои што се потребни за изработка на еден производ.			
	Вредност	0	0	0	9	4	5	0		18	25	72%
	Подреди	0	1	2	3	4	5	NA	Забелешка			
11	Промена / резервни делови се достапни и нивната позиција е правилно идентификувана и јасна за секого				X				За оцена 5 потребно е деловите да бидат достапни за секого, да се знае нивната позиција со што ќе резултира пократок временски интервал за нивно пронаоѓање.			
12	Алатките кои се користат за подесување / мерење се достапни и добро користени					X			Да, но за да се дојде до оцена 5 потребно е истите освен да се достапни треба да се наоѓаат на видно место за истите да се пронајдат во најкратко можно време.			
13	Материјалите што се користат во производството се добро идентификувани и складирани на соодветен начин и се блиску до машините каде што истите ќе се користат					X			Да, тие се наоѓаат блиску да машините но тоа зависи од нивната фреквенција(честоста) на употреба. За оцена 5 потребно е секој предмет да има свое место.			
14	Работната површина / машина е оставена на правилен начин за наредниот ден					X			Доколку/кога ке се постави количката, би требало да достигне до оцена 5.			
	Вредност	0	0	0	3	12	0	0		15	20	75%
	Поедностави / чисти	0	1	2	3	4	5	NA	Забелешка			
15	На крајот на серијата (за машината) и на крајот на смената (општо) сите работни станици се правилно исчистени					X			Да, на крајот на работниот ден станиците се исчистени, но не во целост, што значи за оцена 5 потребни се поголеми напори, односно чистењето да биде секојдневие на вработените.			
16	Превентивното одржување и евиденцијата се прават на правилен начин (според планираното)	X							Се извршува превентивно одржување, но истото не се спроведува по план. (Кога вработениот има слободно време). За да дојдеме до оцена 5 мора превентивното одржување на машините и евиденцијата да се спроведуваат плански.			
17	Масата за контрола се чисти на соодветен начин							X	Нема маса за контрола.			
18	Местото за материјали се одржува чисто и на организиран начин					X			Се одржува, но не во целост. За оцена 5 потребно е местото каде што се поставени материјалите да биде организирано за секој од вработените во секој момент да знае кој материјал каде се наоѓа.			
19	Инструментите и документацијата се одржуваат на соодветен начин (читлив, без оштетување, ажуриран)					X						
	Вредност	0	0	0	0	12	0	1		12	20	60%
	Стандардизирај и одржи	0	1	2	3	4	5	NA	Забелешка			
20	Кога е планирано, извршена е проверка на пример парче и е документирано соодветно							X	Не се прави.			
21	Евиденцијата за планираните контроли е достапна и добро изработена (читлива и јасна)	X							Нема евиденција.			
22	Сличните работни станици / машини се стандардизирани за материјали, документација, евиденција			X					Да, доколку дозволуваат карактеристиките.			
23	Местото за материјали го следи истиот метод за идентификација и ова е стандардизирано				X				На едно место е ставено се. За оцена 5 потребно е да се направи (со визуелизација), за секој материјал посебно место или пак да се обележи кој е кој материјал (доколку се ставени сите на исто место).			
24	Вратата што ќе се одржува затворена е навистина затворена? Дали има валкана врата / ѕид / под.					X			Да, истата е постојано затворена. Се чисти секојдневно.			
25	Скршени / оштетени работи (алатки, врата, прозорец, маса, шкафче) се идентификуваат и се пријауваат за истите да бидат поправени или отстранети доколку не може да се поправат.			X					Да, се идентификуваат и се пријавуваат кои понатаму или се поправаат или се купуваат нови, доколку истите не можат да се поправат.Оцена 2 е бидејќи потреба е потврда од надредениот.			
	Вредност	0	0	4	3	4	0	1		11	25	44%
									Вкупна вредност	81	115	70%

Figure 11 is showing some of the before and after photos of this project.

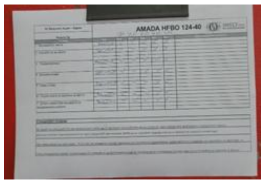
1S	The sort step was implemented using specially designed red tags.	
2S	The set step was implemented using different boxes and labels in different colors. The tools were selected according to the frequency of using. All tools that are commonly used was set in specially designed cabinet. This enables the operators to find the tools easier and identify if any tools are missing.	 
3S	The company already has cleaning system in place.	
4S	To ensure that all implemented changes are respected by the employees, simple daily checklist were created to ensure standardized work of the operators over the workday.	
5S	To sustain the solutions, the upper management will perform yearly 5S audit according to created checklist.	

Figure 11: *Improvement of the 5S – before and after implementation*

This small project was thoroughly planned, and the implementation was monitored and controlled very closely by the team. Before each phase, the project team had presentations for the employees for each 5S phase and the outcomes of each phase. After this, with deadlines in place, SMELT-ING DOO employees implemented the activities for the phases. Before moving to the next 5S step, an evaluation of the 5S implementation was undertaken using the audit checklist.

Figure 12 is showing the progress of the 5S in the company.

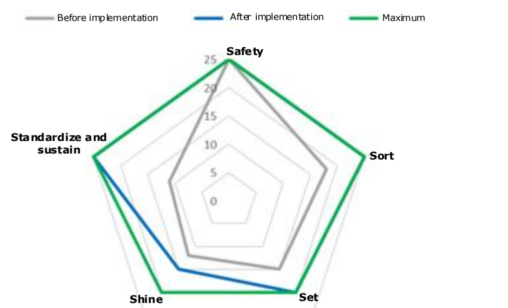


Fig. 12 *Improvement of the 5S*

According to Figure 12, in the beginning, the 5S score was 81 points. At the end of the implementation, the score was enhanced up to 110 points out of 115 possible. Due to time constrains, the procedure for preventive and corrective maintenance of the machines was not implemented.

4.4. Portable tools trolley

Due to the many different tools that were usually left all over the machines in the production area, without any order, the need for a solution for better organization was needed. With the implementation of this trolley, every tool got its own place which was labelled accordingly. The trolley is designed to be portable, and the operators can move it on the shop floor (Figure 13).

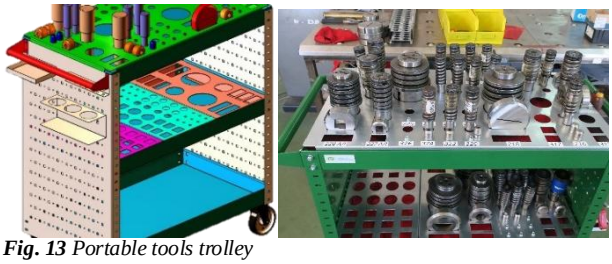


Fig. 13 *Portable tools trolley*

The trolley is equipped with brakes so that the operators can stop the trolley when they are working with the tools, or they are simply storing it on the shop floor. The trolley consists of three drawers, where the first drawer is dedicated for the most frequently used tools. Both vertical sides of the trolley are also utilized with the most common tools as screwdrivers, pliers, etc., as well as protective equipment for the operators (gloves, anti-noise earplugs, etc.). This trolley directly helped the previous mini project and significantly helped achieve the satisfactory 5S score in the company. The trolley is designed and produced by SMELTING DOO and is now offered to the clients as one of their products.

5. Conclusion

The project with title “Improvement of the production processes based on the lean methodology” was implemented in SMELT-ING DOO. The project lasted for nine months, was carefully planned and consisted of four mini projects with specific results from each:

- Improved visualisation
- Digital work order
- Implementation of 5S
- Portable tool trolley

The demand for those mini projects was established at working meetings and mutual agreement, aided by the KAIZEN board. Before that, a 4-months detailed analysis was conducted where the following elements were created: spaghetti diagrams, process capacity tables for the products, standard work combination sheet, process chart, diagram of the document flow – from order to delivery, and capacity analysis for all machines. The conclusion from the analysis was that the company needs to work more on decreasing the time for setup and less for the operative time.

The implementation of 5S required the most time to be executed, as planned. Every stage of the methodology was organized with a presentation for the workers, plan of tasks to be undertaken, time to implement actions and evaluation of the performance at the end. The digital working order helped the company better plan and control the production processes, clearly stating the check points. The improved visualization, together with the portable cart, organized the production department even further and decreased the time the workers need to initiate the work orders.

The involvement of the company’s employees was essential during this project and that is one of the main lessons learned during the implementation. They welcomed the improvements with great enthusiasm and provided many creative ideas for improvement of their organization. The changes were easily managed and accepted as the project team ensured to present and communicate the newly implemented changes prior to the implementation.

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Измерване на шум на работно място при механично обработване на метали и оценка на риска за работещите от въздействието му

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Abstract: *The aim of the present study is to measure the noise level at workplaces related to metal machining - turning and milling, assessing the risk to the health of exposed workers..*
Keywords*: noise level; metal machining, occupational noise*

1. Въведение

Експозицията на шум при работа може да увреди здравето на работещите. Най-известният ефект от шума при работа е загубата на слух, един проблем наблюдаван сред майсторите на медни изделия през 1731 г. Той обаче може също така да изостри стреса и да увеличи риска от злополуки.

Загубата на слуха, причинена от шум, обикновено се дължи на продължително излагане на силен шум. Първият симптом обичайно е невъзможността да се чуят звукове с висок регистър. Докато на проблема с прекомерния шум се обърне внимание, слухът на съответното лице продължава да се уврежда, включително до степен да среща затруднения при откриването на звукове с по-нисък регистър. Обикновено това се случва и за двете уши. Увреждания при загуба на слуха, причинена от шум, са трайни.

Целта на настоящото изследване е да бъде измерено дневното ниво на шум на работни места свързани с механично обработване на метали – струговане и фрезоване, като бъде оценен риска за здравето на експонираните работещи [1].

2. Изложение

По своето хигиенно значение шумът е на едно от първите места сред неблагоприятно действащите фактори на работната среда. От физична гледна точка шумът се определя като съвкупност от звукови вълни с различна честота и амплитуда, които се разпространяват във въздуха и се възприемат от човешкото ухо. От физиологична гледна точка шумът е всеки нежелан, неприятен и дразнещ звук, който не само може да увреди здравето, но също така и да смути отдиха, да наруши съня, да доведе до намалена работоспособност и да пречи на трудовата дейност.

В хигиенната практика шумовият фактор се характеризира с два основни параметъра:

- *Интензитет (сила) на шума*. Представлява количеството звукова енергия, която преминава за единица време през площ, перпендикулярна на посоката на звуковата вълна. В акустиката е възприето интензитетът да се оценява в бел или децибел. Минималната интензивност, доловима при пълна тишина се нарича праг на чуване, а силата, при която възниква неприятното усещане – праг на болката. Общата сила на шума за всяко работно място нараства при увеличаване броя на източниците на шум. Важна особеност на характеристиката на скалата на децибели е, че тя не представлява сбор от различната сила на шума.

Два различни източника на шум всеки със сила 80 dB заедно дават 83 dB, а не 160 dB. Важно е също така да се знае, че изменението от 80 dB до 83 dB се възприема от човешкото ухо със същата сила, както се възприема при прехода от 40 dB до 43 dB, т.е. изменението от 3 dB, както е в случая, винаги има еднакво въздействие при възприемането на шума, независимо от първоначалната му сила.

- *Спектър на шума (честота)*. Честотната характеристика на шума представлява съвкупността на честотите на съставящите го тонове. Слуховият анализатор е способен да възприема звуци, характеризиращи се с честота на колебанията от 16 Hz до 20 000 Hz. С увеличение на възрастта този диапазон физиологично се стеснява. Разговорната реч е между 100 Hz и 7 000 Hz.

В зависимост от промяната на интензитета шумът може да бъде:

- ✓ Постоянен шум – шум, чието ниво с течение на времето се изменя с не повече от 5 dB;
- ✓ Непостоянен шум – шум, чието ниво се изменя с повече от 5 dB. Той от своя страна се разделя на:
- ✓ Импулсен – шумов сигнал във вид на отделни импулси с продължителност от 1 до 200 ms и възприемани от ухото като следващи един след друг;
- ✓ Прекъсващ шум – нивото, на който спада внезапно за къси интервали и многократно – до околното ниво и флуктуиращ шум, чието ниво непрекъснато варира.

Нормативни изисквания

Нормативните изисквания относно шума на работните места са регламентирани в Наредба № 6 [2] и Наредба 7 [3]. Наредба № 6 определя граничните стойности на експозиция и стойностите на експозиция за предприемане на действия на база дневните нива на експозиция на шум и върхово звуково налягане както следва:

- Гранични стойности на експозиця: Lex, 8h = 87 dB(A) и Ppeak = 200 Pa, съответно 140 dB(C);
- Горни стойности на експозиция за предприемане на действие: Lex, 8h = 85 dB(A) и Ppeak = 140 Pa, съответстващо на 137 dB(C);
- Долни стойности на експозиция за предприемане на действие: Lex, 8h = 80 dB(A) и Ppeak = 112 Pa, съответно 135 dB(C);

Въздействие на шума върху здравето на работещите

Въздействието на шума върху организма се обуславя от следните по-важни фактори:

- Параметри на шума – интензивност, честотна характеристика, вид на шума (постоянен, променлив, прекъсващ, импулсен);
- Експозиция на шумовото въздействие през работния ден;
- Характер на извършваната дейност (предимно физически или свързан с нервно-психично напрежение труд);
- Индивидуална чувствителност, пол, възраст;
- Наличие на други вредни фактори на работната среда – вибрации, неблагоприятен микроклимат, електромагнитни полета и др.

Степента и характерът на въздействие на шума върху организма се определят преди всичко от нивото на звуковото налягане в октавните ивици на звуковите честоти и от продължителността на дневната и обща експозиция.

Оценка на риска при експозиция на производствен шум

За целите на оценката на риска следва да бъдат оценени и когато е необходимо, да се измерят нивата на шума, на който работещите са експонирани. Методите и апаратурата, които се използват за измерване нивата на шума трябва да дават възможност за изчисляване на експозиция, както и за определяне на горни и долни стойности за предприемане на действие.

При оценяване на риска се взема под внимание:

- Нивото, вида и продължителността на експозицията, включително всяка експозиция на импулсен шум;

- Резултатите от измерванията;
- Всеки ефект за здравето и безопасността за работещи, които са особено чувствителни към експозицията на шум;
- Всеки ефект върху здравето и безопасността на работещите, който е резултат от взаимодействието между шума и свързаните с работата ототоксични вещества и между шума и вибрациите;
- Всяко косвено въздействие върху здравето и безопасността на работещитя, произтичащо от взаимодействието между шума и предупреждаващите сигнали или други звуци, които трябва да се следят, за да се намали риска от злополуки;
- Информацията за емисията на шум, предоставена от производителя на работното оборудване, в съответствие с изискванията на Закона за техническите изисквания към продуктите и подзаконовите нормативни актове към него;
- Случаите, при които експозицията на шум продължава и след приключване на работното време, включително по време на почивка, за които е отговорен работодателят;
- Всяка информация, получена от здравното наблюдение на работещите, както и публикувана информация;
- Наличие на средства за защита на слуха с подходящи характеристики за намаляване на шума.

Разработват се карти за оценка на риска. Определят се цифрово елементите на риска и стойността (рисковото число), като се посочват и мерките за ограничаване на риска.

P	=	B	x	E	x	T
/рисково число/		/вероятност/		/експозиция/		/тежест/

Оценката на риска е краен резултат, който установява допустимостта на риска и необходимостта от прилагане на допълнителни мерки за неговото намаляване. Използвана е цифровата методика дефинирана в[4, 5].

Опитни данни и резултати

Обект на настоящото изследване са работни места при обработка на метали, като са направени измервания и е оценен риска за работните места:

- *Оператор струг*
- *Оператор фреза*

Метод на измерване и технически средства

Измерването на шума се извършва съгласно БДС EN ISO 1999 [6] и БДС EN ISO 9612 [7].

За работниците или групите с хомогенна експозиция на шум, които ще бъдат оценявани номиналният ден се разделя на задачи. Всяка задача да се дефинира така, че да има вероятност $L_{p,A,eqT}$ да бъде възпроизводимо. Трябва да се внимава да се обхванат всички приноси на съответните шумове. Подробната информация относно продължителността на задачите е особено важна при източници на шум с високи нива на шум. Установяването на източници на шум и задачи, които дават най-високи шумови нива е важно за точното изчисляване както на $L_{p,A,eqT}$, така и на $L_{p,Cpeak}$.

За всяка задача $L_{p,A,eqT,m}$, представляващо шумовата експозиция на работника трябва бъде измерено. Измерванията трябва да обхващат промените в нивата на шум в рамките на всяка задача във времето, пространството и условията на труд.

Продължителността на всяко измерване е достатъчно дълга да съответства на средното еквивалентно продължително ниво на звуково налягане за конкретната задача. Ако продължителността на задачата е по-малка от 5 минути, продължителността на всяко измерване трябва да бъде равно на продължителността на задачата. За по-дълги задачи, продължителността на всяко измерване трябва да бъде минимум 5 минути. Може, обаче продължителността на всяко измерване да се намали, ако нивото е постоянно или се повтаря, или ако шумът от задачата носи незначителен принос към общата експозиция на шум.

Ако шумът по време на задачата е цикличен, всяко измерване трябва да обхваща продължителността на най-малко три добре дефинирани цикъла. Ако продължителността на трите цикъла е по-малка от 5 min, всяко измерване трябва да бъде най-малко 5 min. Продължителността на всяко измерване трябва винаги да съответства на продължителността на определен брой пълни цикли.

За всяка задача трябва са направени най-малко три измервания. За да се обхванат действителните промени в нивата на шум, препоръчително е измерванията да се направят в различни моменти по време на задачата или при различни работници в групата.

Измерваните нива на шум са представителни за нивата на шум, възприемани от ухото на работника. Ако звуковото поле е еднородно, точното място на измерване не е толкова критично.

Измерванията са извършени с микрофон, поставен на мястото, където се намира главата на работника по време на нормалното извършване на работа или задача. За предпочитане е да се постави в централната равнина на главата на работника, на линията на очите, с ос, успоредна на погледа на работника и в отсъствие на работника. Трябва да се вземат под внимание различни съответстващи положения на главата на работника в пространството. Средното ниво на звуково налягане на работното място може също да се получи чрез движение на шумомера (с махово движение) в представляващата интерес зона.

В случаите, когато се налага работникът да присъства на работното място, микрофонът е разположен или да се държи на разстояние между 0,1 m и 0,4 m от външния отвор на ушния канал от страната на ухото с най-голяма експозиция.

Ако дейността на работника или конфигурацията на работното място прави невъзможно спазването на дистанция от 0,4 m, препоръчва се да се използва уред, който да бъде поставен на работника.

Ако местоположението на работника е в голяма близост до източниците на шум, звуковото поле трябва внимателно да се проучи. Ако положението на главата на работното място не е добре дефинирано, може да се използват следните позиции на микрофона

а) работник в изправено положение – 1,55 m ± 0,075 m над повърхността, на която стои работникът;

б) работник в седнало положение – 0,80 m ± 0,05 m от средата на равнината на седалката, като седалката е поставена във или възможно най-близо до средната точка на нейното хоризонтално и вертикално регулиране.

Разширената неопределеност на измерването, заедно със съответния коефициент на покритие се посочва за едностранен доверителен интервал от 95% и се изчислява съгласно Анекс С от БДС EN ISO 9612.

Измерванията са направени с калибрирани технически средства, съответстващи на изискванията на IEC 804 и IEC 651:

- Звуков калибратор, „CEL 120/1", Ид. № 3941747, CASELLA Англия
- Интегриращ шумомер, CEL 430/2, Ид. № 087889, CASELLA Англия

От направените измервания на еквивалентното ниво на шум се изчислява дневното ниво на експозиция на шум по формула [1]:

$$L_{EX,8h} = L_{Aeq,Te} + 10\lg\left(\frac{Te}{To}\right),$$

където: Te – експозицията на шум, h; To – продължителността на работния ден (8h); $L_{Aeq,\ Te}$ – измереното еквивалентно ниво на шум, dB(A);

Резултатите от направените измервания и изчисления на дневното ниво на експозиция на шум на изследваните работни места са представени на табл. 1.

Табл. 1. Данни от измерванията на шум

№	Място на измерване (помещение) размер на групата, длъжности, описание на работните задачи и дейности	Източници на шум допринасящи за шумовата експозиция за всяка задача	Продължителност на всяка задача, min и номинална работен ден свързан с $L_{ex,T}$, dBA	Изчислено еквивалентно ниво на шум за всяка задача, L_{eq} dBA	Изчислено дневно ниво на експозиция на шум, $L_{ex,T}$, dBA	Неопределеност свързана с $L_{ex,T}$, dBA	Долна стойност на експозиция на шум за предприемане на действие, dBA	Горна стойност на експозиция на шум за предприемане на действие, dBA
1.	Оператор струг							
1.1	Настройка/подготовка на машината	оборудване в цеха	1,0 h	65,1				
1.2	Обработка на метални детайли	струг Durmazlar SB 3013NT	6,5 h	87,6	**86,7**	3,0	**80**	**85**
1.3	Физиологична почивка	-	0,5 h	52,1				
2.	Оператор фреза							
2.1	Настройка/подготовка на машината	оборудване в цеха	1,0 h	65,4				
2.2	Фрезоване на метални детайли	фреза - FU 321	6,5 h	86,5	**85,6**	3,0	**80**	**85**
2.3	Физиологична почивка	-	0,5 h	52,1				

Оценяване на риска на работните места

След определяне на елементите на риска и степента му, данните за изследваните места са показани в табл. 2

Табл. 2. Резултати от оценяването на риска

Работно място	**Оценяване на риска РЧ = В х Е х Т**				**Степен на риска**
	В	Е	Т	РЧ	
Оператор струг	3	6	3	54	II
Оператор фреза	3	6	3	54	II

Диапазонът на рискови числа е в интервала 20 < Р < 70, което съответства на риск от втора степен. Рискът е допустим, овладян на приемливо ниво, но би могъл да се увеличи. Във всички случаи е необходим контрол за запазване на нивото на съществуващите рискове в тези граници и възможно намаляване. Към момента са предприети следните мерки:

1. Работодателят е осигурил на всички работещи с ЛПС – антифони (вътрешни или външни), които са произведени в съответствие с европейските стандарти (БДС EN 352-1 и БДС EN 352-2), със звукоизолираща способност до 25 dBA, притежаващи сертификат за съответствие;
2. Работещите са обучени за правилно използване на осигурените антифони;
3. Осигурено е медицинско наблюдение на работещите, включващо преглед при специалист УНГ и аудиометрично изследване на слуха;
4. Разработен е и въведен физиологичен режим на труд и почивка. Има възможност и за допълнителни, спонтанни почивки;
5. Създадена е възможност за преместване на работещия на друго работно място по медицински показания;

3. Заключение

За запазване на нивото на съществуващите рискове в тези граници и възможно им намаляване, могат да се вземат следните постоянни мерки:

1. Да се провежда обучение на работещите относно правилното поддържане и съхранение на антифоните, съгласно изискванията.

2.Да се провеждат периодични проверки на състоянието на ЛПС

3.Да се изисква от работещите постоянно носене на антифоните, както и това да се контролира.

4. Поддръжка и ремонт на машините, с цел профилактика на шума и вибрациите.

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Energy assessment of a grid connected photovoltaic thermal (pv/t) liquid cooling system

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Abstract: *Solar energy has a great potential in Albania. The use of hybrid photovoltaic - thermal (PV/T) systems has shown an impressive progress in recent years. PV/T system can produce electricity and thermal energy simultaneously. In this paper, a 200 W PV/T system is introduced using water as cooling fluid, in order to regulate the temperature increase of the photovoltaic panels. The heat is collected via working fluid in a water tank. This study analyses the energy generation of this experimental setup, and aims to provide some accurate information in future developments and implementation of this technology in Albania. Coupling of PV/T system with heat pumps in buildings to meet the energy requirements could be of great interest for Albania's energy consumers*

Keywords*: ENERGY, PHOTOVOLTAIC, THERMAL, EXPERIMENTAL, ON-GRID*

1. Introduction

Solar energy potential in Albania is of great interest, due to its favorable geographic position in the Mediterranean. The new energy crisis the world is facing only confirms the need to exploit the renewable sources and developing new technologies to resolve the problems with heat and electricity supply. Albania is affected by the energy crisis resulting generally in higher fuel and energy prices. On the other hand this is reflected considerably in the economic burden of a typical Albanian household. Thus, exploitation of solar energy is being seen as a very promising opportunity for the Albanian consumers. Photovoltaic panels have shown to be a promising method for the conversion of solar energy into electricity and heat in a sustainable way [2]. Decrease of photovoltaic panel prices in the last decade has helped in promotion of this energy sector. Globally the PV market growth rate is estimated around 35-40 % per year [3]. This trend of PV market is being observed in Albania as well. Photovoltaic thermal system (PV/T) can produce heat and electricity simultaneously. The heat can be collected from a cooling fluid to a water tank for further use to produce hot water, space heating and cooling. Electricity could be stored or distributed to a grid connected system. Diversification of energy sources is a priority of the Albanian National Energy Strategy. Therefore, it requires full efforts of all the interest groups to embrace this approach. This is greatly enforced due to an increase of heat demand in the residential sector. The application of such systems will reduce the country's dependence on hydro resources, firewood, gas and electricity. In addition, PV/T systems result highly useful in terms of:

- the total efficiency per unit area of a PV/T panel is higher than the sum of the efficiencies of individually PV panels and thermal collectors [4].
- the energy payback of a PV/T system would be 2 years, whereas under equal climate conditions it would be 3.4 for PV system and 4.3 for a thermal collector.

However, a disadvantage of PV/T systems is the influence of PV cell temperature on electrical efficiency [5]. The decrease of the PV temperature shows an increase of the efficiency [6], resulting in necessity to cool down the PV panel. In this experimental study carry out in Tirana, water is used as working fluid to cool down the PV panel. The thermal energy extracted from the photovoltaic panel is collected into a water tank. The thermal efficiency of the PV/T panel is expressed as the ratio of thermal energy extracted by the flowing water with total energy reaching the module. In this paper we are focused on the energy production from a 200 W PV/T panel grid connected. The PV/T module is cooled down using water as working fluid. The experimental investigation takes into account the relevant factors of Albanian climate conditions. A special focus is paid to analyze the weather data collected throughout a year, such as air temperature and solar irradiation.

2. Solar energy situation in Albania

Albania's energy sector is highly dependent on hydro resources. Approximately 99.6 % of the electricity generation is based on hydropower. However, this is only one side of the situation. On the average Albania imports annually about 30 % of the total electricity consumption to meet the country's demand. The diversification of the country's electricity sector is critical, as the current system is almost entirely hydro-based and thus susceptible to climatic variations [7]. The National Energy Strategy stresses on diversification of energy sources with the main focus to increase the share of renewable energy, such as wind and especially solar power. Figure 1 shows the total installed photovoltaic capacity in Albania. From the graph we can figure out the prompt increase of the solar power installation in the last two years. This is a promising step to continue this trend in the near future in order to meet the goals set in the National Energy Strategy. These goals are further supported by the Government introduction of the solar Feed-in-Tariffs promote scheme. According to Ministry of Infrastructure and Energy 88 applications for the construction of the solar PV plants up to 2 MW have been accepted. From those 12 PV plants have been already authorized for construction.

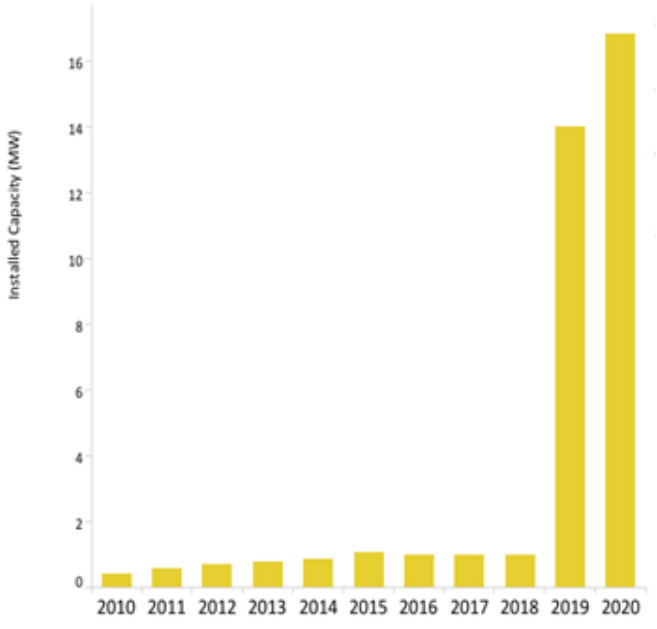

Fig.1 Photovoltaic installed capacity in Albania through the years [8]

Albania has outstanding solar irradiation within most of its territory at more than 1 500 kWh/m^2 annually, particularly in the western part of the country. The country has some of Europe's highest number of sunshine hours per year, presenting significant potential for development of solar PV for power generation and solar thermal for heating purposes. On average, the country has 220 sunshine days, or about 2 700 hours of sunshine per year.

Fig. 2 *Photovoltaic power potential in Albania*

According to IRENA studies on the cost-competitive renewable energy potential in South East Europe, Albania's technical potential for the deployment of solar PV is estimated at 2 378 MW, with production of 3 706 GWh annually [9]. Based on a very optimistic energy scenario half of the above capacity is proposed to be installed by 2030.

3. Case study of a PV/T system

A 200 W photovoltaic/thermal panel has been investigated in this study. The device is installed at the terrace of Polytechnic University of Tirana [10]. In Figure 3 is given a clear view of the panel installation and temperature sensor positioning.

Fig.3 *PV/T panel demonstration with temperature sensor installation*

The temperature measurement and monitoring is critical for the PV/T panel since it has a high influence on panel total efficiency. The panel temperatures were measured at four points using temperature sensors connected as presented in the Figure 4.

Fig.4 *View of the PV/T panel process installation devices*

4. Solar irradiation data

The energy production of PV/T system basically depends on the intensity of the solar irradiation. In this study annually climatic data were collected using the meteorological station at Agriculture University of Tirana. The station offers a wide range of weather data. However, the main focus was air temperature data and solar irradiation. In Figure 5 and Figure 6 are shown the air temperature distribution and solar insolation during the year.

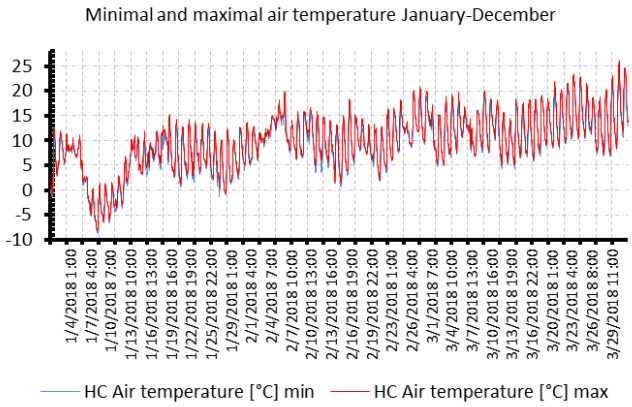

Fig.5 *Ambient temperature variation throughout the year*

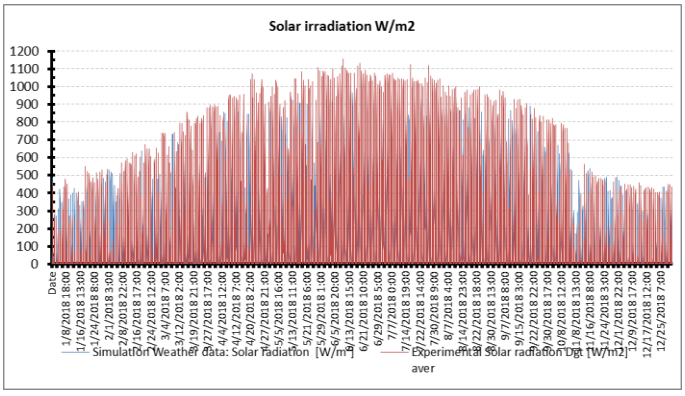

Fig.6 *Experimental and simulated solar irradiation data*

4. Results and Discussions

The 200 W PV/T system is a grid connected panel via a micro inverter. The inverter converts DC power from the solar cell into AC. The output of the PV/T system depends significantly upon air temperature, solar irradiation and wind speed. However, the solar irradiation has the highest influence on the performance of the PV/T

system. Solar irradiation has a significant impact on electrical output. The detailed simulations were run primarily for summer season from June up to September. This period of the year was selected as the solar irradiation increases during this time of the year. The electrical power output of the system for the considered period of the year is presented in Figure 7. The output variation pursues the solar radiation fluctuations.

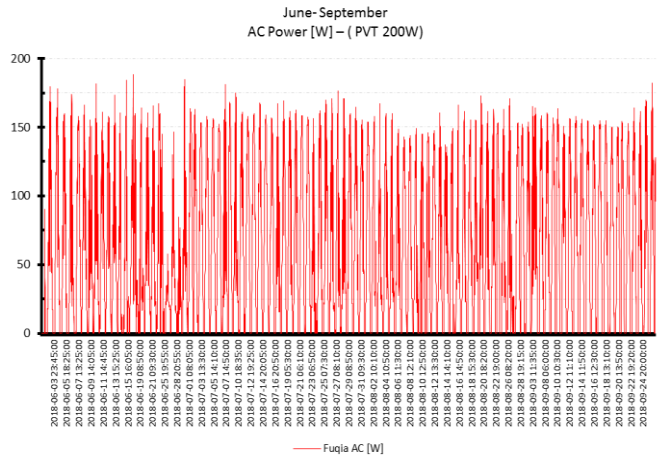

Fig.7 *AC Power output from PV/T panel during June- September*

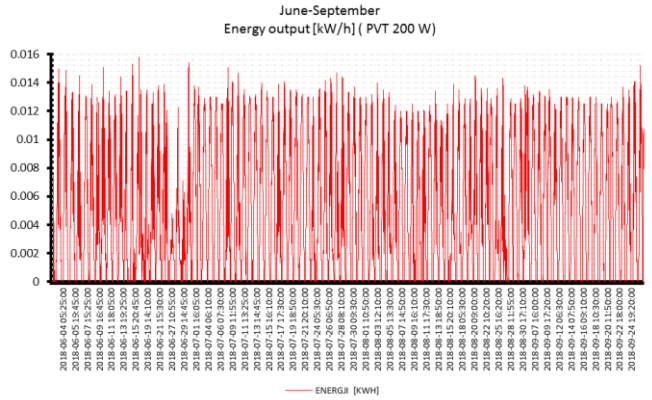

Fig.8 *Energy production of the PV/T panel during June-September*

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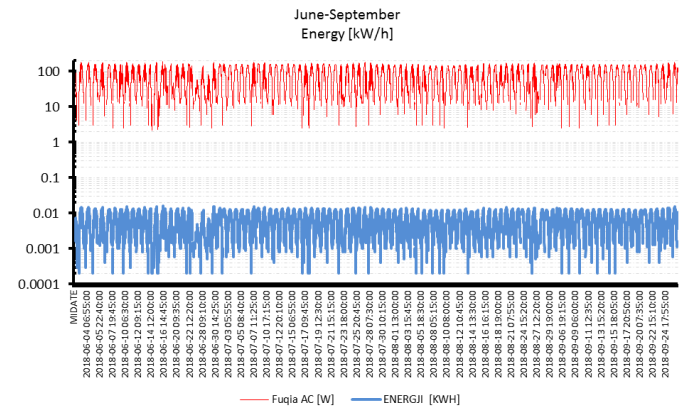

Fig.9 *Power and energy production during the period of experiment*

Total energy generation from the PV/T system is illustrated in Figure 8 and Figure 9. In Figure 9 the energy production is shown with blue color whereas power is presented in red color. Thermal energy production for the observed equals to 665 kWh. On the other hand the electrical energy production of the system accounts to 237 kWh for the time period. Overall electrical energy production is summarized in Figure 9. The results extracted from the experimental investigation in the selected time period show the importance of hybrid PV/T system use especially in climatic conditions comparable with Albania. Simultaneous production of thermal and electrical energy for a typical consumer could increase its energy consumption and further reduce the dependence on other energy sources.

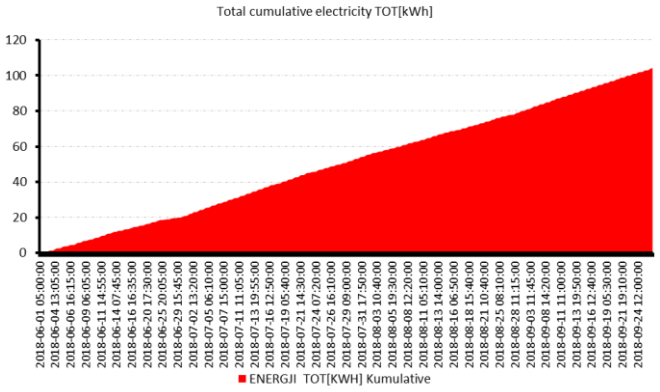

Fig.10 *Cumulative electricity generation*

4. Conclusions

Albania has an outstanding solar energy potential. The country enjoys 220 days of sunshine annually with approximately 2700 hours per year. Photovoltaic plant investments have been increased considerably in the last two years. This is supported by the FiT schemes applied recently by the government. However, the capacity installation remains below the technical potential. A photovoltaic thermal panel was analyzed in this study. Water flows in the panel in order to decrease the temperature which has an influence on energy efficiency. Climatic data have been collected experimentally at the meteorological station placed in Tirana. Energy production of the PV/T system was investigated for the time period June-September of the year. From the analysis results the annual thermal energy production of the PV/T it was found to be 665 kWh. The electricity generation by the PV/T system results about 237 kWh. Thermal energy and electricity production rate will show the way to further discussion on coupling PV/T system with heat pumps in building. The use of PV/T systems in buildings in integration with heat pumps will be the focus of another study in the near future.

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Arduino базиран инкубатор за птичи яйца

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Abstract: *В тази работа е разгледан Arduino базиран инкубатор за инкубация на птичи яйца. Разгледани са компонентите на автоматизираната система за управление на инкубатора, елементите на инкубатора, тяхната свързаност, процеса на изграждането му и ръководство за експлоатация.*
Keywords: *Arduino, инкубатор, инкубация на птичи яйца*

1. Въведение

Люпене на пилета – има два начина да се постигне това в домашни условия. Първият е да се използват птици-мътачки, а вторият е да се разполага с инкубатор. Използването на инкубатор за размножаване на домашни птици, позволява да се произведат домашни птици в по-големи количества [1].

Съвременните промишлени инкубатори, са сложни апарати с прецизен контрол и поддръжка на основните параметри за инкубация – температура и влажност. Тези апарати са снабдени със системи за вентилация и обръщане на яйцата през определен период от време, стараейки се да осигурят максимално близки условия до естествената инкубация за голямо количество яйца. При домашните инкубатори, от съществена важност са също поддържането на основните параметри – температура и влажност, както и завъртането на яйцата през определен период от време. Завъртането е от значителна важност за правилната ориентация на ембриона, предотвратяването на изсъхване на ембриона, както и равномерното затопляне на яйцето. При естественото люпене, птицата става и разравя яйцата така, че да може да се затоплят равномерно.

Целта на настоящата статия е да представи направата на автоматизиран апарат за инкубация на неголям брой яйца, в домашни условия, който да е финансово изгоден и да сведе до минимум участието на човешки фактор в процеса на инкубация.

2. Инкубация на птичи яйца

Режимът на люпене представлява комплекс от условия в инкубатора, които създават подходяща среда за люпенето на яйцата. Средата за люпене трябва да наподобява, а в новите инкубатори - да бъде и по-добра от тази, която създават мътачките, с което се гарантира висока люпимост на оплодените яйца. Режимът на люпене зависи от умелото съчетаване на няколко фактора - температура, относителна влажност на въздуха, въздухообмен (вентилация), обръщане на яйцата и други, по-слаби косвени влияния. В днешно време почти всички нови типове инкубатори се контролират с електронни устройства, снабдени с цифров дисплей и контролен панел. Някои от тях, освен температурата и влажността, отчитат часа и деня от залагането на яйцата за люпене, което улеснява инкубатористите за времето за провеждане на операциите. Контролът с помощта на измервателните уреди се съчетава с биологичния контрол, с който се проследява ходът на развитието на ембрионите. Биологичният контрол дава информация, както за състоянието на микроклимата в инкубаторите, така и за някои качества, характеризиращи пълноценността на яйцата за люпене [2].

Етапи на инкубация

Етапите на инкубация се делят на няколко:

• *1 до 8 ден, в който започва процесът* - Формира се сърцето и кръвоносните съдове на зародиша. През това време яйцата трябва да се обръщат минимум на всеки 2 - 3 часа, като температурата в инкубатора трябва да е 37.8 °C - 37.9 °C, а влажността на въздуха е в интервала: 55% - 56%.

• *8 до 14 ден - Основен етап* – Това е времето, в което се формират скелетът и мускулите на пилетата. Яйцата се обръщат през около 2 часа, като е добре да се осигури и проветряване два пъти в денонощието. Температурата в уреда трябва да се поддържа 37.3 °C. Ако през това време яйцата се погледнат на овоскоп или силна светлина, вътрешността на оплодените и добре развиващите се яйца трябва да е потъмняла.

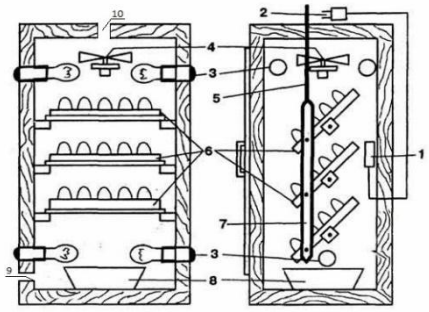
• *15 до 18 ден е заключителен етап* – Този етап може да се раздели на две фази:

Фаза 1: Температурата се поддържа отново в границите на 37.3 °C ±0.1 °C. В това време се оформят вътрешните органи и тъкани на пилетата. Проветряването е два пъти в денонощието с продължителност от 15 мин. Завъртането на яйцата се увеличава до 6 пъти, а влажността на въздуха трябва да клони към 55%.

Фаза 2: Втората фаза от заключителния етап позволява намаляването на топлината до 37 °C. Обикновено тази фаза настъпва към 18 ден от инкубацията. В края на периода може да се усети формирането на птичките при разклащане на яйцата, както и да се забележи почукване в тях.

• *18 до 20 - 21 ден - излюпване* - Този етап започва с появата на пукнатини в черупката. Когато пукнатините се появят не е нужно обръщане на яйцата, но проветряването на инкубатора се увеличава до 4 пъти в денонощието, а влажността на въздуха се подържа в интервала от 65% до 70%. Излюпят ли се първите яйца, съдът с водата, с който е снабден инкубаторът, трябва да се махне от апарата [2].

Устройство на инкубатора



Фиг. 1 *Принципна схема на инкубатор [3].*

На Фиг. 1 е изобразена принципна схема на инкубатор. На нея с (1) е означено чувствителните елементи за измерване на температура и влажност. С (2) е означен терморегулатора, който може да е комбиниран с влаго-регулатор. Терморегулатора е настроен да сработва в определен хистерезис, като включва и изключва релета, управляващи нагревателни лампи. (3) са нагревателни лампи. (4) представлява вентилатор, (5) е рамо на обръщащия механизъм, чрез който ръчно или автоматизирано, се задвижва обръщащия механизъм. (6) е тавичката за яйца, върху която се подреждат

яйцата. (7) представлява обща рейката на обръщащия механизъм. (8) е тавичка с вода, която принадлежи към овлажнителната система на инкубатора. Вентилационните отвори, отбелязани с (9) и (10) са отвори в инкубатора, направени с цел естествена вентилация и навлизането на свеж въздух [3].

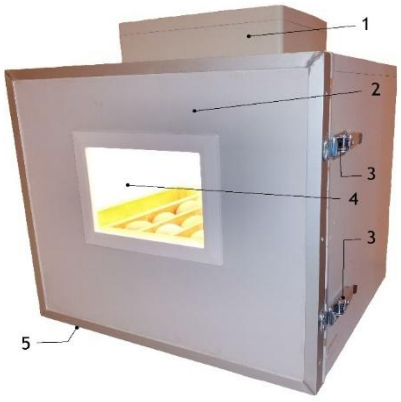
3. Елементи и изграждане на инкубатора

За изграждането на системата е използвана принципната схема за направа на инкубатор (Фиг. 1), като за реализирането на апарата, са избрани следните компоненти:

• Arduino UNO – управлява терморегулацията на инкубатора [4, 5];
• Чувствителен елемент BME280 - прецизен сензор за измерване на температура, влажност и налягане;
• Релеен модул с две релета;
• Осветителни тела – 4 бр. крушки P21W, които са с оперативно напрежение 12 V и мощност 21 W;
• Вентилатор - 12 V/0.15 A, с размери: 80 мм × 80 мм × 25 мм. Той служи за разместване и уеднаквяване на различните слоеве въздух в инкубатора, получени в следствие на нагряването с нагревателните лампи;
• 4×20 LCD Дисплей с I2C драйвър;
• Real Time Clock модул DS3231 - отмерване на времевите интервали между отделните фази на инкубирането;
• Драйвер за DC мотори L298N.

Фиг. 2 *Контролен панел на инкубатора.*

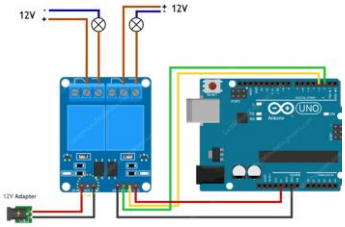
Контролния панел на апарата (Фиг. 2), се състои от (1) LCD дисплей показващ текущото състояние на системата, бутони за настройка и задаване на параметри: (2) Бутон MENU/SET; (3) Бутон UP; (4) Бутон DOWN, светлинна сигнализация за различните състояния на системата: (5) LED индикатор за нормално състояние на системата (зелен цвят); (6) LED индикатор за режим „ВНИМАНИЕ“ (жълт цвят); (7) LED индикатор за режим „АЛАРМА“ (червен цвят); USB порт за комуникация с компютър, означен на схемата с (8), както и отвор на пиезо-излъчвателния сигнализатор (9), за звукова сигнализация.



Фиг. 3 *Корпус на инкубатора.*

На Фиг. 3 е изобразен корпусът на апарата, който е изработен от ПДЧ плоскости с размери Ш/Д/В – 450/380/405 мм., като габаритните му размери са Ш/Д/В – 480/500/505 мм. В други случаи, корпусът може да бъде изработен от термоизолационни панели, в зависимост от желанието и възможностите на потребителя, като подобно изпълнение би оскъпило апарата. Вратата на инкубатора е обкантена с алуминиев П-образен профил и импрегнирана с епоксидна смола, с цел по-дълъг експлоатационен живот и защита от влага. Вратата е оборудвана с прозорче за визуален контрол на процеса на инкубация. Вътрешността на уреда е импрегнирана с епоксидна смола и силикони с цел предотвратяване на влага, която би увредила корпуса.

Фиг. 4 *Вътрешно устройство на инкубатора.*



Фиг. 5 *Свързване на нагревателните крушки към контролера.*

На Фиг. 4 е изобразена вътрешността на апарата, където са разположени:

• 1 - Вентилатор 12V/0.15A 80×80×25 мм. за разместване и уеднаквяване на различните слоеве въздух в инкубатора.
• 2 - Нагревателни крушки P21W, които са разположени на около 150 мм. от повърхността на яйцата, с цел тяхното оптимално подгряване. Нагревателните крушки са свързани към контролера и релейния блок по схемата показана на Фиг. 5.
На нея нагревателните крушки са свързани паралелно 2×2 към контролера на два отделни кръга, с цел предотвратяването на моментен пад на напрежението при комутация на релетата, което води до нежелано рестартиране на контролера. Двата кръга се захранват поотделно от два различни импулсно-захранващи блока.
• 3 - Изходящ вентилационен отвор Ф60 мм. с възможност за регулиране на въздушният поток.
• 4 - Чувствителен елемент BME 280 за измерване и контрол на температурата и влажността в уреда.
• 5 - Обръщащ механизъм за въртене на яйцата изобразен на Фиг. 6, служещ за равномерното подгряване на яйцата и създаването на оптимални инкубационни условия.

Фиг. 6 *Обръщащ механизъм за въртене на яйцата в инкубатора.*

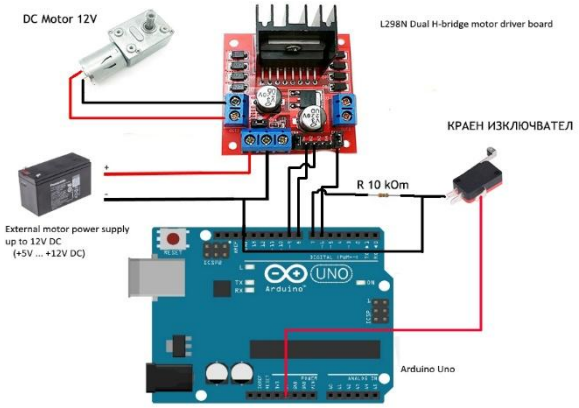
Обръщащият механизъм (Фиг. 6) е пригоден и оптимизиран за люпенето на кокоши яйца, като с леки модификации, той може да се пригоди и за друг вид птици, като например пуйки, патици, пъдпъдъци и др. Той е конструиран от вътрешна дървена рамка (6) с пет отделения събиращи по четири кокоши

яйца, правотоков електродвигател (4) с редукция на оборотите от три оборота в минута, рамо с изместен център (5) за придвижването на рамката, краен изключвател (3) за установяване на начална позиция на рамката, куплунг RJ14 (1) през който, чрез проводници се осъществява комуникацията с контролера, като също позволява откачането и премахването на устройството от апарата, посредством свързващата розетка (2).

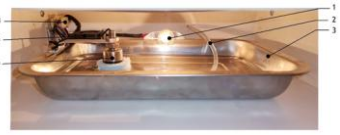
При включването на апарата към електрическата мрежа и настройване на параметрите, след стартиране на програмата, обръщащият механизъм се установява в начална позиция, посредством крайният изключвател (3), като устройството е настроено да обръща яйцата на 180° на всеки един час.

Отмерването на времевите интервали се извършва чрез Real Time Clock модул DS3231. Електродвигателя на механизма се управлява от контролера, посредством драйвер за DC електромотори L298N.

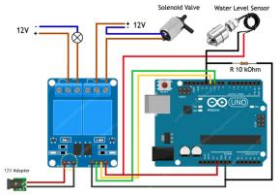
Драйверът е свързан към контролера по следната схема изобразена на Фиг. 7.



***Фиг. 7** Свързване на DC мотор към контролера посредством драйвер за DC мотори L298N.*



***Фиг. 8** Овлажняващ механизъм.*



***Фиг. 9** Схема на свързване на овлажняващия механизъм към контролера.*

На Фиг. 8 е изобразен овлажняващият механизъм на инкубатора, който е конструиран от метална тавичка (3), която покрива ½ от дъното на инкубатора, осигурявайки по-голяма площ за изпарение на водата. Тавичката е снабдена със захранващ маркуч за вода (2), който е свързан със соленоидният клапан, осигуряващ постъпването на вода в тавичката. Нивото на водата се контролира чрез нивомер (6), който е от поплавков тип, работещ на принципа на рид-ампула. Водата в тавичката се подгрява чрез нагревателна лампа (1), с цел да се образува водна пара и повиши влажността в уреда. Нагревателната лампа се контролира от контролера чрез релеен блок, като се получават данни за нивото на влажност от сензора за температура и влажност BME280. Влажността се задава предварително, при стартиране на програмата, като тя се намалява и увеличава автоматично, спрямо различните етапи от инкубационният цикъл. Първоначално през първите 8 дни, тя се поддържа в хистерезис - 2% от зададената – до зададената.

Ако влажността не се поддържа в оптимални граници е възможна появата на аномалии при излюпените пилета или загиване на ембриона по време на инкубация. Повишаването на влажността към края на инкубационния цикъл, се прави с цел по-лесното освобождаване на пиленцето от черупката. Ако въздухът в инкубатора към този момент е много сух, се получава залепване на черупката на яйцето към перата на птичето и то обикновено загива при загуба на енергия, в опит за освобождаването от нея. Изпарената вода от нагревателната лампа в тавичката, се обдухва от турбинен вентилатор (5), като по този начин се постига равномерното разпределение на водните пари в уреда. Овлажняващият механизъм е снабден със свързващ щекер (4), който има за цел да позволи отделянето на устройството от апарата и неговото ревизиране.

Схемата на свързване на отделните компоненти на овлажняващия механизъм към контролера, са изобразени на Фиг. 9.

***Фиг. 10** Заден панел на инкубатора.*

На Фиг. 10 е изобразен задния панел на апарата където се намират:

- Контейнер за захранване на овлажняващия механизъм с вода, означен с (1);
- Соленоиден клапан (2), служещ за пускане/спиране на притока на вода към тавичката на овлажняващия механизъм;
- Импулсни преобразуватели на напрежение (3) от 220 V към 12 V DC;
- Захранващ кабел (4). Стандартен кабел 3×1.5 кв. мм.

4. Ръководство за експлоатация

Преди зареждането на яйцата в инкубатора е препоръчително той да бъде включен от предната вечер, за да се изпробва неговата функционалност и да се отстранят евентуални проблеми. Също е препоръчително яйцата да престоят 24 часа в помещението, в което е инкубатора, с цел тяхното климатизиране. В деня на зареждането, уреда се изключва и се дезинфекцира старателно със спирт, най-вече механизмът за обръщане на яйца, който е в пряк контакт с тях.

Устройството е проектирано да се захранва с напрежение 220 V – 50 Hz. При свързване на захранващия кабел към електрическата мрежа, дисплеят на апарата светва, като се чува и кратък звуков сигнал отчитащ свързването на уреда под напрежение. Показанията на дисплея са: текущата температура и влажност в уреда. Към този момент системата е в режим на изчакване на задаване на параметри.

Задаването на параметри се извършва, като се задържи бутона “MENU/SET” (Фиг. 2) за около три секунди, след което на дисплея се изписва надпис “SET TEMPERATURE 35”.

Минималната температура, която може да се зададе е 35 °C, като при опит да се зададе по-ниска, на дисплея се появява надпис “MIN” до задаваната стойност. Максималната температура, която може да се зададе е 40 °C. При опит да се зададе по-висока, на дисплея се появява надпис “MAX” до зададената стойност.

След като сме избрали желаната температура за инкубация чрез бутоните “DOWN” и “UP” се натиска бутона “MENU/SET”, като на дисплея се появява надпис „SET“ и зададената температура. Надписът премигва три пъти и системата преминава в режим на очакване на стойност за поддържане на влажност, като на дисплея се изписва надпис “SET HUMIDITY 50”.

Минималната стойност на влажността, която може да се зададе е 40%, а максималната е 80%.

След въвеждането на параметрите и стартирането на програмата, нагревателните лампи се включват и температурата и влажността започват да се повишават до зададените стойности. Първоначално, след стартиране на програмата, ако тавичката с вода е празна или има недостатъчно вода, на дисплея ще се появи надпис “WATER LEVEL LOW” и жълтата светлина „ВНИМАНИЕ“ ще свети.

За улеснение на оператора, апарата показва началото на стартиране на апарата и отброява дните и изминатите часове от започването на инкубацията. Така, във всеки един момент се знае, към кой етап на инкубацията е достигнато.

Апарата автоматично регулира влажността, като през първата фаза от инкубацията (до осмият ден) я поддържа в зададените от оператора граници. На осмият ден, влажността се понижава от програмата с 5%, като на осемнадесетият ден, тя се повишава с 15%.

Температурата също се регулира автоматично. През първата фаза се поддържа в граници ±0.25 °C от зададената от оператора, като след това, на осмият ден се понижава с 0.5 °C, а на осемнадесетия - се понижава с още 0.3 °C.

Режим „АЛАРМА“. Инкубатора е оборудван със звукова и светлинна сигнализация за оповестяването на оператора за нежелани температурни стойности, които може да се достигнат в процес на инкубация в следствие на неизправност на системата, изгаряне на нагревателен елемент и др.

След настъпването на началото на заключителната фаза от инкубацията, а именно на осемнадесетия ден, устройството за въртене на яйцата се премахва от инкубатора, като се поставя специална рамка изобразена на Фиг. 11, която е направена от дървени летвички, а от горната страна е поставена мрежа за да може да не се възпрепятства движението на въздух и водни пари в инкубатора. Яйцата се поставят легнали върху рамката, като вече не е необходимото тяхното въртене. През това време ембрионът вече започва да се ориентира в позиция за излюпване.

Фиг. 11 *Полагане на яйцата върху рамка, след изваждането им от механизма за въртене.*

Към деветнадесетият ден е възможно появата на пукнатини по яйцата, като от този момент до към двадесет и първия, а в някой случаи и до двадесет и втория ден, яйцата започват да се люпят. Излюпените пиленца се оставят за няколко часа (4 ч. – 5 ч.) в инкубатора, като през това време, те трябва да са се ориентирали в обстановката и да са поизсъхнали, след което биват преместени.

При спазване на правилата за подбор на яйца и тяхната инкубация, след приключване на инкубационния период, ще разполагате със здрави и жизнени малки пиленца (Фиг. 12).

Фиг. 12 *Новоизлюпено, в представения инкубатор, пиленце на еднодневна възраст.*

5. Заключение

Чрез универсалността, ниската цена и лесната достъпност на платформа Arduino е реализиран автоматизиран инкубатор за инкубация на птичи яйца. Предимствата на изградената система са нейната компактност и надеждност, както и ниската цена на части при евентуална подмяна. Контролният панел на системата е интуитивен и лесен за боравене. Системата е конструирана така, че да изисква минимална намеса от страна на оператора. Системата не изисква сериозна поддръжка и не се нуждае от специални материали за нейното функциониране. Тя е изключително опростена за настройка и експлоатация, което въз основа на ниската цена на използваните компоненти, би повишило интереса на обикновения потребител към нея, спрямо други готови решения на пазара.

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World technology market: features and current trends

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Annotation. *The definition of the world technology market is given and its features are characterized. The structure of the world technology market formed by institutional elements is considered. The following segments of the world technology market have been studied: the market of patents and licenses, the market of scientific and technological products, the market of scientific and technological specialists, the market of high-tech capital. According to Ukraine's ratings in the world technology market (2018-2019), the reasons for its lag in it are named. The tendencies of the world market of technologies are substantiated.*
KEYWORDS: HIGH TECHNOLOGIES, PATENTS, LICENSES, SCIENTIFIC AND TECHNOLOGICAL PRODUCTS, SCIENTIFIC AND TECHNOLOGICAL SPECIALISTS, HIGH-TECH CAPITAL.

1. Introduction

In the modern post-industrial economy there is a new paradigm of the world order, in which competition is based on knowledge. The country's ability to create and implement its own innovations and develop high technologies is becoming a key resource for sustainable economic development, financial stability, and competitiveness. This ability determines the place in the world economic space [1].

The world economy demonstrates the focus of national economic systems on the intensive development of high-tech products. A qualitative change in the system of world economic relations was the formation of the world technology market, which today is global in nature.

The formation of the world technology market took place in the second half of the twentieth century, when the volume of international commercial transactions in technology exceeded the scale of national exchange. This made it possible to distinguish international technology exchange into a separate form of international economic relations.

According to the IMF, the number of countries exchanging technologies only during the 60's to 90's of the twentieth century. Increased from 22 to 84 [2]. The volume of annual licensing transactions has significantly expanded. Per unit cost, the currency effect of the sale of technological resources on the world market is much higher than the export of ordinary goods. Technological exchange exceeds traditional international flows of goods, services and capital.

The global technology market is a set of international market relations of entities regarding the commercial use of property rights to its objects (productive technologies, process technologies and management).

The scientific and technical potential of countries, the state of their participation in the international division of labor and international technological exchange gives many advantages, determines the modern picture of the world and its development. This process most fully reflects the model of the world economy "Center - Periphery", according to which the world economy consists of two interconnected and interdependent parts - the center and the periphery, the relationship between which is mainly "dominance - dependence".

Center - countries that are mainly members of the Organization for Economic Cooperation and Development. The periphery is structured and splits into separate "concentric circles" equidistant from the center. Distance is determined by the level of economic and social development on the principle: the farther from the center, the worse. The locations of these countries are defined as follows: East Asia, Eastern Europe, Russia, India, Latin America, African countries and the Arab-Muslim world.

The objective prerequisites for global development and acceleration of technology in modern conditions are:

- formation of information and technological structure of social development;
- increasing priority, compared to the triad of factors of production (capital, labor, natural resources), and today the fourth factor - innovative entrepreneurship, which is simply defined as technological;
- increasing the requirements of the world community to minimize technological and anthropological impact on the environment.

2. Features and structure of the world technology market

The structure of the world technology market is formed by institutional elements that mediate the movement and interaction of world technologies. The institutional elements of the global technology market include:

- objects - products or processes - carriers of technology;
- subjects - legal or natural persons;
- commercial and non-commercial technology transfers. The main forms of commercial technology transfer are: sale of patents; sale of licenses; sale of know-how, leasing; copyright agreements; franchising; provision of knowledge-intensive services. Non-commercial forms of technology transfer include international technological assistance - technological grants (free provision of technology and equipment, consulting and training, etc.); co-financing of projects (part of the costs is covered by the company or the recipient country); use of technologies to obtain a social or environmental effect;
- forms of transfer and legal protection of innovations and technologies (patents, licenses, know-how, leasing, franchising, copyright);
- channels of transfer and diffusion of innovations and technologies (trade in innovative products, licensed trade, scientific-technical and information cooperation, etc.).

The global technology market is heterogeneous in its structure and includes four segments:

1. The market of patents and licenses. The most dynamic segment of the technology market is the market of licenses and patents with an annual growth of over 10%. The leading exporters and importers of the license and patent market are industrialized countries that register patent applications (Table 1).

2. The market of science and technology-intensive products (Table 2). The international exchange of scientific and technical knowledge has an objective character of development. The exchange is an objective necessity, allowing to widely introduce into production the latest achievements of world scientific and technical thought. This leads to the growth of the exchange of scientific and technical knowledge in various forms of interaction and joint efforts of large companies to solve current problems of science.

An important component of the global technology market is the export of high-tech products.

Table 1 *Patent applications (2018-2019)*

Country	2018		2019	
	Value	Place in the ranking	Value	Place in the ranking
Japan	496,46	1	490,35	1
Republic Korea	444,63	3	461,15	2
Taiwan, China	480,33	2	447,42	3
Switzerland	322,48	4	321,65	4
Sweden	271,58	7	256,32	6
Finland	285,97	6	255,31	7
USA	144,09	13	143,99	13
Singapore	121,25	14	118,66	15
Norway	115,24	16	113,69	17

Source: grouped by authors according to data [6].

Table 2 *Scientific publications (2018-2019)*

Country	2018		2019	
	Value	Place in the ranking	Value	Place in the ranking
USA	2002,3	1	2088	1
Great Britain	1235,7	2	1289	2
Germany	1083	3	1131	3
Japan	887,3	6	919,3	6
Switzerland	834	9	867,7	9
Sweden	749,3	98	779,3	11
Finland	545,7	19	571	19
Norway	502,7	20	532,3	20
Singapore	466,7	24	493,7	23

Source: grouped by authors according to data [6].

Leading positions in the export of high-tech products (Table 3) has Germany (10.8% of total world exports of high-tech goods), followed by South Korea, China, the United States and Singapore (they account for 45.05%). The total volume of exports of high-tech goods in 2018 was estimated at about 2 trillion. dollars USA. Exports of high-tech products from developing countries are growing twice as fast as the corresponding exports from developed countries. This indicates the strengthening of the global high-tech market in Asian countries.

Table 3 *World leaders in the volume of exports of high-tech products as at 01.01.2019*

Country	Export volume, million USD
Germany	209,610
South Korea	192,789
SAP Hong Kong, China	161,877
USA	156,365
Singapore	155,446
France	117,814
Japan	111,020
Malaysia	90,395
Netherlands	85,790
Great Britain	76,533

Source: grouped by authors according to data [6].

3. The market of scientific and technological specialists. The creation of a high-tech sector is facilitated by the presence of highly qualified specialists and a large number of high-tech startups. An important characteristic of the labor market is its diversity (Table 4), which means similarities and differences between workers in terms of age, cultural background, physical abilities and disabilities, race, religion, gender and sexual orientation.

Table 4 *Diversity of the workforce (2018-2019)*

Country	2018		2019	
	Value	Place in the ranking	Value	Place in the ranking
Singapore	5,8	2	5,8	1
UAE	5,7	5	5,7	2
Australia	5,6	8	5,7	3
Canada	5,9	1	76,4	5
USA	5,8	3	5,5	7
Qatar	5,4	12	5,5	10
Romania	5	26	5,3	18
Sweden	5,4	13	5,2	20
Switzerland	5,5	11	5,2	21

Source: grouped by authors according to data [6].

4. High-tech capital market.

Industrialized countries account for about 90% of the world technology market, including more than 60% are in the United States, Japan, Britain, Germany and France.

Most of the trade in licenses in the global technology market, of the total volume of commercial transactions, falls on the following industries:

- electrical and electronic industry – 19%;
- general mechanical engineering – 18%;
- chemical industry – 17.4%;
- transport engineering – 10.2%.

The objects of the world technology market are goods classified according to the technological capacity of trade developed by UNCTAD, which is indicated as the ratio of research and development costs to the total cost of production and trade in goods. However, the largest percentage of the state budget for research is spent by Israel and the Republic of Korea (Table 5).

Table 5 R&D expenditures (2018-2019)

Country	2018		2019	
	Value	Place in the ranking	Value	Place in the ranking
Israel	4,3	1	4,3	1
Republic Korea	4,2	2	4,2	2
Switzerland	3	8	3,4	3
Sweden	3,3	4	3,3	4
Japan	3,3	3	3,1	6
Finland	2,9	9	2,7	10
USA	2,8	11	2,7	11
Singapore	2,2	17	2,2	14

Source: grouped by authors according to data [6].

Objects presented in an intangible form are the result of intellectual activity and are intangible carriers of various types of technology. Such objects can be classified by internal integrity into:

- non-market (information arrays, knowledge, experience and skills acquired during research and can be transferred through training, internships, exchanges and migration of specialists);
- potential market (patents, know-how, scientific and technical documentation, management consulting);

- market (patent and non-patent licenses, engineering, leasing, franchising, research services, staff training).

In the world market of technologies there are subjects of all structural levels:

- micro level - universities, research institutions, business centers, venture firms, individual innovators;

- meso level - TNCs, national companies, science and technology complexes (technology and research parks, which are the leading implementers and patenters of innovations);

- macro level - state and national scientific and technical systems that ensure the functioning and development of the global technology market;

- mega-level - interstate formations and integration groups, within which efforts are focused on certain areas of STP;

- metalevel - international organizations, including the United Nations, which provide technical assistance to countries that develop and shape the world market for economically safe technologies.

The most important role in all segments of the global technology market is played by the following countries: USA, Japan, Great Britain, Germany, France.

They account for 60% of international technological exchange. In general, industrialized countries account for about 90% of the global technology market, and developing countries - 10%.

For the former socialist countries and republics of the Soviet Union, the share of high-tech exports is much smaller. This is a consequence of the landslide deindustrialization of the former USSR and Eastern European countries in the 1990s. Only the Czech Republic and Poland stand out in a positive way. Thus, Ukraine in this area belongs to the periphery of the technology market and has the following ratings (Table 6).

Table 6 Ratings of Ukraine in the world technology market (2018-2019)

Country	2018		2019	
	Value	Place in the ranking	Value	Place in the ranking
Diversity of the workforce	4,5	62	4,6	59
Scientific publications	215,7	50	229,3	50
Patent applications	1,41	62	1,56	62
R&D costs	0,6	56	0,4	67
Trademark applications	653,88	60	744,49	59
Quality of research institutions	0,04	44	0,04	44
Cooperation with many stakeholders	3,7	56	3,8	58
International joint inventions	0,5	56	0,53	55
The state of cluster development	3,2	106	3,5	96

Source: grouped by authors according to data [6].

Modern processes of globalization have affected the structure of the global technology market and identified a number of its features, namely:

• the world market of technologies contributes to the intellectualization of the world economy in general [3];

• the main actors are TNCs, which share the results of research and development by parent and subsidiary companies, as a result of which the global technology market is better developed than the national [4]. 2/3 of the world's technological exchange is accounted for by intra-firm exchange of TNCs. More than 60% of licensed revenues of industrialized countries account for the share of intra-corporate revenues (in the US - 80%) [5];

• the largest TNCs concentrate research on themselves and contribute to the monopolization of the world technology market (the level of monopolistic control is 89–90%) [3];

• technological gap between different groups of countries causes a multi-stage structure of the global technology market;

• the global technology market has a specific regulatory framework (International Code of Conduct on Technology Transfer), as well as international regulators (World Trade Organization Agreement on Intellectual Property Rights) (TRIPS), the UN Conference on Technology Transfer Committee and Development (UNCTAD), the World Intellectual Property Organization (WIPO), the Export Control Coordinating Committee (COCOM), the Technology Security Expert Meeting (STEM)).

3. Trends in the global technology market

The trends of the world market of high technologies include:

- a high degree of monopolization of the world technology market. This is due to the fact that the implementation of research and development requires significant costs, which can only be done by the largest companies or countries;

- stable dominance in the world market of technologies of industrialized countries, whose share in the international scientific and technological exchange is almost 90%. Exports of high-tech products account for the five most developed countries in the world: the United States, Japan, Britain, Germany and France. In Europe, technology exchange takes place mainly within the EU, most often inter-firm exchange;

- formation of a two-tier structure of the market of high-tech goods and services by relocating production to countries with lower labor costs and widespread use of outsourcing. This applies to the countries of Southeast Asia. Leaders in outsourcing are India and China);

- high level of monopolization of the world market of high-tech products (over 90%) (due to the unique properties of high-tech goods and the transformation of multinational corporations into major market players). Concentration of scientific and technical developments in transnational corporations, joint use of R&D results by parent and subsidiary companies contribute to the development of the global technology market, allows the establishment of monopolistically high prices for patented products and control over the market as a whole;

- an increase in the number of small and medium-sized venture firms (corporations transfer to them the risk of research and development, development of new products, testing of innovations).

The United States remains one of the top five countries in terms of both high-tech exports and imports, despite growing competition. Take the lead in the market of telecommunications, computer and information technology, software (the most famous are Apple, Cisco, Hewlett-Packard, IBM, Intel, and Microsoft). The country dominates the export of computer equipment (75%) and software (65%), remains the world leader in innovation (although most research and innovation focuses on products that are produced abroad and then exported back to the United States). The main trends in the high-tech sector are the development of social media platforms and the active introduction of "cloud" technologies.

The threat to the United States is caused by the penetration of Chinese companies into the American market. To reduce the competitiveness of Chinese companies, a ban on the sale of programs used in sensors, drones and satellites to automate the recognition process. In 2020, the US government imposed restrictions on the export of artificial intelligence technologies. But the US high-tech market has a margin of safety, many of the leading high-tech corporations and firms are American; there is no absorption of American companies by European ones, on the contrary, there are reverse processes; higher education is more in line with the needs of the innovative economy, and higher education is more qualified and prestigious; high-tech products meet the high demands of consumers. Concealed protectionism is an instrument of state support for the high-tech sector of the American market.

The European high-tech market is inferior to the following countries: the United States in areas such as telecommunications and electronics; Japan and the newly industrialized countries of Southeast Asia - in the field of mass production of knowledge-intensive goods. The number of European high-tech companies in the domestic market is only 30-40% of their total. With high energy prices and declining sales, big business has reduced its IT spending, and small and medium-sized enterprises cannot afford to invest heavily in this area.

The reasons for the weakness of the European high-tech market are:

- reduction of demand for ICT compared to the rest of the world;
- insufficient funding for research by states;
- lack of qualified personnel and reduction of graduates in engineering, mathematics and information specialties;
- there is an innovation deficit.

According to a study by Euromonitor International, the production of high-tech goods in the EU is expected to triple and reach 16 trillion US dollars in 2030 through the pooling of resources for investment in several high-tech industries, including the development of innovation in the Internet of Things and the creation "Smart" companies. Finland, Denmark, Sweden and Norway are considered to be the most ready for this.

A common feature of the Asian segment is the crucial role of the state in the effective development of advanced technologies. Japan is one of the leaders in the world market for high-tech goods and is one of the largest competitors in the United States. The main driving forces in the development of high-tech industries in the country were political factors, especially active interaction with the United States and external demand and external financial resources. Japan ranks first in the export of electronics and information.

4. Conclusions

1. The world technology market is one of the most important factors in the development of the world economy as a whole.

2. The growth rate of international technology exchange significantly exceeds the growth of traditional world economic flows, including money capital.

3. The growth of the world market of technologies reflects the objective need for the formation of new systems of productive forces, the introduction of new technological components.

4. Technology is becoming the main determinant that affects all areas of individual and social life and the process of transformation of the technological structure of planetary civilization.

5. Leadership in the development of high technology was achieved by those countries that were aimed at producing competitive products based on their own innovative developments and focused primarily on the European market.

6. The main limitations of intensifying the participation of Ukrainian entities in the processes of technology transfer in the foreign market are:

1) the level of a significant number of domestic scientific developments and science-intensive product does not meet the requirements of the modern market;

2) violation of the system of interaction (cooperation) of research institutions and enterprises in the development and commercialization of science-intensive products;

3) shortage of resources (financial, personnel) for the implementation of innovative activities of enterprises on their own, as well as for the acquisition of innovations abroad;

4) lack of mechanisms for implementing the programs and concepts of scientific and technical development declared by the state.

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Smart sustainable city

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Abstract: *Cities today are highly endangered by the global urbanization trends and the sustainability issues that they may bring. With the increasing environmental awareness and the development of technology, there is an urgent need to rethink how we plan and manage our cities. With the advancements in technology, we are entering the era of smart cities where information and communication technologies are used to collect large amount of data to transform city economies, social cohesion and city governance. This paper explains the concept of the smart city and its characteristics which can be used to solve the sustainability problems that the city may face. Following the introduction, the paper continues by presenting six main characteristics of smart cities and their role in sustainability. The chapter then proceeds to a description of a smart sustainable city model that derives from merging three main city models related to sustainability and smartness, namely the eco-city, compact city and data driven city. Finally, the application of smart city technologies that are being used to achieve sustainability in some randomly chosen cities is presented and discussed.*

Keywords*: SUSTAINABILITY, SMART CITY, ENVIRONMENTAL AWARENESS, TECHNOLOGICAL ADVANCEMENT, URBANIZATION.*

1. Introduction

The growth of population, technological development, and urbanization are considered as contemporary challenges that seek efficient, effective and economic approaches to better governance [1]. As it is claimed by the UN reports, by 2030 there will be an increase by an additional 1.5 billion people which will place a great pressure on resources, infrastructure, jobs and healthcare [2]. This dramatic population growth will increase the human impact on the environment not only because of the huge increase in numbers, but also because of the new technical power to dig deeper, cut faster, build larger, and travel more quickly great distances in automobiles, trucks, and planes [3]. These activities have caused many serious environmental problems on global scale including the climate change, loss of biodiversity, decline in water quality and degradation of ecological systems. As a response to these challenges a number of creative approaches need to be taken into consideration in order to ensure the proper development of the cities while protecting the environment and the life quality of the citizens. One of the approaches that have been implemented recently is the concept of "smart city". The creation of smart cities is a natural strategy to mitigate the problems emerging by rapid urbanization and urban population growth.

According to the World Economic Forum, the smart city programs are increasingly being implemented around the world, including a broad range of fields such as governance, economy, citizen participation, natural and built environment, transportation and urban life [4]. These technologies are used to monitor activity in the city by way of traffic lights, traffic speeds and traffic flows, criminal activity, movement of pedestrians, number plates, media access control (MAC) addresses, faces and gaits, transport meter readings, energy usage, and environmental pollution [5]. With the increasing environmental awareness and concern, these technologies have been adapted in a way they would produce smart solutions to contribute to environmental and social sustainability.

The paper is divided into two parts. The first part deals with the smart city regarding the definition of the smart city concept and how that it relates to sustainable development of a city. This section includes a description of tools and technologies that can be applied to smart cities and the benefits they have related to sustainability. The second part includes some case studies where smart city technologies have been adapted and a description how they affect the sustainable development of the cities.

2. Smart city and sustainability

The term "smart city" is a broad concept with many different definitions, all of which emphasize the use of technology and innovation in order to improve the quality of human lives. Simply explained, smart city uses innovative technologies to provide better services for citizens, improve the urban live quality and use resources in a best way while impacting the environment less [6].

Many researchers have divided this concept into several characteristics and dimensions in order to clarify what a smart city is doing and the reason for this is the complexity of the smart city as a comprehensive approach. Among them, Nam and Pardo frame the smart city by three dimensions: technology (infrastructures of hardware and software), people (creativity, diversity and education) and institutions (governance and policy) [7]. The technology dimension can be clustered in six different definitions, the digital city, the intelligent city, the ubiquitous city, the wired city, the hybrid city and the information city; the human dimension "people" is described in four clusters, which are the creative city, the learning city, the human city and the knowledge city; the institution dimension has two different definitions the smart community and the smart growth [7]

A smart city could, but does not have to be a sustainable city. To judge sustainability development of a smart city, it is necessary to evaluate the ICT solutions in the city in terms of economic, social and environmental sustainability [8]. Sustainability is often defined by three pillars: environmental, economic and social aspects. In the so called Brundtland Commission Report it is described as a "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [9]. Considering this, we can define a smart sustainable city as an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operations and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economical and environmental aspects" [6].

Smart cities around the world are complex and differ in terms of their characteristics, requirements and components. One of the most basic classification frames the smart city under four main components each of it consisting of four other assets; utilities (power, water and waste), transportation (rail, road, air and logistics), real estate (residential, commercial, retail/hotel and public buildings), and city services (healthcare, education, fire/police/defence and municipal services) [10]. Apart from that,

the Department of Spatial Planning, Vienna University of Technology, has proposed a more comprehensive classification by developing six key components measure the smartness of 70 European medium-sized cities since 2007 [11]. These are the smart economy, smart environment, smart government, smart living, smart mobility, and smart people, as shown in Table 1.

Table 1. *Smart City Characteristics. Source: Giffinger et. al. 2007*

Smart Economy (Competitiveness)	**Smart People (Social and human capital)**
• Innovative spirit • Entrepreneurship • Economic image and trademarks • Productivity • Flexibility of labour market • International embeddedness • Ability to transform	• Level of qualification • Affinity to life-long learning • Social and ethnic plurality • Flexibility • Creativity • Cosmopolitanism/Open-mindedness • Participation in public life
Smart Governance (Participation)	**Smart Mobility (Transport and ICT)**
• Participation in decision making • Public and social services • Transparent governance • Political strategies and perspectives	• Local Accessibility • Inter-national accessibility • Availability of ICT infrastructure • Sustainable, innovative and safe transport systems
Smart Environment (Natural resources)	**Smart Living (Smart living)**
• Attractivity of natural conditions • Pollution • Environmental protection • Sustainable resource management	• Cultural facilities • Health conditions • Individual safety • Housing quality • Education facilities • Touristic attractivity • Social cohesion

According to Bibri & Krogstie, the novel model for smart sustainable cities integrates two models of sustainable urban form which are the compact and eco-city, with the data-driven city [12]. Furthermore, they add that the focus should be on the design concepts that characterize the compact city (compactness, density, diversity, mixed-land use, and sustainable transport) and eco-city (renewable resources, passive solar design, ecological and cultural diversity, greening, environmental management, and other key environmentally sound policies), as well as innovative solutions and sophisticated approaches being offered by big data technologies and their novel applications for sustainability, which relate to the data-driven city and its components [12].

3. Smart city - case studies

Smart city applications are various and deal with many problems that cities face around the world including congestion, population growth, limited infrastructure, ineffective service delivery, poverty, lack of liveability, climate change issues, and natural and man-made disasters [13]. Nowadays, cities are increasingly implementing projects with smart solutions in waste management, traffic congestion, citizen safety, affordable housing, water resource management, smart buildings, efficient use of energy, renewable energy resources, facilitating navigation of autonomous vehicles, citizen participation and stakeholder consultation. Integrating digital technologies, into a city's systems and services presents new and affordable opportunities for a city to solve its challenges. This in turn will help it achieve the Sustainable Development Goals through efficient use of its resources, effective stakeholder engagement, informed decision-making and better governance [13]. In the following section, some examples of successful smart city solutions are shown in the following key themes: governance and policy, society, infrastructure and services, environment, and business and economy (Table 3).

3.1 Copenhagen Cycling Infrastructure – Copenhagen, Denmark

Copenhagen is a world leader in providing cycling infrastructure, with more than 450 kilometres of cycle lanes used by 36,000 cyclists every day [13]. In 2007, the City of Copenhagen introduced "Eco-Metropolis. Our vision for Copenhagen 2015", which had three out of 11 goals related to cycling. One was that the city should aim to achieve a 50% bicycle share in commuting to workplaces and educational institutions by 2015. The other two goals related to reducing accidents by 50% and reducing the number of those killed and seriously injured. An intense political focus on cycling issues developed in the following years, with the city delivering cycle infrastructure through the Cycle Secretariat. This resulted in a connected network of 2.2-metre-wide cycle paths on each side of city streets, between sidewalks and cars; additional features include coordinated traffic signals ("green wave") and footrests at traffic lights. The figure below shows the infrastructure system and its benefits in Denmark (fig. 1).

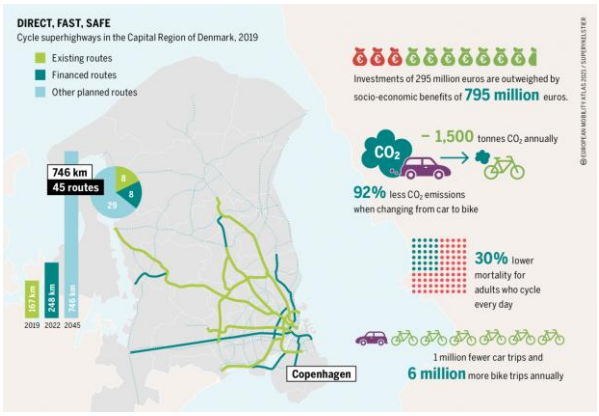

Fig. 1. *Cycling Infrastructure in Denmark. Source:httpseu.boell.orgencycling-copenhagen-the-making-of-a-bike-friendly-city*

3.2 Circular Glasgow – United Kingdom

Cities seek to create a healthy competitive environment for small and medium-sized enterprises, develop policy incentives to encourage business growth and attract private interest to solve urban challenges. An ecosystem of innovation further attracts private investments, encourages entrepreneurs to expand their businesses and provides valuable economic growth.

Circular Glasgow is an online platform designed to support the implementation of circular business models and strategies to tackle universal and local challenges. Glasgow was the first city to host an online challenge, reaching over 600,000 people globally with 59 ideas submitted from 13 countries. The partnership with the design studio Graven, the first of its kind and a result of the city's global design reputation, led to the launch of a bespoke consultation programme and has resulted in 10 design-led circular innovations [13].

Because of its harmful effect, there is a need to find new ways to manage waste. As it is estimated in the International Resource Panel (IRP), by 2050 the material consumption in cities will grow up to 90 billion tonnes, which is 50 billion more than it was in 2010. In the 2018 World Economic Forum White Paper "Circular Economy in Cities" it is reported that, there was a 1.3 billion t of solid waste generation in cities in 2012 [14]. This would make a footprint of 1.2 kg per person per day and it is expected to rise to 2.2 billion t in 5 years [14].

In order to avoid the landfill sites and the environment pollution that can be caused by unregulated waste management and disposal practices, we should adopt a more practical method of production and consumption in the way that we can ease the burden of waste on cities. This is what the circular economy approach aims to do. The purpose is to achieve sustainability by restoring the resources and protecting the natural environment from the negative effects of the industrialized waste [13].

According to the Circular Glasgow website, the project team "work closely in partnership with Zero Waste Scotland, Glasgow City Council and Circle Economy to deliver a programme of business engagement to raise awareness of the benefits and opportunities of the circular economy." The initiative has 19 "ambassadors from businesses across Glasgow who are helping to share their experience and knowledge of the circular economy" [13].

4. Conclusion

Cities are experiencing rapid digital transformation and creating innovative models to integrate the new technologies into their services, infrastructure and governance. With the increase of population in one side, and the limited earthly resources on the other, the need for smart sustainable solutions in cities is increased.

This paper aimed to describe smart sustainable cities by analyzing six main characteristics of a smart city and their role in achieving the optimal level of sustainability. Following this, the city models of sustainable and smart cities were described, namely compact cities, eco-cities, data-driven smart cities, as well as how they intertwine with one another in the context of sustainability. Finally, case studies where smart city applications are used in order to achieve sustainability considering the following key themes: governance and policy, society, infrastructure and services, environment, and business and economy. The advanced technology used in smart cities addresses diverse challenges including congesting, gaps in infrastructure, pollution and other environmental problems, uncontrolled population growth ext.

Considering the fact that cities are characterized by different key characteristics, some technology systems might work in one city and might not in another. Therefore, for a smart city to function properly, all the key systems need to work together, by using all of their resources to deal with the challenges the city faces.

As we are experiencing a time when COVID-19 has disrupted even our most basic daily habits such as moving freely across the city, sharing close space with people in a restaurant, an office or a square, we can understand much better how our physical lives can be affected and we must learn to develop new tools to improve our urban experience. Basically, because of the unprecedented scale of the events of early 2020, the case studies listed in this paper, among many other cities around the world, have taken big steps to make the urban environment more inclusive, equitable, agile, open to new ideas and resilient.

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Implementation of simulation tools in optimization of traffic flows – case study City of Zagreb

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Abstract: *Urbanization and population growth in cities around the world have increased the degree of motorization, which ultimately results in congestion of the transport network within these cities. Traffic simulation tools are essential for the optimization and evaluation of variant solutions in road traffic. By analysing traffic parameters from simulation results it can be decided which variant solution is optimal without high financial inputs. In this paper, the most important simulation tools are explained. As a case study, one district in the City of Zagreb was chosen to present possibilities of simulation tools and their implementation in the evaluation of traffic solutions.*
Keywords*: TRAFFIC MODELLING, SIMULATION TOOLS, CITY OF ZAGREB, OPTIMIZATION*

1. Introduction

The organization of traffic flows is an essential element in the successful operation of the transport system in a designated area. The main goal of traffic optimization is to minimize the cost of traffic flow which is achieved by minimization of crossings on critical intersections in favor of reducing lost time. If organization of traffic flows is not properly optimized, it is possible to create traffic congestions on specific locations what finally affects on complete traffic system [1].

Transport modeling is an integral part of traffic engineering that is used in phases of planning and design. Simulation models are developed to test new solutions and how those new solutions or changes in traffic organization will affect the flow of traffic in the analyzed area. A model is a simplified representation of a part of the real world/system, which focuses on the individual and certain elements considered important from a point of view. Transport models are abstract models based on mathematical formulas and laws. The main elements in the development of transport model simulation are the relationship between traffic demand and traffic supply, where traffic demand is the distribution of activities in space, while traffic supply is defined as the capacity of transport network elements (road, terminals, hubs).

The demand for transport services is highly qualitative and differentiated. There is a whole range of specific demands for transport which are differentiated by time of day, day of the week, journey purpose, type of cargo, the importance of speed and frequency, and so on. A good deal of the demand for transport is concentrated on a few hours of a day, particularly in urban areas where most of the congestion takes place during specific peak periods. Transport supply is service; therefore, it is not possible to stock it and transport service must be consumed when and where it is produced. For this reason, it is very important to estimate demand with as much accuracy as possible to save resources by tailoring the supply of transport services to it [2].

In this paper an overview of the most important simulation tolls will be presented and in the other part of paper an example of implementation of simulation tool VISSIM in the City of Zagreb will be shown.

2. Overview of simulation tools

Traffic simulation is an indispensable instrument for transport planners and traffic engineers. In this chapter some of the most used traffic simulation software will be described.

Modern traffic simulation tools are based on different principles and have two main origins: industrial and academic ones. Industrial simulators (e.g., Vissim, Aimsun), developed for commercial purposes, are generally easier to use and offer user assistance. However, they are less extensible and offer less flexibility and limit the user to predefined cases. The second group of simulators comes from research labs. Developed as part of research work, these solutions are usually less complete and not easy to use for an uninitiated user [3].

Simulation tools offer different levels of traffic modeling usually classified into three following groups: macroscopic, microscopic, and mesoscopic. In macroscopic models, vehicle flow is assimilated to the runoff of a fluid in a pipe and modeled through the equations of fluid mechanics. In contrast, in microscopic and mesoscopic approaches, each actor of the traffic is respectively considered individually and in small homogeneous groups [3].

VISSIM is a microscopic, behavior-based multi-purpose traffic simulation to analyze and optimize traffic flows. It offers a wide variety of urban and highway applications, integrating public and private transportation. Complex traffic conditions are visualized in high level of detail supported by realistic traffic models. VISSIM is a commercial software tool with about 7000 licenses distributed worldwide in the last 15 years. About one-third of the users are within consultancies and industry, one-third within public agencies, and the remaining third is applied at academic institutions for teaching and research. VISSIM is a microscopic, discrete traffic simulation system modeling motorway traffic as well as urban traffic operations. Based on several mathematical models, the position of each vehicle is recalculated every 0.1–1 s. The system can be used to investigate private and public transport as well as in particular pedestrian movements [4].

S-Paramics is used on a wide variety of transport-modelling projects. The strength of S-Paramics is in its ability to apply microsimulation to large area models. The ‘micro’ in microsimulation reflects the level at which the interactions between vehicles are modelled, not a limit to the size of the geographical area in a model. Large models may cover tens of squares of kilometres with hundreds of zones and hundreds of kilometres of road network [4].

The Aimsun transport modelling software is a long-term research programme at the University of Catalonia (UPC), Spain. the software now includes macroscopic, mesoscopic and microscopic models. Expanding in response to practitioners’ requirements, Aimsun has come to encompass a collection of dynamic modelling tools. Specifically, these include mesoscopic and microscopic simulators and dynamic traffic assignment models based on either user equilibrium or stochastic route choice [4]e.

“Simulation of Urban MObility”, or “SUMO” for short, is a microscopic road traffic simulation. The work on SUMO’s design began in the year 2000, with the first implementation being started in the year 2001. SUMO is available as “open source” under the GNU General Public License, both as source code and in compiled, executable form for multiple Windows and Linux platforms. The reason for building an open-source traffic simulation was that while working on traffic simulations within the academic field, it was noted that many different, small simulations were developed as tools within diploma or doctoral theses, in order to evaluate the objective that was the thesis’ real topic [4].

3. Implementation of simulation tools – City of Zagreb example

Transport network capacity is one of the most important attributes while analyzing transport networks. Capacity defines maximum number of vehicles crossing a section of road per unit of time at any selected period. City of Zagreb Master Plan defines current traffic capacities on road network in City of Zagreb area and it is used as a starting point in analyzing transport network in that area. Master Plan data defines the capacity of all types of roads. City avenues have a capacity from 1.000 up to 3.000 vehicles in one way per hour, while other road types have a capacity of under 1.000 vehicles in one way per hour [5].

Same as capacity, the volume of traffic is another important attribute used to analyze traffic congestions on a traffic network. Traffic volume presents the number of vehicles crossing a section of road per unit time at any selected period. The volume/capacity (V/C) ratio is one of the most important elements of transport that describes the state of the transport network. The result given by V/C ratio expresses road congestion, namely, usage of road capacity on the analyzed road. It is also often used as a precautionary measure to detect roads that are near to congestion level. Congestion arises when demand levels approach the capacity of a facility and the time required to use it (travel through it) increases well above the average. [2] Congestion level is considered every V/C/ ratio over 0,75 or 75 %. If the ratio is over 75 % it is necessary to present optimal solutions to reduce congestions. If the ratio value is over 1,00 or 100 %, it is considered that analyzed network demand is higher than supply.

During the development of the Master Plan of the City of Zagreb, a transport model of the City of Zagreb and surrounding counties were created in the simulation tool PTV Visum, which shows the current state of roads in the analyzed area as seen in **Fig 1**.

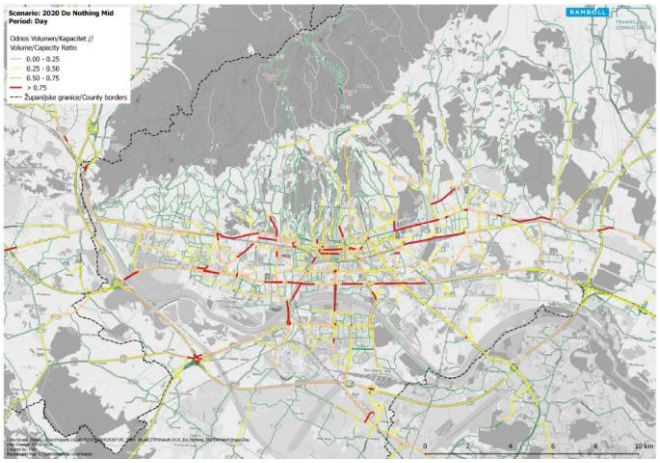

Fig 1. *V/C ratio in City of Zagreb area*

In this paper, one city district in the City of Zagreb is analyzed to evaluate the effects of the proposed traffic optimization solutions using simulation tools. The analyzed city district is located in the northern part of the city and is characterized by geographical and traffic limitations and traffic congestions during weekends due to increased recreational and social activities in the area.

In order to check the relationship between traffic supply and demand and to check the possibility of congestion, macro and microsimulation models were developed as a part of the proposed solution. The macrosimulation model developed in PTV Visum will be used to evaluate new traffic solutions for the construction of a new road to relieve the existing ones and increase the level of traffic safety in the area. The macrosimulation model aims to show the current situation on the transport network and to compare it to the future situation after the implementation of a new road. The microsimulation tool, PTV Vissim, will be used to analyze the reconstruction of the busiest intersection in the whole district and to determine the movement of traffic on the reconstructed intersection.

As previously stated, the district is characterized by congestions during weekends due to large recreational activities that are going to additionally increase in the future with the introduction of a new cable car in the analyzed area. The new cable car will contain an underground garage and outside parking lot with a capacity of about 330 parking places and additional problems in form of traffic congestion are expected in the analyzed area.

The proposal of traffic optimization of the analyzed city district is reflected in the reconstruction of the busiest intersection and the construction of a new transversal road for additional connection of the neighborhood with the city center.

The simulation of the newly proposed intersection reconstruction was performed in the PTV Vissim simulation tool by creating a model of reconstructed intersection. The creation of the model required the creation of modeled intersection from zero.

As a first step in creating a transport model, traffic counting has been carried out. Traffic counting was performed in one hour period during afternoon peak hour with a goal to receive traffic data during the most congested period of the day. Due to the implementation of a new road in the intersection, traffic count was also conducted on the following intersection with the goal of gathering additional data on traffic distribution.

After traffic counting was carried out, the creation of a transport model in the simulation tool has been started. Firstly, the link and connectors were created that are the foundation of every microsimulation model. Links, that are stand-alone objects, represent roads on the network, while connectors, which must be attached to the previously created link, represent turns on the network. The microsimulation model was created with 55 links and connectors that represent the transport network in the analyzed area.

After the implementation of roads, the next steps were to determine desired speeds, reduced speed on connectors, conflict areas, and priority rules on the analyzed intersection. Data gathered during traffic counting is implemented as vehicle inputs and static vehicle routes attributes. Those attributes describe the number of vehicles passing through the intersection and the distribution of vehicles on it. After implementation of all needed attributes, transport model creation was complete, and the model was simulated as seen in **Fig 2**.

Fig 2. *Simulation process of the developed microsimulation model in PTV Vissim*

After the simulation of the transport model, evaluation data was calculated. Evaluation data were collected to analyze traffic elements on the intersection. Analyzed data consisted of the average speed of vehicles in the intersection, maximum queue lengths on the links, lost time while waiting in the intersection, and level of service for each intersection approach. Data for each of the above-named data are seen in Table 1

.

Table 1: *Data collection measurements from the developed model*

Intersection approach	Average speed [km/h]	Maximum queue length [m]	Lost time [sec]	Level of service
1 – west	46,56	10,37	2,92	LOS A
2 – south	44,87	0,00	3,18	LOS A
3 – east	26,61	54,70	16,33	LOS C
4 – north	27,02	11,55	3,74	LOS B

Unlike evaluation of results within the microsimulation model, within the macrosimulation model, the data of congestion of the complete traffic network is analyzed in the monitored area.

As the most common parameter used to evaluate the transport network when monitoring private transport within the macrosimulation model is certainly the traffic volume that passes through a certain section of traffic in a certain time interval. Within created macrosimulation, the traffic volume was presented for a period of one day.

The development of the macrosimulation model was conducted within the PTV Visum simulation tool, which is used to show the entire traffic network in the analyzed area. Input data of the amount of traffic entering the area of the transport network were obtained by field research, i.e. by counting traffic on characteristic locations. Traffic counting data were obtained in a period of one hour and was recalculated to AADT (annual average daily traffic) to implement it to the model.

Macrosimulation models are built from a few network elements that recreate the analyzed area. The first element is nodes that represent intersections on roads, the second element is links that represent transport network, and the third element are zones that represent areas from where and where to trips happen. Created macrosimulation model contains 145 nodes, 314 links, and 28 zones that represent the analyzed area.

Created macrosimulation model (**Fig 3.**) was used to test the construction of a new road that should relieve the existing transport network and ensure an increased level of safety on insecure intersections.

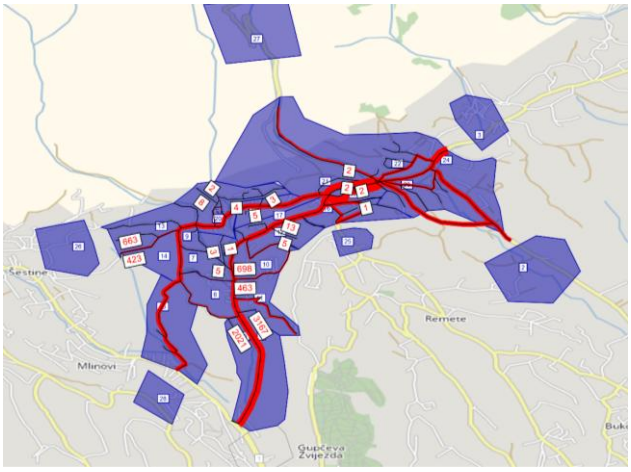

Fig 3. *Macrosimulation model of the district in City of Zagreb created within PTV Visum*

After the implementation of the traffic network simulation with implemented solution, a major change in the distribution of traffic in the analyzed area was visible. Newley implemented transversal road took over around 50 % of existing traffic, relieving existing busiest road in the area by 50 %. Such relief in traffic congestion can ensure a high level of service and a high level of safety for all users.

4. Conclusion

With the increase in population on the outskirts of the city, roads built in the past find it much harder to handle the traffic currently passing through such an area. Due to spatial possibilities, peripheral settlements in the analyzed area of the City of Zagreb have very narrow roads which make it difficult for two-way traffic. In such a state is the traffic network in the area of the analyzed city district. As part of this paper, an analysis of the current state of road transport infrastructure and the transport system in the analyzed area was carried out, and based on the obtained results, conceptual solutions were given for the purpose of optimizing and improving the transport system.

By developing simulation models and evaluating the results of simulations, conclusions were obtained that the implemented solutions are suitable and that they fulfill the purpose of implementation, ie to optimize and improve the traffic system in the entire area of the analyzed district in the City of Zagreb.

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Tax challenges of home office regime following the COVID-19 pandemic

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Abstract: *Covid-19 pandemic has made it necessary to move work from employers' workplaces to home offices. The employee works from home using digital technologies. However, the Home Office scheme is accompanied by significant employee costs, covered by private employees' funds. Among them for example cost of electricity, water, sewers, the cost of suitable workplace equipment and its amortization, costs of quite free space, cost to cover speedy internet. On the other hand, the employers receive work from the employees, but the cost of the working environment and resources they save significantly. The Home Office regime will remain in place after the pandemic, so it is time to consider a financial solution to the cost of home office staff – for example, in the form of tax instruments.*

Keywords*: DIGITALIZATION, MEASUREMENT, EFFECTS OF REMOTE WORK, EMPLOYEES EXPENDITURES, TAX DEDUCTIBLE ITEM*

1. Introduction and review of literature

From March 2020, every aspect of our lives is exposed to a new situation – the COVID-19 pandemic. Technologies, including information technology and digitalisation, are importantly helping to combat the pandemic. According to Fournier, "the digital economy is an area of economics that is engaged in studying the cost of intangible goods traded over the internet." (Fournier, 2013) One of the first definitions of digitalisation was authored in 2001 by Mesenbourgh and Atrostic who state the digital economy has three prims - supporting infrastructure, electronic business processes (how business is conducted), and electronic commerce transactions (selling goods and services online). They add that reliance on computer networks, and the benefits they can provide, is the "bottom line" difference between electronic and other kinds of business. (Mesenbourg & Atrostic, 2001) According Muggah, Rohozinski and Goldin „COVID-19 is accelerating the shift towards digitalisation, ... and the digital economy is growing faster than the real economy. Depending on how it is defined, its total value could be 11.5 trillion USD, or 15% of global GDP. Researchers believe this could rise to as high as 37 trillion USD, or 26% of GDP, by 2040. "(Muggah R. R., 2020)

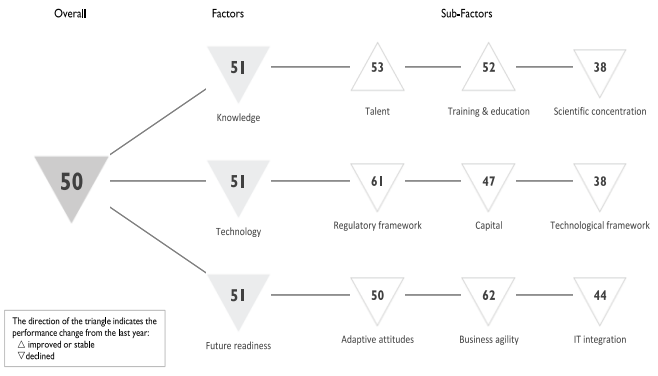

Figure 1 *IMD World Digital Competitiveness Ranking (WDCR) – Slovak republic, overall performance (2020)*
Source: (IMD World Competitiveness Center, 2020, p. 144)

A number of indicators are used to measure and compare countries' readiness in the field of digitalisation internationally. Among them, for example *IMD World Digital Competitiveness Ranking (WDCR*) which was created by *IMD World Competitiveness Centre*, the fourth edition of the ranking report of 63 countries was issued in 2020. WDCR measures countries' ability and readiness to adopt digital technologies leading to their economic and social transformation. The ranking of countries depends on three factors: knowledge, technology and future readiness. (IMD World Competitiveness Center, 2020, s. 3). According to the results of IMD World Digital Competitiveness Ranking (WDCR), the Slovak Republic ranked 50th out of 63 countries, down from 47 in 2019. (IMD World Competitiveness Center, 2020) What is the state of digitalization in the Slovak Republic according to the three assessed factors and their subfactors is shown in Figure 1.

In February 2021, the European Parliament and the Council adopted the Regulation (EU) 2021/241 of the European Parliament and of the Council of 12 February 2021 establishing the Recovery and Resilience Facility (RRF) while the scope of application of the mechanism covers six pillars, including digital transformation. On the basis of the RRF European Union Member States have developed recovery and resilience plans. To track digitalization in the European Union, the Digital Economy and Society Index (DESI) is applied. The structure of DESI 2021 is built on four dimensions, while each dimension measures several sub-indeces, they are (sub-indices are in brackets): Human Capital – digital skills (at least basic digital skills, ICT Specialists, Female ICT Specialists), Connectivity (gigabit for everyone i.e. fixed very high capacity network coverage, 5G coverage), Integration of Information Technology (SMEs with a basic level of digital intensity, AI, cloud, big data), and Digital Public Services (digital public services for citizens, digital public services for businesses). (European Commission, 2021, s. 14) Four dimensions of DESI reflect intervention fields set by the RRF. Namely, dimension Human Capital is equivalent to intervention field 3 (Human Capital) of the RRF, dimension Connectivity is the equivalent to intervention field 1 (Connectivity), dimension Integration of Information technology is the equivalent to intervention fields 5 (Digitalisation of businesses) and 6 (Investment in digital capacities and deployment of advanced technologies), and dimension Digital Public Services is the equivalent to intervention field 4 (e-government, digital public services and local digital ecosystems) of the RRF.

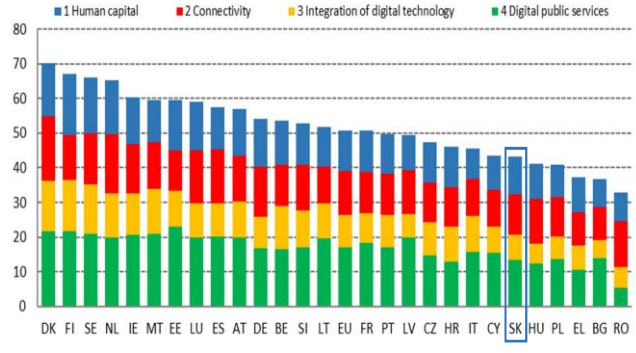

Figure 2 *European Union DESI – overall position of the Slovak Republic*
Source: (European Commission, 2021, p. 3)

The EIB Investment Survey confirmed that most firms surveyed believe that COVID-19 will lead to further acceleration of the use of digital technologies. (Ficarra, Rückert, Virginie, & Weis, 2021), (EIB, 2020a) The current state of digitalization in the Slovak Republic, as assessed by DESI, is shown in Figure Figure **2**. Slovakia has a score of 22 in DESI 2021 among the 27 Member States of the European Union which means that the situation of

digitalization is below the European Union average overall and in four DESI 2021dimensions.

The need for a digital transformation in the European Union is accentuated by the European Investment Bank, which developed a type of composite index - *EIBIS Corporate Digitalisation Index*. The index measures the degree of adoption of digitalization in the EU and the US, which, like previous indices, is composed of several elements, they are digital intensity, digital infrastructure, investment in software and data, investment in organisational and business process improvements, the use of a strategic monitoring system, and the digital outlook, with purpose to summarise indicators on digitalization. (EIB, 2021, s. 6) According to *EIBIS Corporate Digitalisation Index*, the Slovak Republic belongs to the moderate states, as illustrated in the Figure 3.

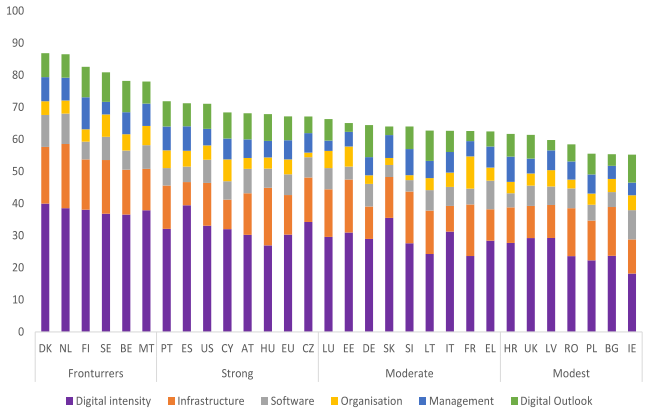

Figure 3 *EIBIS Corporate Digitalization Index, by country*
Source: (EIB, 2021, p. 7)

During the COVID-19 pandemic, it was digitalization that made it possible to continue to work for employees with the reduced mobility necessitated by the pandemic. It has enabled employees to continue working by giving them the opportunity to work remotely - online, thanks to information technology, the internet and digitalization. A questionnaire survey conducted in the Czech Republic found that "home office work use increased significantly compared to the situation before the pandemic. The most significant increase was in the state administration. More than 80% of government executives confirmed the increase, with more than 60% of respondents reporting this in municipalities and nonprofits." (Ministry of Labour and Social Affairs, Czech rep, 2021). In addition, both employers and employees say that they wish to keep their home office work after the COVID-19 pandemic. For example, in an opinion poll commissioned by EON and made by YouGov, "71 percent of respondents who work from home said they would like to continue this way of working in the future. This number is higher compared to the beginning of the pandemic, or a survey last May, when only 58 percent of respondents said so." A similar survey by YouGov made in the UK showed that they "five want to work from home full time after the pandemic." (YouGov, 2021)

This paper aims to examine the regime for remote work, in particular the Home Office regime, its legal definition and impact it has on household or individual expenditures that are required to cover superfluous costs of households or individuals rooted in it. The rest of the paper is structured as follows. Next section provides review of different concepts of remote work and a legal definition of home office work regime in the Slovak republic. Section three is first mapping non-financial effects of remote work, then financial effects of remote work.

2. The different concepts of remote work

In different countries of the world, different labels and definitions are used for remote work, among the most famous there are remote work, telework, work at home, home-based work – see Figure 4 . Sullivan defines out-of-employers' premises work and he set general and project-specific definition of remote work, while in the second case he emphasizes two decisive factors, transportation impact on remote work and one of the most fundamental elements - the use of ICTs. (Sullivan, 2003, p. 3-4) ILO together with Eurofoundation state that there are two key dimensions of telework/ICT-mobile work (T/ICTM) – workplace/mobility and intensity of use of ICT. Based on this, the following categories of out-of-employers' premises work are listed: 1) regular home-based telework, 2) high mobile T/ICTM, 3) occasional T/ICTM, 4) always at employer's premises (ILO; Eurofound, 2017, p. 14)

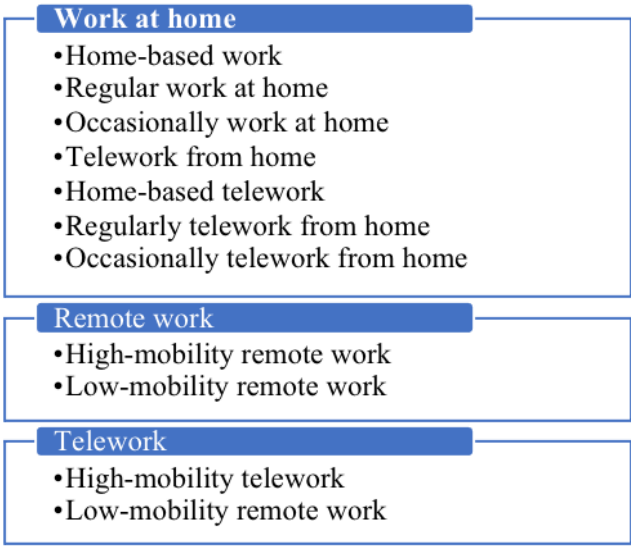

Figure 4 *The different concepts of remote work*
Source: author's own processing based on (ILO, 2020)

In the Slovak Republic, it was in connection with the intensive use of work in the home office mode that the Labour Code No 311/2001 Coll. of Laws was amended on 1 March 2020. In the case of work outside employers'' premises, regular home-based telework, teleworking and, in addition, irregular work from home (home office) are distinguished.

- ***Regular home-based telework*** is regulated in §52(1) to (4) of the Labour Code and its essential feature is that it is carried out from outside the workplace regularly, not just occasionally.
- ***Teleworking*** (high mobile/ICTM) is also set in the Labour Code. In its features it is very similar to homework, especially in that outside the employer's workplace it is carried out regularly, not just occasionally. The difference is that electronic data transmission takes place.
- ***Home office***, (occasional T/ICTM) is regulated in the Section 54(5) of the Labour Code, but its positive legal definition is not provided. On the contrary, it is defined only negatively compared to regular home-based telework and teleworking, namely what is not considered to be regular home-based telework and teleworking even though it is also carried out from an out-of-work premises of employers agreed in the employment contract, usually from home. An essential feature of the Home Office is that outside the employer's workplace it is carried out only occasionally or only in an emergency situation.

3. Effects of remote work

3.1 Non-financial effects

Out-of-employers' premises work convey new effects and challenges of work, not known before. Wheatley, Hardill and Buglass indicate effects and challenges of out-of-employers' premises. Among them there are: career advancements, gender dynamics, mental health, physical remote work environments,

remote team management, remote work, resilient operations, virtual collaboration and teams, work redesign, work, family, and identity, work-life balance, worker well-being (Wheatley , Hardill, & Buglass , 2021). ILO and Eurofound list several groups of effects of T/ICTM work which require both research and the adoption of appropriate regulations: first group, working time: working hours and working time organization (it includes effects of T/ICTM on work duration, effects of T/ICTM on working time organization, effects of T/ICTM on working time autonomy), second group, individual and organizational performance (it includes working time flexibility and work–life balance as a means of improving individual and organizational performance, effects of T/ICTM on work–life balance including its gender dimension), third group, impact of T/ICTM in occupational health and well-being (it includes autonomy and intensity of work, ergonomics, risk isolation, risk of the blurring of the boundary between paid work and personal life – see Figure 5,), and right to be disconnected.

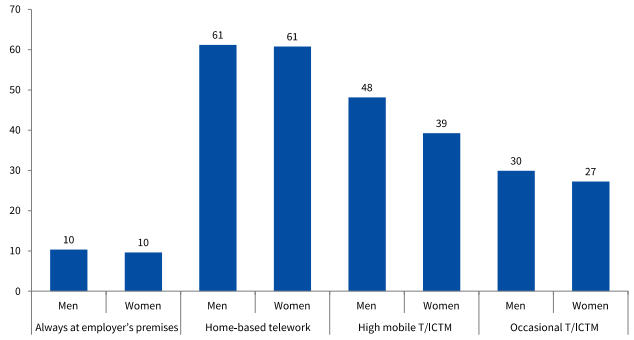

Figure 5 *Employees reporting working in their free time to meet work demands daily and several times a week by type of T/ICTM and gender, EU28 (%)*
Source: (ILO; Eurofound, 2017, p. 30), (Eurofound, 2021)

Empirical literature covers several effects of remote work; however, it does not cover financial consequences of out-of-employers' premises work.

3.2 Financial effects of remote work and Cclassification of employee unpaid costs accompanying home office work mode

The Home Office differs from regular home-based teleworking and teleworking by three characters. Firstly, it is the *occasional* work from home or work from home just and only in an *emergency* situation. Secondly, from a legal point of view, Home Office differs from regular home-based teleworking and teleworking by the agreed place of work, of which it is a compulsory and essential particular of the employment contract, otherwise employment contract would be legally invalid. In the case of occasional work from home (home office) in the employment contract, the main place of work shall indicate the place of employment in employers' premises. Only occasionally, or in emergency situations, and in agreement with the employer, can the employee also carry out work from home, if the nature of the work permits. Nevertheless, the employer must allow employee access to the workplace, employer must provide employee with the technical means necessary for the performance of work, he must protect personal data during electronic data transmission, respect employees' the right to disconnect outside working hours, must prevent the isolation of the employee, enable him/her to educate. Thirdly, unlike regular home-based teleworking or teleworking, where an employee occasionally or in an emergency situation performs work not at the place of work specified in the employment contract, but from home, **the employer is not obliged to reimburse the employee for his home office costs.**

While for the first two categories, i.e., domestic work and teleworking, the employer is obliged to reimburse the employee for the costs associated with the employee working at home, in the case of home office work, which is only occasional work from home in the event of an emergency, the employer is obliged to reimburse the employee for the costs incurred by the performance of work from home.

The third type of remote work, occasional home office work, started to be used at the time of the COVID-19 pandemic. The COVID-19 pandemic has required home office work in many professions where possible.

In this section, we aim to systematically display and summarize the costs of employees who have been working from home for 23 months during the COVID-19 pandemic, i. e. it is no longer about fulfilling the condition of occasional work, on the contrary, employees work long-term and regularly from home.

The costs of staff working in the Home Office during a pandemic can be classified into several groups.

- **Firstly**, the electricity consumption associated with the use of technical security, mainly computers.
- **Secondly**, the cost of connecting a private household to a high-performance Internet, as the performance of work in the Home Office is carried out online in the emergency situation of the COVID-19 pandemic, which requires high data consumption and a sufficiently fast internet, both telecommunications companies charge a higher monthly amount.
- **A third** group of costs of an employee working during the COVID-19 pandemic in home office mode is increased water and sewerage consumption as employee stays at home during the whole day.
- The **fourth** group of home office staff costs are the cost of heat in the apartment and especially the room where the work is carried out during working hours, since, unlike doing work in the workplace, it can no longer regulate daily heat consumption by dampening the heating during its absence.
- The **fifth** group of costs of a home office employee is linked to the need to carry out work from the place where the employee resides, i.e., from an apartment or house which is his own property or he just rents it, and in doing so he can secure an **undisturbed** space reserved for 8.5 hours a day to perform work.
- The **sixth** group of costs is the cost of the equipment with suitable furniture and its wear and tear by frequent use.

Conclusion

As has already been said, work from home which is occasional or during an emergency (Home Office) does not impose an obligation on the employer to reimburse the employee for the costs incurred by the employee in connection with the performance of work from home. **Furthermore, we state and arguments** in favor of specific preferential tax treatment of wages and salaries of employees who have been working long-term from home. Namely, the proposal is to implementation a new tax-deductible item applicable when determining tax base of personal income tax from wages and salaries for employees who have been ordered to work from home due to an emergency situation (COVID-19 pandemic). The following are arguments that justify the proposal:

Firstly, employees of state administrations, ministries and other central government bodies, employees of public administrations and self-governing bodies, as well as university teachers have been performing work home office mode for already 21 months. It is quite clear that the work from home in Home Office mode, has lost one of the essential elements of its legal definition - namely, working from home during a pandemic situation is no longer of an occasional nature, on the contrary, it is regular, and has been changed to a 'new normal'.

Secondly, employers have ordered work from home and do not reimburse the costs of Home Office employees, arguing that in employment contracts with employees signed before the outbreak,

the employer's workplace is listed as the place of work. However, in this case the form over content is preferred.

Thirdly, employers enjoy significant savings during the long term and regularly home office mode – less electricity consumption associated with light and non-connection of computers, printers, less water consumption and sewerage, lower demands on furniture equipment and wear and tear.

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Supplier's Reverse Logistics Process Management

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Abstract: *Reverse logistics processes generate significant logistics costs if not optimized continuously and are often being undetermined. Logistics companies emphasize the necessity for optimization and process uniformization to its highest possible extent, while disadvantages as process duration, educated personnel, and unsatisfied consumers are reverse logistics barriers. For the paper research, the focus has been directed to reverse logistics process analysis at the location of a supplier on the Republic of Croatia logistics market. The case study consists of highlighting reverse logistics issues, on-site analysis, and possibilities to optimize time-consuming processes. Analysis has been provided throughout time measurement of individual reverse logistics process with suggestions for optimization.*
Keywords*: REVERSE LOGISTICS, REVERSE LOGISTICS PROCESSES, PROCESS OPTIMIZATION, SUPPLIER PROCESSING*

1. Introduction

The paper's focus of research is reverse logistics process analysis at the supplier's level. Research has been modified in a way providing operational process analysis and activities and measuring the time duration of processes and activities. At the observed subject, supplier's reverse logistics processes are observed through the interrelationships between the customer and the branch, the branch and the supplier or LDC (logistic distribution center), the service department and the supplier, or the LDC and the external supplier as shown in the paper. Based on the analysis of available data, several suggestions for improving the observed system are given.

Fig. 1 *Uniformity of forwarding distribution vs. individuality of reverse logistics processing*

By recent research [1, 2], reverse logistics processes are often not satisfyingly organized. Some disadvantages that occur on behalf of this, are directly connected and are influencing on company's profit margin.

Reverse logistics processes, always of the secondary matter when compared to optimization of forwarding chain, often are marginalized nevertheless optimization can maybe not directly gain your profit, but it will reduce your logistics costs.

Authors [3, 4] highlighted issues regarding reverse logistics process optimization. Individual approach for each company, focus on the individuality of items in return, focus on clients, information system, reverse logistics return center, are some of the ways to gain reverse logistics process optimization or implementation. Each company needs its focus on its reverse logistics business, due to the individuality of occasions during processing returns.

Different case studies can give us detailed information on similar problems in the supply chain from a reverse logistics point of view. Detecting similarities and analyzing your companies' processes, can influence optimization and reduction of logistics costs. The scientific approach gives us a different perspective while combining it with real case studies can make a significant influence.

2. Reverse logistics processing

In addition to handling returned items, reverse logistics, if optimized, ensures a reduction in the cost of the entire supply chain, leading to improved customer satisfaction, reduced investment in resources reduced inventory and distribution costs. [3]

Economic reasons include the benefits of the introduction such as cost reduction; reducing the number of raw materials; the better relationship between the end-user and the company; adding value to products and increasing the company's reputation related to marketing [3]

The supply chain system includes the interaction of the involved entities, such as customers, suppliers of raw materials and intermediate goods, producers of final products, distributors (wholesalers), retailers, logistics operators, carriers. This interaction is manifested in the flow of goods, information, and financial resources between and within individual stages of the supply chain. The supplier is the business subject responsible for delivering the product to the seller. He has a direct relationship with manufacturers, wholesalers, or retailers. In other words, it connects the market with producers. [4,5] Sustainability is the high trend at the moment, focusing on greening, among else, logistics processes. Supply chains of the future are transparent and environmentally friendly while customer satisfaction is on a very high level. [6,7]

3. Methodology and collected data

Logistics market supplier's specifications

The company included in the study is one of the leading IT distributors and suppliers in the Croatian market. The area of business refers to closer neighboring countries, European Union, and Far Eastern countries. The number of different partners with which the company cooperates exceeds 5,000, to which it delivers more than 200,000 products every month. The total number of employees in the distribution center is over 500 people. The company does not own its retail locations, but cooperates and procures goods for many companies, while through the online platform it provides retail and delivery services to the end customer. The procurement process conducted within the organizational unit in charge of the supply of goods and timely delivery to the appropriate place at the appropriate price mostly refers to computer equipment and components 59% and consumer electronics 30%. The rest of the business refers to computer software 8% and children's toys 3%.

The company's warehouse is structured as a low free-standing facility with a ground floor and three floors to which access is possible by freight elevators with a capacity of up to 2 tons. The total land area is about 57,000 m2 with access to the building from the south, while the total storage area is just over 25,000 square meters. The height of the storage space is up to 12 meters. LDC has a total of 64 forklifts, most of which are motor hand pallet trucks.

The warehouse is equipped with technology for tracking goods through the warehouse and is supported by its own designed WMS (Warehouse Management System) that provides insight to employees in 33,000 pallet places that the company owns with more than 15,000 SKU (Stock Keeping Units).

The space intended for various reverse logistics activities covers a total of 200 square meters and has a capacity of 40 pallet places. The space is divided into three sectors: inspected goods for return, not inspected goods for return, and goods for service. The figure

below represents the layout of the warehouse included in the study with highlighted return zone.

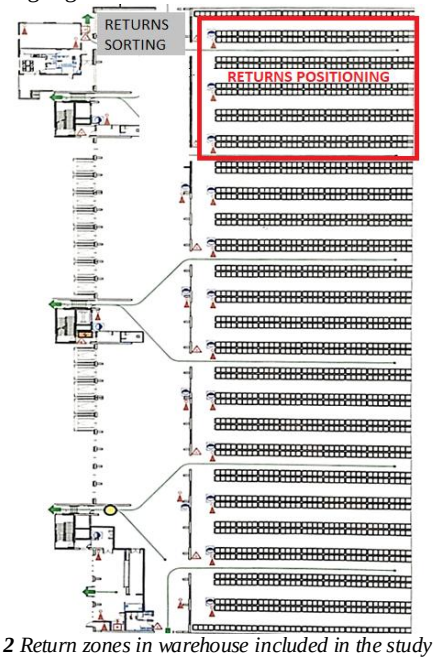

Fig. 2 *Return zones in warehouse included in the study*

Measurements

The observed supplier in the WMS system has more than 15,000 different products. The number of pallets in the observed period from 1st July 2020 until 31st July 2020 is 210 pallets in return, which means 7 pallets per day. The average number of items per pallet was 58 items, 53% of which related to toys, 28% to consumer electronics, and 19% to computer equipment and components. This gives a total of 12,180 items every month of which 6,456 are toys, 3,410 consumer electronics, and 2,314 computer equipment and components, shown in the figure below.

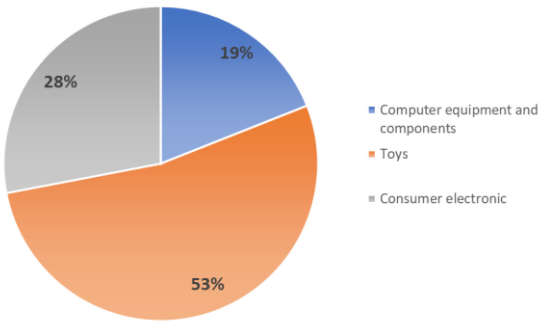

Fig. 2 *Return categories*

To direct the return flow of goods as efficiently and accurately as possible, the company has created several categories of returns or types of returns:

- Return type 1: the return originally packed goods
- Return type 2: DOA (Dead / Defective on arrival) return of defective goods returned by the end-user to the partner eight days from the date of sale (contains a retail invoice),
- Return type 3 return: Damaged goods (open goods, exhibits),
- Return type 4: Return of damaged goods in transport to the customer, not picked up by the customer upon delivery. The customer's return receipt must be made on the same day, ie on the day of damage to the goods, or no later than the next working day, ie twenty-four hours from the occurrence of the damage. It is forwarded to warehouse administrators.
- Return type 5 refund: Refund due to a delivery error. This refers to the quantitative deviation of the physically present in relation to the ordered goods. Also, there is a possibility that item B was delivered instead of item A, which constitutes non-fulfillment of the customer's order.
- Return type 6: Return due to the customer's cancellation of the purchase when delivering the shipment to his address. Also, this category includes cases where the buyer returns the goods due to a price error.
- Return type 7: Refund due to the customer's refusal to pick up the shipment upon delivery of the goods to his address. Also, this type is used if the customer has canceled the order and the goods have not yet left the warehouse.
- Type 8 refund: A refund created by a service order when the defective item cannot be repaired to the customer within the warranty period, there is no adequate replacement, or the customer refuses the replacement item
- Return of commission goods: Reliable partners are given goods from their own warehouse with the possibility of returning unsold goods, ie the return of commission goods given to the commission to individual partners is performed. A reliable partner has its special commission warehouse in ERP (Enterprise Resource Planning) within the group. Commission-related refunds are reversed within the business information system by selecting an option to a warehouse called a commission goods to return warehouse.
- Return type N: Items of private labels whose value does not exceed 30 EUR.

Regarding packaging processing and following activities, the packaging includes:

- pallets
- semi-pallets
- stretch foils
- cardboard boxes

Throughout the LDC area, there are compartments between the shelves into which foil, cardboard, and paper are specially arranged. Employees empty and take full containers of packaging to the press machine located on the outside of the LDC near the end of business hours. Stretch foil is not placed in the pressing machine, but a bale is created from it, which the employee places in a special place outside the LDC. The reason for this is the further sale of bales to companies for the purchase of the stretch film. The rest of the packaging is placed in a pressing machine. After the maximum quantity is collected, the company in charge of collecting cardboard and paper is informed. As for pallets, the company collects damaged pallets inside the warehouse daily. Disposal is done on the outside of the LDC. Once a sufficient number of pallets have been accumulated, the company in charge of the collection is called. Also, the company, in agreement with the warehouse manager, allows all users to remove pallets if they have an adequate vehicle for transporting pallets. This reduces the cost of transporting pallets.

The following presented data, collected during the research will show the average duration of the return process. The average duration of service is 6 days, which refers to the receipt of the item in the service department, inspection, and repair of the item.

The first return process, from the branch office to the LDC / supplier, includes the activities listed in Table 1. These include unloading the goods in the receiving area, transporting the returns to the unsecured return department, checking documentation, control, sorting goods and return type corrections and processing procedures based on the type of return. The average time of the activity of returning the goods from the branches to the LDC or the supplier of the observed company is a total of 124 minutes. A total of three to four warehouse workers participate in the whole process, and with the scope of work, their number increases. The storage unit to which the measurements refer is one pallet in return. This does not mean that it takes 45 minutes to unload it from the truck, but it usually comes with other items that do not fall under the refund status.

Table 1. *Time duration for branch returns at the supplier's logistics distribution center*

Activity	time [min]
Unloading of goods in the reception area	45:00
Transportation of returns to the documentation verification presorting area	01:00
Documentation check	05:00
Control and sorting of goods and correction of the type of return	68:00
Processing procedures based on the type of return	05:00
Total	124:00

The second return process, from LDC to suppliers for non-private label items, includes the activities listed in Table 2. These include activities between KAM (Key Account Management) and suppliers, collection of goods for return, creation of return receipt, control and boarding of suppliers, and conducting administration. 6 to 7 people participate in the whole process, and as the number of work increases, their number increases. The average return activity time from LDC to an external vendor is 87 minutes. The storage unit to which the measurement refers is one pallet in return.

Table 2. *Time duration for LDC returns to suppliers*

Activity	time [min]
Activities between KAM (Key Account Management) and suppliers	30:00
Collection of goods for return	20:00
Creation of return receipt	08:00
Control and boarding of suppliers	25:00
Conducting administration	04:00
TOTAL	87:00

The third return process, from service to supplier, includes the activities listed in Table 3. Depending on the handling of the goods after processing, a minimum of 3 and a maximum of 5 employees participate in the service. The unit of measurement is one pallet, and most of the time after processing in the service it is directed to the activity *denied refund* which is 6 days 1 h 9 min.

Table 3. *Time duration for branch returns at the supplier's logistics distribution center*

Reverse logistics channels	Activity	time [min]
Back to the distribution chain	**Service**	6 (days)/144(h)/8640(min)
	Documentation	08:00
	Scanning and positioning	05:00
	Total	8653 min/ 6 days 13 min
Goods for landfilling	**Service**	6 (days)/144(h)/8640(min)
	Categorization	10:00
	Documentation	08:00
	Repositioning to the warehouse on site	05:00
	Total	8663 min/ 6 days 23 min
Sale	**Service**	6 (days)/144(h)/8640(min)
	Providing new item data	01:00
	Documentation	08:00
	Transport to sale warehouse	04:00
	Total	8653 min/ 6 days 13 min
Refund denied	**Service**	6 (days)/144(h)/8640(min)
	KAM contacting	07:00
	KAM decision process	30:00
	Documentation	07:00
	Goods loading to truck	25:00
	Total	8709 min/ 6 days 1 h 9 min

4. Results and discussion

During the research of the supplier's return process, one of the most common problems was the return of undocumented items by external associates or branches. Also, it often happened that the branch sends several different items within one box, which greatly complicates the process of determining the approved refund, the type of refund, and further handling of items. This problem is related to the clutter of returned goods related to improperly packed goods, lack of parts for multi-component items, lack of instructions for use, etc. Returned goods take up a lot of space, especially during the summer and winter seasons when a large number of employees go on annual vacation. Returned goods then arrive faster than employees can process them. One of the problems is the communication between KAM and reverse logistics employees. It often happens that KAM incorrectly fills in the return receipt, which is later corrected by the reverse logistics employee with the approval of KAM or the warehouse manager. Up to half an hour of working time is lost in this process. Also, one of the problems is not updating the information about the taken return. In the event of this problem, the delivery vehicle arrives at the location of the return collection, but there is no return because it was picked up by another delivery vehicle.

Based on the previously described problems of the observed system, suggestions for reverse logistics process optimization is provided for the improvement of the observed system, and this includes:

- Proper direction of the return of goods from branches

To solve this problem, it is stated that branch employees must document every item they want to return to the LDC. To encourage their work, it is proposed that the observed company gives certain discounts on the selling price of its own products for branch employees if the return of unapproved, improperly packaged, and undocumented goods is set to minimal.

- Organizing return zone

After determining the category of return, the toys should be directed by freight elevator to the 3rd floor, where the storage space is available, especially during the winter and summer seasons. To move a pallet of toys, which is an average of three pallets per day would require 1 worker to set aside an average of 9:30 minutes for such a procedure. An elevator to move the pallets is located 10 meters from the return storage area. By the decision of the warehouse manager, an employee would be selected to move the pallets based on the amount of work he has that day.

- Processing a larger number of pallets in the reverse logistics process

In the observed period, one worker worked in the return zone within the warehouse. His job is to physically process the goods in return and administratively record the processing of the process. As previously stated in the observed period, the daily average of return pallets is 7, which gives 210 return pallets every month. The problem arises with the activities of control and sorting of pallets, on which the most time is lost due to clutter and oscillations in the number of goods on the pallets. The average time required for control and sorting is 68 minutes. The calculation concludes that another worker is needed to successfully control and sort all incoming pallets in return.

To reduce the problems of control and sorting, it is proposed that when sending goods that are returned to the supplier, the branches stack the goods in smaller packages with the item type designation without mixing with other goods. This will eliminate the possibility of returning half-empty boxes, and thus reduce the time of sorting and control. This process enables the processing of a larger number of pallets in return.

The conducted research has highlighted certain disadvantages while processing returns in the observed company from the Croatian logistics market. Research also takes in favor a fact that all companies need to individually approach to solve obstacles during reverse logistics processes.

For further research, the same methodology should be used to analyse different category supply chain subjects and to detect unoptimized processing.

Companies should pay much more analytical attention to reverse logistics processing. Suggested would influence the visibility of each process, unnecessary activities, prolonged activities, unnecessary documentation, and similar.

5. Conclusion

Although issues of reverse logistics are scientifically very often a topic constantly researched, from the other side, on the logistics market is noticed insufficient attention focused on the reverse logistics system. Logistics companies highlight their struggle with processing returns, concerned regarding reverse logistics costs that are easily generating if not maintained.

The paper analyses suppliers' reverse logistics processes, categorization of returns, and the reverse logistics time disposition. The main shortcomings of the reverse logistics process have been identified and suggestions for optimizing the observed system have been given. Some of the observed reverse logistics shortcomings at the observed supplier are the return of undocumented items by external collaborators, the ununiformed packaging of the items in return, the high occupancy regarding average area per item in return, incomplete documentation, etc.

The paper proposes solutions for the optimization of the reverse logistics system as proposed solutions returned items processing from branches, solutions for reserving the space intended for managing items in return.

Proper reverse logistics system management raises the level of business competitiveness within the entire supply chain, which results in greater satisfaction of the end customer. Through various case study analyses, we can detect possible limitations and influence other supply chain subjects.

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Analysis of the eco-indicators for bulgaria and opportunities for their improvement through the sectors of the green economy

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Abstract: *Protecting the environment is vital to keeping life on the planet as we know it. Climate change is a global challenge with a clear complex nature in various aspects - environmental, social, technological, economic and political. At the international and national level, climate change policy is implemented mainly in two directions: 1. climate change mitigation through measures and activities to reduce greenhouse gases and 2. adaptation to the inevitable climate change by assessing risks and mitigation activities of their impact. Implementing these policies requires investment in new technologies and the integration of climate challenges into green sectoral policies at national and local levels.The purpose of this report is to study the state of environmental indicators for Bulgaria and their development dynamics over the last decade. The results reveal the sectors with the strongest influence on the ecological condition of the country and the directions for its improvement.*

Keywords: ECO-INDICATORS, CLIMAT, ENVIRONMENT, GREEN SECTORS, GREEN ECONOMY

1. Introduction

Modern climate models predict continued trends in global warming in the coming decades. As a result of the continuing rise in temperatures, extreme weather events are occurring in some regions and rainfall is becoming more frequent, while others are exposed to heat waves and droughts [1,2]. These impacts are expected to intensify in the coming decades. The effects of global warming lead to:

- Melting polar ice and rising sea levels. When the water warms up, it expands. This change causes sea levels to rise, resulting in flooding and erosion of coastal and low-lying areas.
- Extreme weather, variable precipitation. Heavy rains and other extreme weather events are becoming more common. In some regions there are floods and deterioration of water quality, and in others - a decrease in the availability of water resources [3].
- Risks to human health. Climate change is affecting human health. There has been an increase in the number of deaths. In some regions they are associated with high temperatures, and in others with cold. At the same time, there are changes in the prevalence of some water-borne diseases[4,5].
- Expenditures for society and the economy. Restoring damaged property, infrastructure and human health requires high costs for society and the economy.
- Sectors such as agriculture, forestry, energy and tourism are particularly affected, as they rely heavily on certain temperatures and rainfall levels[6].
- Risks to wildlife. Climate change is happening so fast that some species are disappearing and others are struggling to survive[7]. Some plant and animal species will be at increased risk of extinction if average global temperatures continue to rise uncontrollably.

The degree of climate change over the next few decades depends on the amount of greenhouse gas emissions that civilization will produce[8,9]. Most experts believe that even if modern global warming and related climate change have begun as a natural process, they are strongly supported by human activities.

2. Literature review

According to the latest report of the Intergovernmental Panel on Climate Change (IPCC), published on 9 August 2021 and approved by 195 IPCC member states, many of the climate changes observed are unprecedented for the last thousands, if not hundreds of thousands of years[1,8]. The environmental problems of our society arise as a result of human practices. In contact with nature, people affect its condition and unfortunately worsen it. Industrial development and population growth around the world lead to great environmental pollution.

Numerous scientific studies show that, despite the measures taken for the transition to sustainable development, the state of theenvironment has deteriorated in the last few decades. This is reflected in the exacerbation of environmental problems, including the depletion of the earth's bowels and the depletion of non-renewable resources; air, water and soil pollution; deforestation; the expansion of desert areas; soil erosion; the reduction of drinking water supplies; extinction of valuable animal and plant species. Climate change, in which human activity plays a key role, is currently considered to be the biggest environmental threat [10]. The problems it causes are a summary of fig. 1.

Fig. 1. Global environmental problems as a result of climate change

- **Global warming.** Climate change related to global warming is the result of human practices that increase greenhouse gas emissions. Global warming is leading to higher temperatures in the oceans and on land, causing melting polar glaciers, rising sea levels and unnatural patterns of precipitation such as floods, excessive snow and desertification. With increasing temperatures and changes in the precipitation pattern, crop yields will be significantly reduced, and this will lead to food shortages [2,4].
- **Deforestation of forests.** Organic forests are being destroyed to make room for livestock, palm oil plantations, soybeans and other agricultural monocultures. Today, about 30% of the planet's surface is covered with forests, and about 18 million hectares are destroyed every year [7,10]. Almost all of this deforestation is the result of logging and burning.
- **Air pollution.** Industrialization and motor vehicles are the main source of pollutants on the planet. Air pollution is caused by various gases and toxins emitted by industry and fuel combustion, and soil pollution is caused by industrial waste and harmful chemicals used to treat it.
- **Acidification of the ocean.** It is the result of the direct impact of excessive carbon dioxide production (25% of carbon dioxide is produced by humans) [11].
- **Extinction of biological species.** The list of endangered species continues to grow at an alarming rate, which disturbs the ecological and biological balance.
- **Acid rain.** Acid rain is the result of the presence of certain pollutants in the atmosphere. They can be caused by burning fuels, volcanoes or rotting vegetation [12]. This is an

environmental problem that can have a serious effect on human health, wildlife and aquatic species.

- **Water pollution.** Water pollution is caused by oil spills, acid rain and municipal waste. The availability of clean drinking water is becoming an economic and political problem. Industrial development fills rivers, seas and oceans with toxic pollutants that threaten human health [13].
- **Public health problems.** Modern environmental problems pose a major risk to human and animal health. With increasing temperatures diseases such as malaria, West Nile fever, tropical fever and others. will appear in other areas. Dirty water is a major threat to quality of life and public health.
- **Soil degradation.** Food safety depends on keeping the soil in good condition.
- **Waste disposal.** Excessive consumption of resources and disposal of plastic products are creating a global waste crisis. This is one of the most pressing environmental problems of modern society.

3. Methodology, research and discussions

A conceptual model for analysis of the state of eco-indicators for Bulgaria by categories and indicators is presented in Fig.1. The proposed model is adapted to the example of the indicators and indicators set in the analysis structure of the 2020 Performance Index. (EPI Environmental Performance Index). The 2020 Environmental Indicators Index (EPI) provides aggregated data on the state of sustainability worldwide. [2,3,5] Using 32 performance indicators in 11 categories, EPI ranks 180 countries in terms of environmental health and ecosystem vitality.

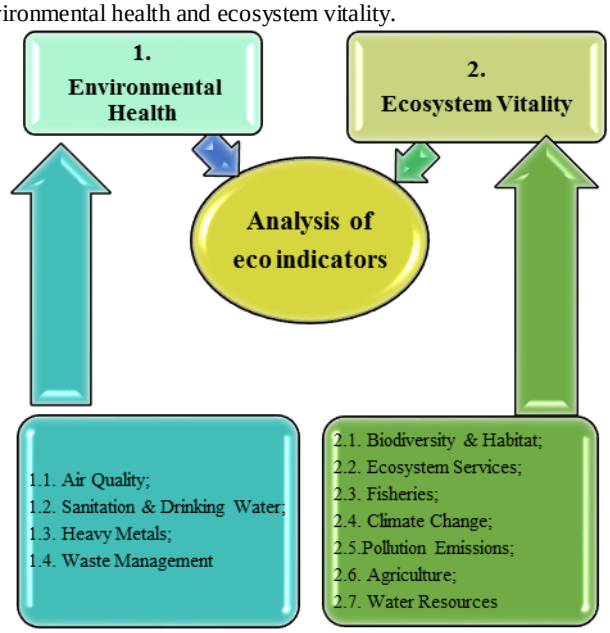

Fig.2 Model for analysis of eco-indicators. (Adapted from EPI)

The analysis of eco-indicators is performed in two categories - 1. Quality of the environment and 2. Vitality of ecosystems.

The first category of **environmental quality** covers the indicators:

1.1. ***Air quality***. Air pollution (indoors or outdoors) is a factor that affects human health, life expectancy and quality of life.

1.2. ***Sanitation & Drinking Water*** - The indicator tracks diseases and deaths from exposure to hazardous sanitation and drinking water. Safely managed sewage (waste) and drinking water are at the heart of public health and sustainable development [14].

1.3. ***Heavy Metals*** - Heavy metals such as lead, arsenic, mercury and cadmium are toxic and pose a significant risk to public health worldwide.

1.4. ***Waste Management*** - an indicator covering the problem of sustainability. Uncontrolled waste disposal generates air and water pollution, soil pollution and an increased risk of exposure to pathogens and toxic substances [15,16]. Poorly managed waste also contributes to climate change by releasing methane gases and in some circumstances can threaten biodiversity.

In the second category of ecosystem viability, the following indicators are monitored for analysis:

2.1. ***Biodiversity & Habitat.*** Biodiversity loss reduces the provision of ecosystem services and undermines progress towards the sustainable development goals. The indicator assesses the actions of the state for the preservation of natural ecosystems and protection of the whole spectrum of biodiversity.

2.2. ***Ecosystem Services.*** The indicator measures the loss of pastures, wetlands and wood cover.

2.3. ***Fisheries.*** Overfishing, declining fish species diversity, acidification of the ocean and deteriorating ecosystems threaten the world's marine stocks [17]. With the growing food needs of a growing population, fishing poses a significant challenge in terms of human nutrition, economic activity and ecosystem health.

2.4. ***Climate Change.*** Global climate change is disrupting human health and safety, as well as the natural ecosystems and resources on which the population depends. Climate change is due to greenhouse gas emissions from burning fossil fuels, land use change and other sources.

2.5. ***Pollution Emissions.*** Human activity causes pollution of air and water and soil, damaging ecosystems in various ways. The main air pollutants, sulfur dioxide (SO2) and nitrogen oxides (NOX), also degrade soil and water quality [3,18] and cause a cascade of environmental effects that reduce biodiversity, putting human communities at risk [4,19].

2.6. ***Agriculture*** - Agriculture provides the food that everyone needs, but agricultural productivity often comes at the expense of sustainability - and leads to soil erosion, land use transformation that damages ecosystems, water pollution and other damage [5, 20].

2.7. ***Water Resources*** - Water is an essential element in providing vital ecosystem services, ensuring public health and sustaining global industries such as agriculture, mining, manufacturing and urban development [21,22]. The indicator monitors the quality and quantity of water on a geographical scale by treating wastewater.

The latest report of the Yale Center for Environmental Law & Policy and The Center for International Earth Science Information Network (CIESIN) at Columbia University's Earth Institute from the 2020 Environmental Indicators Index ranked Bulgaria 41st with 57.0 points from 180 countries surveyed in the world.

The results show that for the last 10 years the country has added 4.2 points to its overall indicator. (Fig. 3)

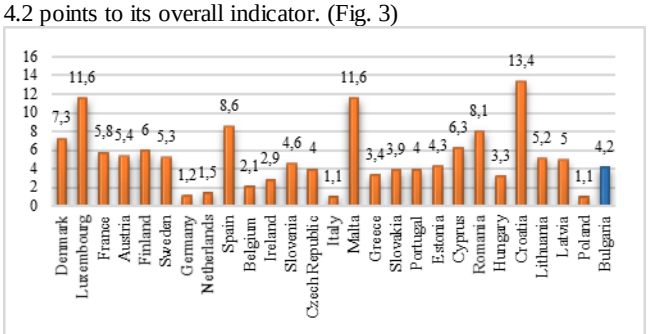

Fig. 3. Ten-year changes in EPI score, EU-27, 2020
Source: https://epi.yale.edu/epi-results/2020/country/bgr

The increase in the result is not a sufficient condition for the country to improve its place in the ranking, on the contrary. From the 30th position in 2018, it falls to 41 position in 2020 and remains last among the 27 member states of the European Union. (fig. 4)

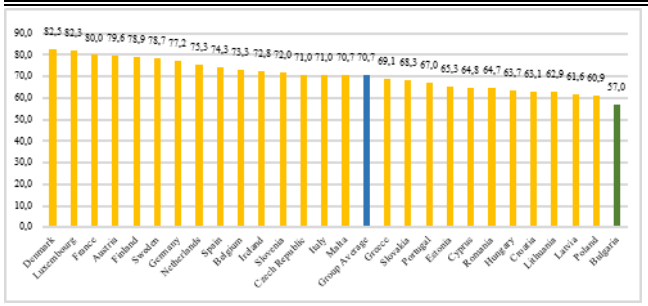

Fig.4. Rankings, EPI scores, EU-27, 2020

Source:https://epi.yale.edu/epi-results/2020/country/bgr

Comparison of the results for Bulgaria with those of the countries of Eastern Europe is presented in fig. 5. The data show that in most of the indicators, Bulgaria performs better than the regional average. The biggest lag is observed in terms of air quality, heavy metals and water resources management.

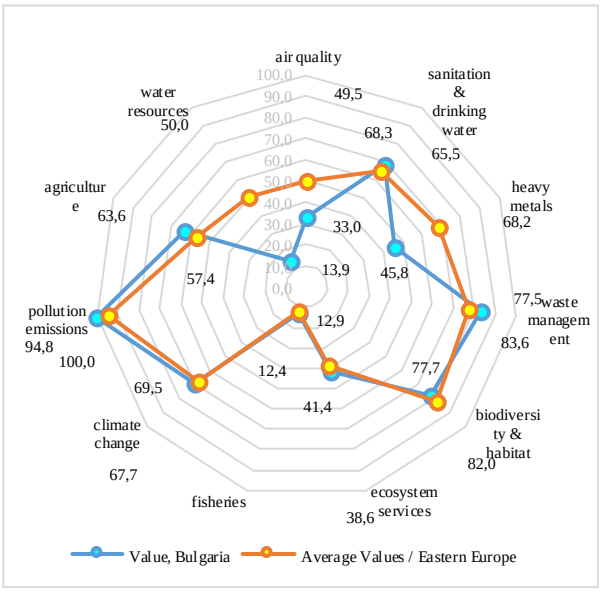

Fig.5. Data for Bulgaria and average values for the region of Eastern Europe

Source: https://epi.yale.edu/epi-results/2020/country/bgr

The change of investments (costs) in the country for protection and restoration of the environment in the period 2010 - 2020 is presented in fig. 4. The trend shows an increase in expenditures, as by 2020, they represent 1.9% of total gross domestic product. (Fig. 6)

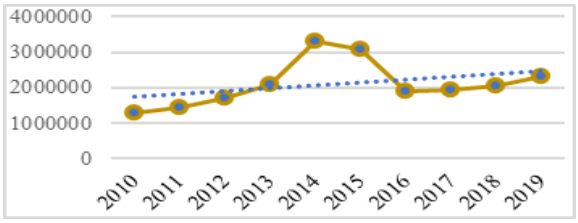

Fig. 6. The change in the costs in the country for protection and restoration of the environment

Source: NSI

The distribution of the available tangible fixed assets with ecological purpose by ecological directions is presented in fig. 7. The largest share is occupied by fixed assets in the direction - wastewater (34.7%), followed by fixed assets in the direction of air protection (30.10%) and fixed assets for waste treatment (28.8%)

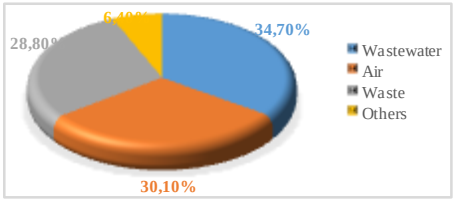

Fig. 7. Fixed tangible assets with ecological purpose by ecological directions by 2020

Source: NSI

The distribution of costs by individual areas related to environmental protection are presented in Fig. 8. A large share of expenditure (nearly 63%) is incurred for waste. The share of water protection costs is about 18% and the share of air protection costs is about 11%. Few expenditures were made for the protection of soil (1.10%) and forests (1.80%). The share of hunting and fishing expenditures is the lowest (0.20%) and expenditures for research, education and similar activities (0.10%). No costs were incurred to prevent noise - 0%.

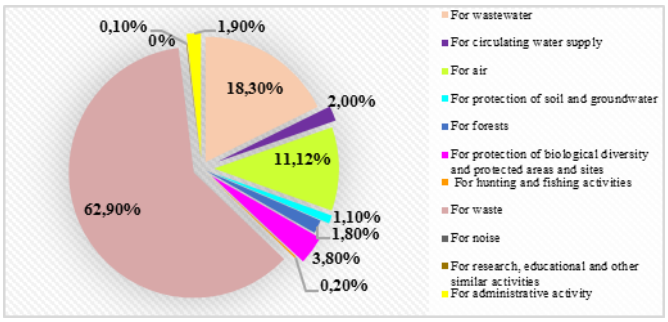

Fig. 8. Allocation of expenditures for environmental protection in Bulgaria for 2020.

Source: NSI

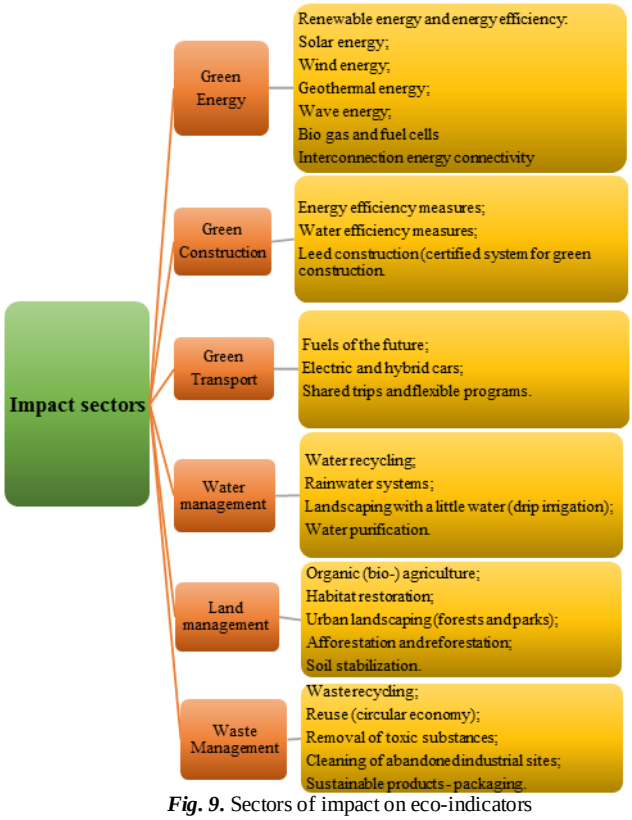

Fig. 9. Sectors of impact on eco-indicators

The analysis reveals the directions in which opportunities can be sought to improve environmental indicators in Bulgaria. They can be searched in the green sectors summarized in fig. 9. The largest is green energy production, followed by green construction, green transport, water management, land management and waste management.

4. Conclusion

The analysis of eco-indicators is performed in two categories *Quality of the environment and Vitality of ecosystems*. The first category of environmental quality covers the indicators: air quality, air pollution, sanitation & drinking water, heavy metals, waste management. In the second category of ecosystem viability, the following indicators are monitored for analysis: biodiversity & habitat, ecosystem service, fisheries, climate change, pollution emissions, agriculture provides, water resources.

The data show that Bulgaria ranks last in the EU 28 in terms of the performance of eco-innovation, as the difference from the European average (for 2021 - 121) is very large (for 2021 - 51. After 2016, the results show a significant increase in the value of the index of nearly 50% for the last four years.

Comparison of the results for Bulgaria with those of the countries of Eastern Europe show that in most of the indicators, Bulgaria performs better than the regional average. The biggest lag is observed in terms of air quality, heavy metals and water resources management. A large share of expenditure is incurred for waste. The share of water protection costs is about 18% and the share of air protection costs is about 11%. Few expenditures were made for the protection of soil and forests. The share of hunting and fishing expenditures is the lowest and expenditures for research, education and similar activities. No costs were incurred to prevent noise.

The world scientific community is adamant that climate change is a fact and the main reason is the increased levels of greenhouse gases, mainly due to human activities. Climate change mitigation is a process that requires a responsible attitude on the part of society as a whole. This requires a transformation of the way it produces, consumes and lives.

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Eco innovations - the foundation of sustainable regional bio-sector

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Abstract: *Mankind faces a number of challenges in the 21st century. Many of them are related to the achievement of the goals and ideas set in the concept of sustainable development of modern UN society. The bio-sector, which is developing within the borders of the Bulgarian economy, has undergone rapid development in the last few years. Many factors have influenced this process, the most significant of which are: increased demand for organic products in international markets, high levels of public support for this type of production and the availability of favorable climatic conditions for their development. Innovation is the main tool for achieving competitiveness and economic growth at all levels - enterprise, industry, region or country. They are the fundamental means of improving people's quality of life. The purpose of this report is to present the results of a survey conducted among bio-enterprises in the regions of Bulgaria and to show that the green innovation in the bio-sectors is the foundation for regional economic, social and environmental prosperity. The results of the study summarize the main directions for achieving regionally balanced sustainable development.*

Keywords: ECO-INNOVATION, INNOVATION ACTIVITY, SUSTAINABILITY, BIO-SECTOR, BIO-ENTERPRISES

1. Introduction

The 21st century has posed a number of challenges to humanity, including limited resources, climate change, ecosystem degradation and a growing population. Global extraction and use of natural resources increased by nearly 80% between 1980 and 2020. Many companies are at risk of shortages of raw materials, instability of valuables, supplies and high values of materials. Disposal costs represent almost 15% of waste management costs, and landfill fees (at European level) are increasing every year, currently ranging between 10 and 80 EUR / tonne.

Overcoming modern challenges and meeting the goals of sustainable development requires comprehensive changes. These changes affect the development of the bio-sectors in the economy. Resource efficiency, sustainable economic growth, environmental and social justice and inclusion are an integral part of the development and creation of future enterprises related to the bioeconomy.

All this imposes the need to open opportunities for production and consumption in accordance with the ecological boundaries of our planet, economic growth compatible with environmental protection, sustainable use of limited natural resources and achieving a social standard of living that reduces poverty [1]. Overcoming these challenges requires a focus on research and innovation, to create new biomass products or new services that help reduce climate change, waste, create new jobs and build bio-production that contributes to sustainable development. modern society.

The bio-sector is the renewable segment building the philosophy of the circular economy, which has undergone rapid development in recent years. The global market for organic products is growing by 10% -15% on an annual basis (approximately $ 5 billion in absolute terms) and by 2020 is approaching $ 100 billion (Fig. 1).

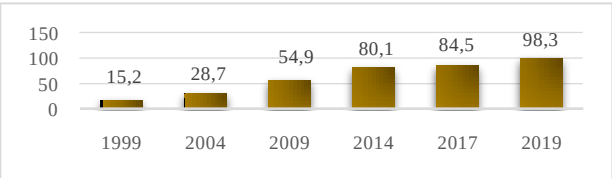
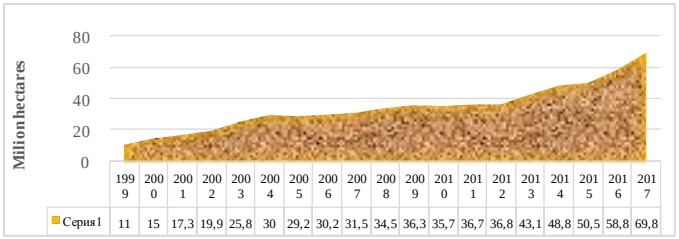


Fig.1. Global market for organic products (USD, billion)
Source: https://www.statista.com/statistics/196952/organic-food-sales-in-the-us-since-2000/

The areas occupied by organic farming (globally) are also increasing - from 44 million ha by 2000 (nearly 1% of agricultural land in the world) to 100 million ha by 2020, (Fig. 2) and the number of organic producers by 2020 exceeds 3 million, an increase of more than 15 times compared to 1999. Forecasts show that by 2025 the organic market will reach 225 billion euros [2].

Fig. 2. Growth of organic agricultural land 1999-2017
Source: Research Institute of Organic Agriculture, FiBL, 2019

The main factors influencing this growth are related to the increased demand for organic products on international markets, high levels of public support for this type of production, the availability of favorable climatic conditions for their development, improving welfare of employees in the organic sectors, the desire of the population to consume healthier products and those produced in an environmentally sustainable way, and last but not least - the existence of government policies that stimulate organic production and "green" practices [1].



2. Literature review

According to the Organization for Economic Co-operation and Development in Europe (OECD) Oslo Handbook (2018) for the collection and interpretation of innovation data, innovation is defined as the introduction of a new or significantly improved product (good or service) or process, a new marketing method or a new organizational method in business practice, workplace organization or external relations. This definition applies very generally to innovation in the bio-sector, which is expected to have two clear and significant characteristics, namely:

- Reflect the idea of reducing environmental impact, whether this effect is pre-sought or accidental.
- Not to be limited to product, process, marketing and organizational innovations, but also to include innovations in social and institutional structures.

In the scientific literature, the concept of eco-innovation was first considered by Fussler and James (1996), who defined eco-innovation as "new products and processes that provide value to customers and businesses but significantly reduce environmental policy"[3]. The definition of Klemmer is similar, which complements the participants in this process. According to him, "Eco-innovations are all measures of relevant actors (firms, politicians, unions, associations, churches, private households) which develop new ideas, behavior, products and processes, apply or introduce them and which contribute to a reduction of environmental burdens or to ecologically specified sustainability targets" [4].

The market orientation of eco-innovation is addressed in the definitions of Andersen and Keeble et al. According to Andersen, "Eco-innovation is an innovation which is able to attract green rent on the market." For Keeble et al. "Sustainability-driven innovation is the creation of new market space, product and services or processes driven by social, environmental or sustainability issues"[5].

In the European Commission's 2007 Competitiveness and Innovation Framework Program, much of which is devoted to the financing of eco-innovation, the term is defined as "any form of innovation aimed at significant and demonstrable progress towards the goal of sustainable development, by reducing the impact on the environment or achieving a more efficient and responsible use of natural resources, including energy"[6]. It emphasizes the link between the concept of sustainable development of modern society and the ultimate goal of eco-innovation. In the INNOVA initiative of the European Commission, the concept is specified "Eco-innovation is the creation of new goods, processes, systems, services and procedures at competitive prices designed to meet human needs and ensure a better quality of life for all with minimal use of life-cycle natural resources (materials, including energy and surface area) per unit of output and minimum release of toxic substances [7]. Two main ideas are linked in this definition: First, eco-innovation is a specific type of innovation designed not only to create new markets or to replace obsolete ones, but mainly to meet human needs and secondly, the environment is affected, which depends on innovation development.

An alternative definition is proposed by Kemp and Foxon, according to which „Eco-innovation is the production, application or exploitation of a good, service, production process, organisational structure, or management or business method that is novel to the firm or user and which results, throughout its life cycle, in a reduction of environmental risk, pollution and the negative impacts of resources use (including energy use) compared to relevant alternatives' [8]. An analogous definition was also proposed by the OECD in 2009. The OECD observer document says that eco-innovation is the creation or implementation of new, or significantly improved, products (goods and services), processes, marketing methods, organizational structures and institutional arrangements which - with or without intent - lead to environmental improvements compared to relevant alternatives" [9].

According to the Environmental Technologies Action Plan (ETAP), „Eco-innovation is the production, application or exploitation of a good, service, production process, organisational structure, or management or business method that is novel to the firm or user and which results, throughout its life cycle, in a reduction of environmental risk, pollution and the negative impacts of resources use (including energy use) compared to relevant alternative" [10].

According to the OSLO Manual [11], „Eco innovation can be generally defined as innovation that result in the reduction of environmental impact, no matter whether or not that effect is intended. Various eco-innovation activities can be analysed along three dimensions:

- Target (the focus areas of eco-innovations: products, processes, marketing methods, organizations and institutions)
- Mechanisms (the way in which changes are made in the targets: modification, redesign, alternatives and creation)
- Impacts (effects of eco-innovation on the environment)" [11].

All the mentioned authors conceive eco-innovation as a process of novelty creation that should be able to lead to a more responsible and efficient use of resources and minimise the impact of human activity on the environment. Eco-innovation is any innovation that reduces the use of natural resources and reduces the release of harmful substances throughout the life cycle. Eco-innovation can be found in all forms of new or significantly improved products, goods, services, processes, marketing methods, organizational structures, institutional arrangements and lifestyles and social behaviors that lead to environmental improvements over relevant alternatives [12]. They involve the development and application of new approaches to value chains of products and processes that reduce the intensity of the use of materials and at the same time increase the intensity of service and well-being.

To be defined as an eco-innovation, an innovation must have at least one of the following six characteristics:

- reduction of the negative impact on the environment.
- efficient use of natural resources.
- realization of energy efficiency.
- use of renewable energy sources.
- recycling of waste and non-waste technologies.
- implementation of environmental standards.

Eco-innovations can be considered and analysed in terms of their purpose, mechanism for implementation and impact on the environment.

- ❖ The goal refers to the main focus of eco-innovation - new products (both goods and services), new processes (production method or procedure), new marketing methods (for the promotion and pricing of products, new market-oriented strategies, etc.), a new form of organization (such as the governance structure and the distribution of responsibilities), institutions (institutional agreements, social norms and cultural values).
- ❖ The mechanism refers to the way in which the change in the goal of eco-innovation is implemented or introduced. It can be technological or non-technological. Eco-innovation in products and processes relies mainly on technological development, while eco-innovation in marketing, organizations and institutions relies more on non-technological change. There are four main mechanisms:
  - Modification, such as minor changes to the product or process.
  - Redesign, which refers to significant changes in existing products, processes, organizational structures, etc.
  - Alternatives such as the introduction of goods and services that can meet the same functional need and exist as substitutes for other products.
  - Creation, design and introduction of completely new products, processes, procedures, organizations and institutions.
  - Impact refers to the effect that eco-innovation has on the environment, the whole life cycle or a single area.

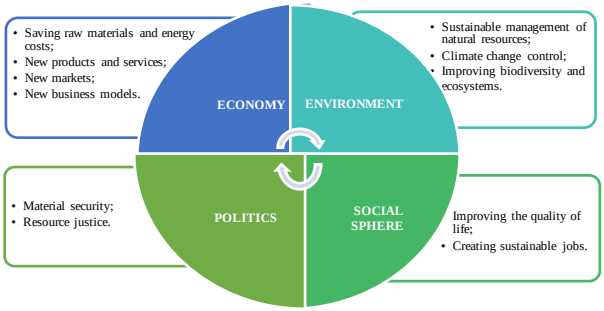


Fig. 3. Relationship between eco-innovation in the bio-sector and regional development

Source: author's interpretation

Eco-innovation is any innovation that leads to significant progress towards the goal of sustainable development by reducing the impact of existing production methods on the environment, increasing the resilience of nature to environmental pressures and achieving more efficient and responsible use of natural resources [13]. The impact of eco-innovation in the regional bio-sector, in the four directions - economy, ecology, social sphere and policies, are summarized in Fig.3.

Bio-sector enterprises are an important factor in creating, introducing and disseminating innovations in the market. This is due to their desire to maintain and increase the innovative nature of their products and the technologies they use for their production.

3. Methododlogy

The analysis was prepared mainly on the basis of a survey, discussions and interviews with experts and organic producers from the regions of Bulgaria. Initial contact and other basic information about all organic producers are collected from the official register of the Ministry of Agriculture and Food of the Republic of Bulgaria - database of producers, processors and traders of organic products and foods produced in organic production in a way that maintains such current database. A total of 234 organic producers from different sectors of the bioeconomy were surveyed in the period April-September 2021. A survey was conducted with the help of a specially developed questionnaire and aims to collect and analyze empirical information to explore the relationship between innovation activity of enterprises and their economic performance and efficiency, and to determine the impact of eco-innovation on efficiency.

The factors that stimulate or hinder companies from developing, creating and implementing eco-innovation are summarized in a table.1.

Table 1. Incentives and limiting factors for the creation and implementation of innovations

Stimulating factors	Obstructive factors
Economically: • growth in the market of eco-innovative products and services; • access to subsidies and financial incentives; • availability of good business partners. • Existence of organizations engaged in research and development.	***Economic and financial:*** • lack of financial resources for the enterprise; • uncertain market demand; • uncertain return on investment; • difficult access to public subsidies.
Politically: • Existing or expected environmental regulations and standards; • Voluntary codes or agreements on good environmental practices; • Creation of clusters and support for clusters.	***Corporate:*** • lack of qualified staff; • lack of expert knowledge and skills; • limited opportunities to improve production efficiency.
Factors related to the companies: • Availability of information and knowledge about technologies in the specific field; • Availability of good organizational and managerial skills.	***Others:*** • Limited environmental awareness among consumers, which leads to low demand for eco-products. • lack of regulatory incentives. • dominance of established companies in the market; • poor interaction between science and business

Bulgaria is no exception to global trends in the development of sectors in the bioeconomy. (Fig. 4) The data on the dynamics in their development and the change in the GVA of the country for the period 2010-2019 are calculated according to the chain volume index (in 2010 = 100), illustrating which bio-sectors have increased or decreased the value during the period 2010-2019.

According to the OECD, by 2055 the bioeconomy and the bio-sectors that develop within its borders will be the basic principle for the development of the regions. In Fig. 4 are ranked the sectors of the bio-iconomy, which will attract the greatest investor interest in the next 20 years [14] (production account and generation of income by industry) The data show that the focus will be on developing and implementing innovative methods for the production of renewable bio-resources in agriculture, forestry and aquaculture, and new methods for the production of bio-products, and biomass and bio-energy will become the main source of industrial raw materials.

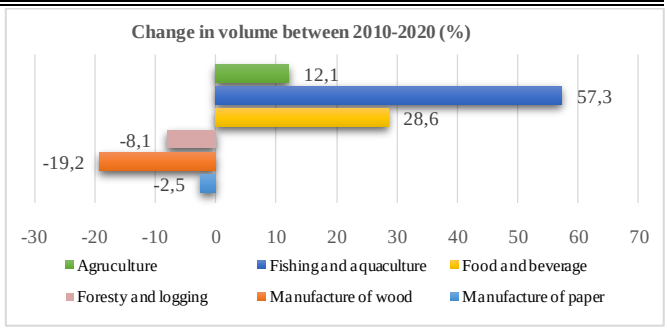


Fig. 4. Change in gross value added in the sectors of the bioeconomy in Bulgaria
Data source: author's calculations (production account and income generation by industry)

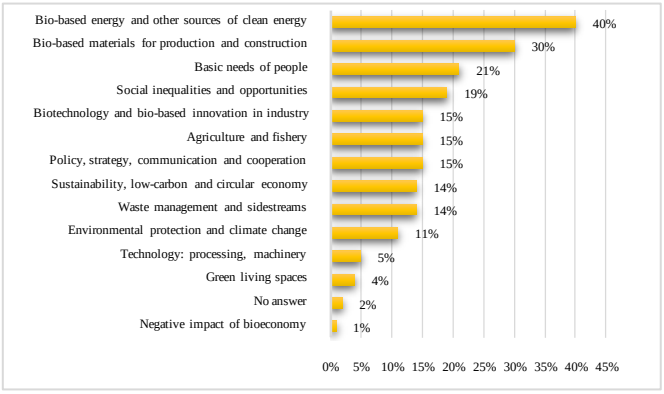


Fig 5. Sectors of the bioeconomy with a perspective for development in the next two decades.
Data source: author's calculations

The forecast study shows that the bio-sector needs innovation. The role of innovation is fundamental. They are seen as the key to success in improving environmental degradation and resource consumption. At the same time, they are an incentive for building entrepreneurial structures and sustainable regional growth.

4. Exploration

The survey conducted in the period April-September 2021 among companies in the bio-sector with different subject of activity and size. It was implemented on the basis of an open and closed questionnaire, distributed by e-mail.

A questionnaire was used to collect data from a sample of 234 enterprises, which were selected by a stratified method of random sampling from all subsectors of the Bulgarian bio-industry. The respondents are representatives of all major subsectors of the bio-industry in Bulgaria and their relative shares are shown in fig. 6.

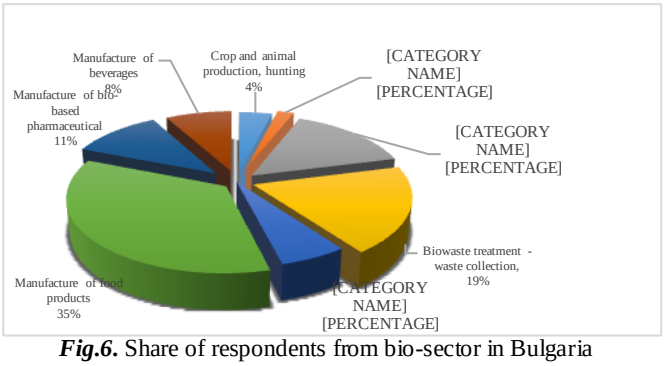


Fig.6. Share of respondents from bio-sector in Bulgaria
Data source: author's calculations

In Fig. 7 reflects the ecological impact of eco-innovations implemented by bio-enterprises on the development of the regions in Bulgaria.

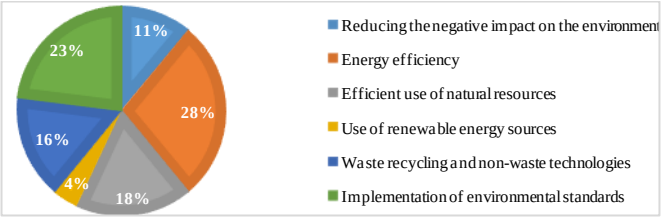


Fig.7. Ecological impact of innovations on regional development

Data source: author's calculations

In the first place, the respondents put the innovations related to increasing the energy efficiency (28%). Innovations related to the establishment and compliance with the Implementation of environmental standards are ranked second (23%).

The results of the author's research were used to determine the innovative activity of enterprises and to identify the factors influencing it. A comparison was made between the results of the survey and the official data of the NSI and the EU. In conclusion, based on the analysis of the results of the survey, the following conclusions were made:

Of all the surveyed enterprises by the survey method, about 30% are innovative. Such is the share of innovative enterprises in Bulgaria according to official statistics. The largest number of companies have managed to implement product innovations. There is a tendency to increase new products.There is a decline in organizational innovation and a significant increase in eco-innovation.Process and marketing innovations vary up and down, but within small limits. The strongest favorable impact on innovation from the internal factors for the enterprise has the presence of entrepreneurial spirit, and from the external factors - the public innovation programs; The strongest impediment to innovation from internal factors for the company is the lack of qualified staff, and from external - the lack of external sources of funding. The indicators for measuring the eco-innovation activity of the surveyed enterprises can generally be classified as research and development costs, applications of patents, technology implementation, participation of skilled workers, etc. It can be concluded that in medium-sized enterprises the highest employment of R&D staff is observed - 50%, followed by small enterprises - 35%, in micro-enterprises the employed staff is 13%, and in large enterprises it has the smallest share - 2%. This is most likely due to the financial capacity of large companies to purchase licenses, patents and know-how, as well as to use external consultants for their innovation activities. In terms of the share of R&D expenditure as a% of total expenditure, the survey showed that large enterprises make the highest R&D expenditure, followed by medium and small enterprises.

The summarized results for the whole set of surveyed enterprises show:

During the period under review the number of eco-innovations carried out in the surveyed enterprises is small, but with a tendency to increase - the increase is by 57.14%. For innovations such as "Innovative production methods that are new only to the company" this increase is 33.33%, and doubled "Innovative production methods that are new to the company and the industry." There is an increase in the costs that companies spend on eco-innovation - both total and average for a single innovation. According to the managers interviewed, the eco-innovations carried out in their enterprises did not have a high level, assessed as a degree of novelty and significance of the change. Innovations such as "Innovative production methods that are new only to the company" had a lower level during the study period. Estimates of the level of eco-innovation show that small, insignificant changes with a low degree of novelty have usually taken place in enterprises.The implemented eco-innovations have led to an increase in sales compared to the previous year - both for the enterprises that have implemented the innovations and on average for one innovation. These results show that innovation through the introduction of innovative production methods, new to the company and the industry have led to the largest increase in sales of enterprises. The eco-innovations that have been implemented have had a moderately strong impact on improving the environmental protection of enterprises. This is due to their relatively low level and applies to both types of innovation. The impact of the implemented eco-innovations on the reduction of energy costs for 1st production is relatively strong. Apparently, companies have focused mainly on the introduction of energy-saving processes.

5. *Conclusion*

The advantages for the enterprises from the bio-sector as a result of the introduction of eco-innovations are related to the achievement of flexible business models; higher revenues as a result of opening new markets and customers; reducing costs by achieving material, energy savings and increased efficiency and compliance with regulatory requirements.

The benefits of developing and implementing eco-innovation for the development of sustainable regions can be summarized in the following areas:

• From an environmental point of view, the use of natural resources is expected to be reduced and the release of harmful substances during the life cycle of the product or service will be limited.

• Social benefits are associated with - job creation, change in people's behaviour and lifestyle, leading to improved quality of life and health.

• From an economic point of view - opening new market opportunities, higher revenues and competitive advantages for business.

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Cyber security of SCADA systems using Machine Learning

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Abstract *- For the purposes of this paper, we built a machine learning system based for detecting and preventing sophisticated reconnaissance cyber-attacks on a tank used for water storage and distribution using Supervisory Control and Data Acquisition (SCADA)* system. *The goal of the machine learning model was to follow the packets and the traffic in Modbus communication protocol in order to detect possible cyber-attacks. We used four supervised machine learning techniques which were: Logistic regression, Decision tree classifier, Random forest, Naïve Bayes. The performance of aforementioned machine learning models were tested from various aspects like: feature importance, accuracy, precision, recall, false alarm rate, un-detection rate and f1-score. According to the observed results, it is shown that the Decision tree approach delivered best performance among the considered models.*

Keywords: *CYBER-SECURITY; MACHINE LEARNING; SCADA SYSTEM*

1. Introduction

Water distribution systems are a crucial part of urban area infrastructure. In the past their main components were controlled manually, but today they are automated by Supervisory Control and Data Acquisition (SCADA) systems. These, SCADA systems in the past were isolated and today they are often connected to the Internet. Consequently, due to the sensitive nature of the main components in these systems, they are vulnerable to threats, hackings, malware etc. Generally, the SCADA systems are not designed with an accent on their cyber-security. As a result, the vulnerable SCADA systems are a potential source of danger for public safety, physical disasters, leakage of secret information, and fraud. In 2015, the United States Department of Homeland Security (DHS) responded to 25 cyber-security incidents in the water sector and to 46 incidents in the energy sector [1]. Comparatively, between 2014 and 2015, the reported number of water sector incidents actually increased by 78.6% (from 14 to 25) [1]. In Israel there were three attacks between 2019 and 2020. The first attack in 2019, managed to change the free chlorine level of the water which ruined the water quality in the system. In 2020, hackers managed to change the operation point of the pumps, resulting in high pressure and increased leakage in the system [1].

The connectivity of SCADA systems with external networks will continue to grow in the future. As a consequence, cyber-attacks are expected to become more advanced and sophisticated, which will inevitably increase the risks and the need to improve security, the need to find new modern tools and also improve the old ones. One of the ways for improving the cyber-security of the SCADA systems is through Machine Learning (ML). ML is known for its strong capabilities to track behavioral changes, to analyze patterns and to learn from them in order to prevent similar attacks in the future. ML can make cyber-security simpler, cheaper and more effective, only if there is a sufficient amount of data which can effectively capture the essential dynamic of the analyzed process. In this paper, we analyzed the network traffic in a SCADA system designated for water storage, treatment and distribution. The goal was to develop and implement a ML approach which will be capable of detecting a potential cyber-attack, based on the network traffic in the Modbus TCP/IP protocol. The ML approach will be established on a predefined dataset gathered from the network traffic of the SCADA system during normal operation and when the system is under attack [2].

2. Prerequisites and means for solving the problem

Part of a water management system which is integrated in a larger system for water treatment and distribution is shown on Fig.1. This system is used as a simulation platform for generating data containing the network traffic during normal operation and under reconnaissance attacks.

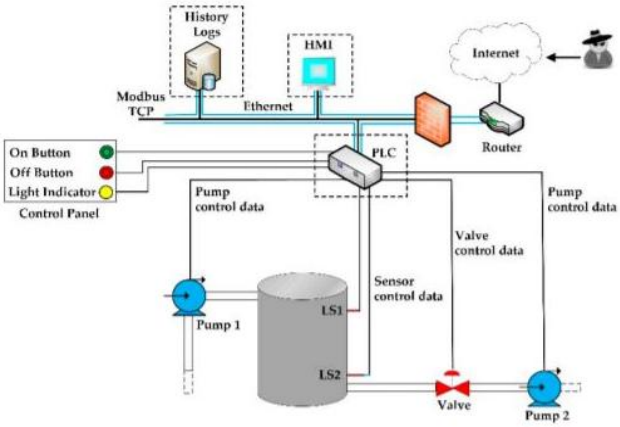

Fig. 1 Illustration of the SCADA system [3]

Cyber-attacks often target the Modbus TCP/IP protocol, since this is one of the most vulnerable points in the SCADA system. It can be used as a portal to the equipment of critical importance for reliable operation of the entire SCADA system. In order to test the security of the Modbus TCP / IP protocol, in [4] a thorough examination of potential points of attack was performed on water management and control system. The research led to the conclusion that the attacker can achieve their malicious goals if they acquire sufficient knowledge about the system in order to change the actuator commands or sensor readings. In other words, in order to attack the

SCADA system's integral parts, the first thing the attacker should do is to acquire enough information about the system. This type of attack is known as a reconnaissance attack [5]. In this paper, we will use ML algorithms that detect such sophisticated reconnaissance attacks. Usually, hackers use scanning tools to scan the network topology and identify all devices connected to it, as well as their vulnerabilities. On Fig. 1, the vulnerabilities and potential places of attack are shown with dashed lines [3]. There are many variants of reconnaissance attacks. The simplest among them are the ones that do scanning of the communication network by sending a large amount of packets per second to the target device via Modbus TCP and wait for an acknowledgment. If they get an affirmative acknowledgment, it means that the targeted host or device is active and an attack can be carried out. However, these attacks are easily detected by the firewall, since they create an abnormal variation in the network traffic [3].

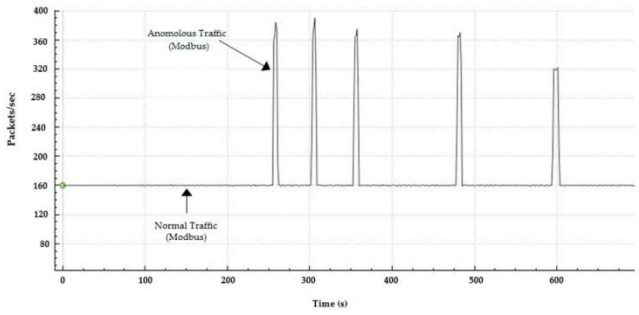

Fig. 2 Network traffic obtained under easy-to-detect attacks [3]

Fig. 2 shows an example of the behavior of network traffic obtained in [2] using scanning tools.

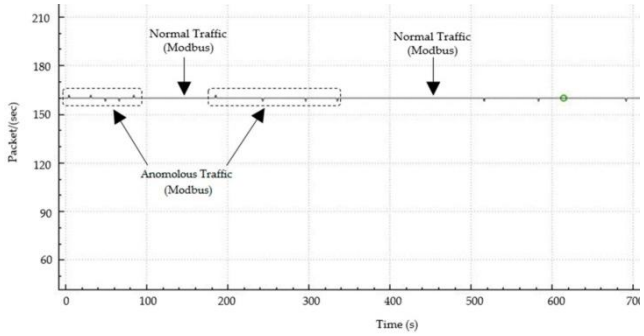

Fig. 3 Network traffic obtained under difficult-to-detect attacks [3]

Among the different types of cyber-attacks, there are some that are capable of masking their activity by not disturbing the normal behavior of the communication network (see Fig. 3) [3].

In this paper, we used different ML algorithms to detect such difficult-to-detect attacks. The performances of the ML algorithms were tested on a dataset given in [3], which was acquired during the normal behavior of the network and during an attack. The dataset contains 7,037,983 samples which are characterized by 6 features. The features and their descriptions are:

- Source Port (Sport) – The port number of the source,
- Total Packets (TotPkts) - Total transaction packet count,
- Total Bytes (TotBytes) - Total transaction bytes,
- Source packets (SrcPkts) - Source/Destination packet count,
- Destination Packets (DstPkts) - Destination/Source packet count,
- Source Bytes (SrcBytes) - Source/Destination transaction bytes.

The data in the dataset is distributed such that, 95% of the data belongs to the class of the normal traffic and 5% percent of the data belongs to the class of the anomalous traffic. On Fig. 4, the pie chart of the class distribution is given.

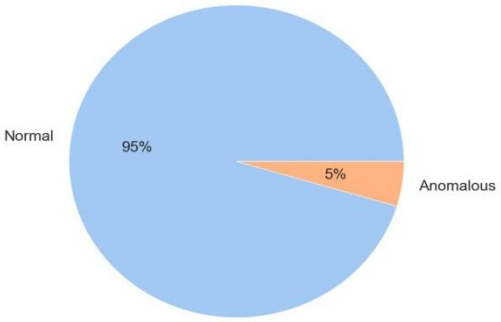

Fig. 4 Pie chart of the class distribution

3. Detection of cyber-attacks by ML methods

We used four supervised (Logistic regression, Decision tree, Random forest and Naïve Bayes) ML algorithms. The dataset was split in 80/20 ratio for training and testing data. To prevent overfitting while tuning the parameters, we did 5-fold cross-validation. The effectiveness of each ML algorithm was evaluated by the following performance measures: accuracy, false alarm rate, un-detection rate and f1-score.

3.1 Performance metrics

The models are evaluated by using a confusion matrix, which is defined as given in Table 1,

Table 1: Confusion matrix

	Predicted 0	**Predicted 1**
Actual 0	True Negative (TN)	False Positive (FP)
Actual 1	False Negative (FN)	True Positive (TP)

where each of the terms in the table has the following meaning:

- True Negative (TN) – Normal traffic correctly classified as a normal traffic,
- False Positive (FP) – Normal traffic misclassified as an anomalous traffic,
- False Negative (FN) – Anomalous traffic misclassified as a normal traffic,
- True Positive (TP) – Anomalous traffic correctly classified as an anomalous traffic.

The second metric that we used, is the accuracy metric.

It is defined by equation (1). This metric gives a percentage number which describes the ratio of the number of correctly predicted classes over the total number of predictions.

$$Accuracy\,[\%] = \frac{TP\ +\ TN}{TP\ +\ TN\ +\ FP\ +\ FN} \times 100 \quad (1)$$

The false alarm rate gives the percentage of normal samples (not an attack) misclassified as abnormal (as an attack) .

$$False\ alarm\ rate\ [\%] = \frac{FP}{FP + TN} \times 100 \quad (2)$$

The un-detection rate gives the percentage of how many attacks are not detected by the model.

$$Un - Detection\ rate\ [\%] = \frac{FN}{FN + TP} \times 100 \quad (3)$$

Precision quantifies the number of positive class predictions that actually belong to the positive class (the class of the attacks) .

$$Precision\ [\%] = \frac{TP}{TP + FP} \times 100 \quad (4)$$

Recall quantifies the number of positive class predictions made out of all positive examples in the dataset.

$$Recall\ [\%] = \frac{TP}{TP + FN} \times 100 \quad (5)$$

Combining the Precision and Recall values we can define the F1 score which is defined as the harmonic mean between Precision and Recall. It is often used in problems with imbalanced classes.

$$F1\ [\%] = 2 \times \frac{Precision \times Recall}{Precision + Recall} \times 100 \quad (6)$$

3.2 Logistic regression

Logistic regression is a ML model mostly used for binary classifications. It takes a linear equation as input and uses a logistic (sigmoid) function to make a binary classification. For further information on this algorithm see reference [6]. The confusion matrix for this algorithm is given with the following matrix:

$$\begin{bmatrix} True\ Negatives & False\ Positives \\ False\ Negatives & True\ Positives \end{bmatrix} = \begin{bmatrix} 1325283 & 1396 \\ 431 & 80487 \end{bmatrix}.$$

From the confusion matrix we can see that Logistic regression model out of 1,326,679 samples of normal traffic, it classified well 1,325,283 samples, and misclassified 1,396 (false alarms). Furthermore, the Logistic regression model failed to properly classify 431 samples of anomalous traffic.

3.3 Random forest

The Random forest algorithm is a classification and regression method that works on the principle of constructing a set of Decision trees. When applied to classification problems, Random forests apply a majority voting process and receive a vote from each constructed tree and the determination of the final classifier is based on a majority vote. For further information on this algorithm see reference [7]. The input parameters used to train the Random forest model are shown below:

- n_estimators = 200
- criterion = ‘entropy’
- max_depth = 6
- min_samples_leaf = default = 1
- max_features = ‘auto’

The confusion matrix for this algorithm is given below:

$$\begin{bmatrix} True\ Negatives & False\ Positives \\ False\ Negatives & True\ Positives \end{bmatrix} = \begin{bmatrix} 1326519 & 160 \\ 2 & 80916 \end{bmatrix}.$$

If we observe the confusion matrix we can clearly see that the Random forest algorithm failed to detect only 2 attacks out of 80,918. Also, the number of False Positives is very low, 160 in total.

3.4 Naïve Bayes

The Naive Bayes classifier is a simple probability classifier based on the use of the Bayes theorem with strong naive assumptions about independence of the input variables. For further information on this algorithm see reference [8]. One caveat related to this algorithm is that the input parameters must be standardized in the interval [0,1], before its implementation. The confusion matrix for this model is given below:

$$\begin{bmatrix} True\ Negatives & False\ Positives \\ False\ Negatives & True\ Positives \end{bmatrix} = \begin{bmatrix} 1320133 & 6546 \\ 407 & 80511 \end{bmatrix}.$$

According to the confusion matrix, even though it has similar number of False Negatives as the Logistic regression model, this algorithm is worse than the previously observed models, because of the high number of False Positives (6,546).

3.5 Decision tree

Decision trees are a hierarchical data structure that processes data through a 'divide and conquer' strategy. It is a tree-like model of decisions and their possible consequences. This method is one of the most powerful and popular tools for classification and prediction. For further information on this algorithm see reference [9].

We used the following parameters for training the Decision tree model:

- criterion = ‘entropy’
- max_depth = 6
- min_samples_split = default = 2
- min_samples_leaf = default = 1
- max_features = default = None

The confusion matrix for this model is given below:

$$\begin{bmatrix} \text{True Negatives} & \text{False Positives} \\ \text{False Negatives} & \text{True Positives} \end{bmatrix} = \begin{bmatrix} 1326667 & 12 \\ 0 & 80918 \end{bmatrix}.$$

The confusion matrix clearly indicates that the Decision tree algorithm detects all the attacks, which are 80,918 in total. The interesting fact is that this algorithm detects only 12 False Positives. This means that out of 1,326,679 normal traffic samples, the model misclassified only 12 samples. Analyzing closely those 12 misclassified samples, we came to the conclusion that 11 of them have the same characteristics, i.e. they are identical, which partially explains the cause of the misclassification.

4. Feature importance

Feature importance is a methodology of scoring and ranking the features based on their usefulness in predicting the output variable. The information about feature importance improves the predictive power of the algorithm and its efficiency. The features for training of the algorithm were assumed to be the same as in the paper [2]. In this paper, we sort the features by their importance for each algorithm to get a better insight into the nature of the problem and the influence of the features.

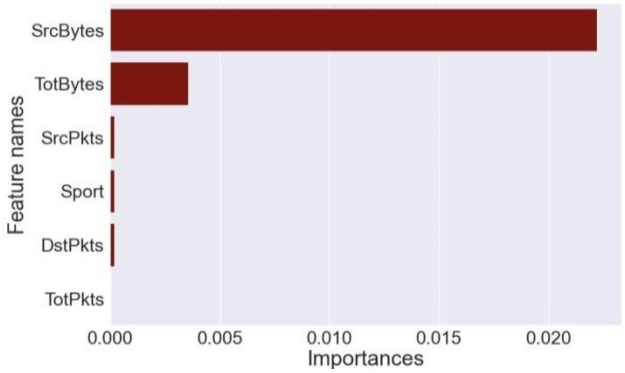

Fig. 5 Feature importance for Logistic regression model

Fig. 4 shows the feature importance for the Logistic regression model and we can see that 'Source Bytes' is the most important feature. With the exception of 'Total Bytes' all other features have very low importance.

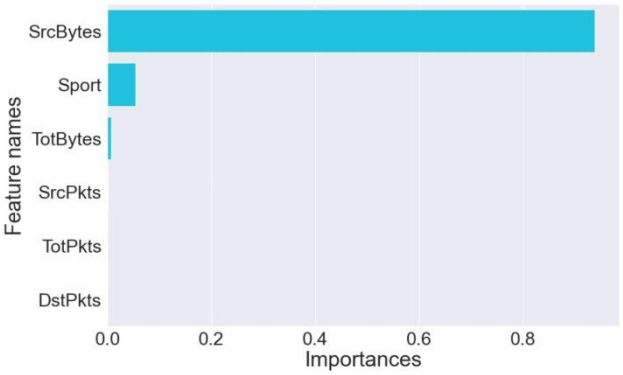

Fig. 6 Feature importance for Decision tree model

On Fig. 5, we can see the feature importance for the Decision tree model. 'Source Bytes' is again the most useful feature when it comes to predicting the output variable and its importance is way higher than its importance in the Logistic regression model. Fig. 6 shows the feature importance for the Random forest model.

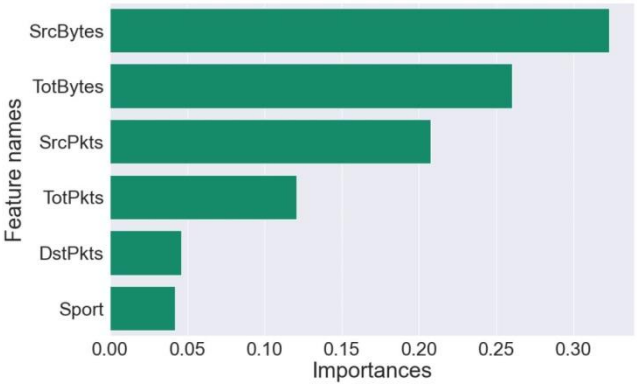

Fig. 7 Feature importance for Random forest model

It is noticeable that the importance is here more uniformly distributed among the features, but 'Source Bytes' is the most important feature again.

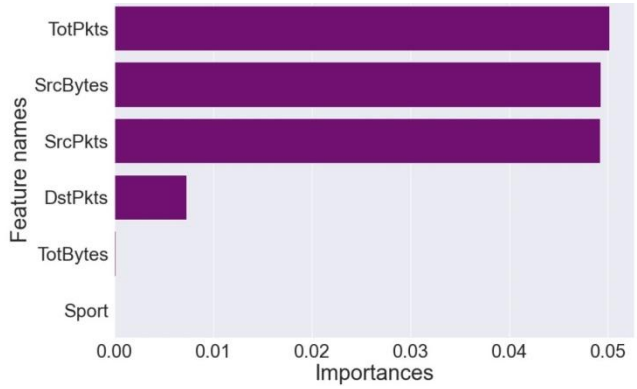

Fig. 8 Feature importance for Naive Bayes model

Fig. 7 illustrates the feature importance for the Naïve Bayes model. It is noticeable that three features have almost equal importance in predicting the output, but unlike the previous models, here we can see that 'Total Packets' is the feature with the greatest importance.

5. Results

In this section we will compare the scores of each algorithm according to the aforementioned evaluation metrics. The comparison will be done based on the bar charts containing the numerical values of the separate evaluation metrics, achieved by each algorithm.

5.1 Accuracy

Fig. 8 illustrates the graph for the accuracy. Random forest, Logistic regression and Decision tree have the highest scores, but Decision tree is the best among the considered models. This metric is not very relevant in the classification problem we are dealing with, because the analyzed dataset has unbalanced distribution of the classes, where as shown in Fig. 4, the class of normal traffic is way larger than the class of anomalous traffic. Therefore we will use additional evaluation metrics to compare the models.

Fig. 9 Accuracy scores for the examined algorithms

5.2 False alarm rate

The next evaluation metric that we used is the false alarm rate metric, which defines the percentage of normal traffic samples incorrectly classified as abnormal traffic. The lower the value of this metric, the better the model. On Fig. 9, the graph for the false alarm metric is shown.

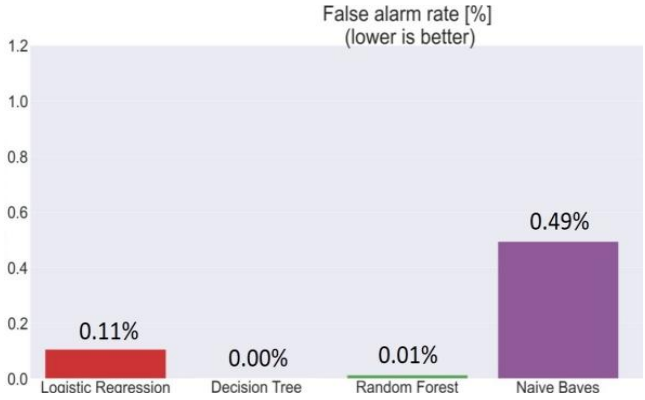

Fig. 10 False alarm rate scores for the examined algorithms

In datasets that have unbalanced classes, in which one class is dominant to another, it is expected the false alarm rate to be low, as a result of the model's bias towards the dominant class. From Fig. 10 we can see that the Decision tree model has the lowest false alarm rate because of its 12 false positive elements in the confusion matrix, while the worst model according to this metric is Naïve Bayes with 0.48%.

5.3 Un-detection rate

The un-detection rate metric, gives us the percentage of anomalous traffic that is incorrectly classified as a normal traffic. This metric is more critical than the false alarm rate because it represents the number of un-detected attacks that can harm the system. The lower the value of this metric, the better the model. On Fig. 10, we can see the bar chart for this metric. Decision tree had 0 false negatives and Random forest had only 2 which makes them by far the best models appropriate to be used as a defensive mechanism against reconnaissance attacks.

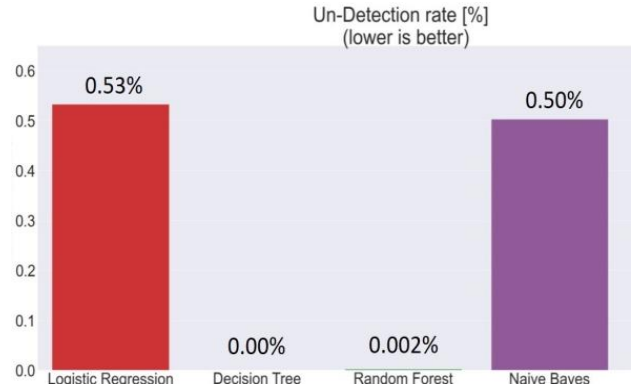

Fig. 11 Un-detection rate scores for the examined algorithms

5.4 F1 – score

F1 – score is a relatively good metric for datasets with unbalanced classes. On Fig. 11, the bar chart for this metric is shown. According to this metric all models have excellent scores. Yet again, Random forest and Decision tree models have achieved best results. Comparing these two among them, it is clear that the Decision tree model beats the result of the Random forest model by a very tiny margin.

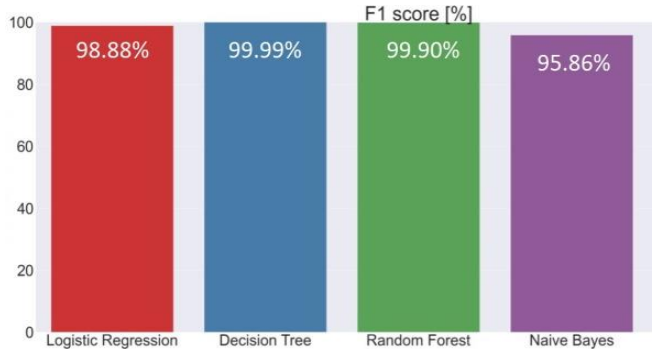

Fig. 12 F1 - scores for the examined algorithms

6. Conclusion

The goal in this paper was to design a ML approach that will be capable of detecting potential attacks in Modbus TCP/IP communication protocol of the SCADA system for treatment and distribution of water. For that purpose, four supervised ML algorithms were used. The supervised algorithms were: Logistic regression, Decision tree, Random forest and Naïve Bayes. Using various performance indexes we quantified the classification capabilities of each ML model to detect anomalous behavior in the network traffic. Analyzing the values of these performance metrics we came to the conclusion that the best ML models among the analyzed are Decision tree and Random forest. Relative to the other algorithms, they showed superior performance. In conclusion, ML is capable of scanning large amounts of data, applying statistical analysis to them, discovering patterns among the data, and is being able to detect unusual anomalous behavior in the system in a relatively short time.

7. References

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Application of 3-D modeling in minimally invasive surgical treatment of traumatic chronic subdural hematomas

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Abstract*: The Report considers the issues of organization, composition of technical and informational equipment for minimally invasive methods of surgical treatment of chronic subdural hematoma of the brain. An innovation is the introduction of information support into the operation process and the use of online 3D-computer and spatial models with original software of both the operating area and the hematoma itself. The report discusses various approaches to the technical and informational equipment of minimally invasive techniques for conducting neurosurgical operations.*

OBJECTIVE:.
To clarify the effectiveness of 3D modeling at various stages of minimally invasive surgical treatment of traumatic chronic subdural hematomas (CSH).

MATERIAL AND METODS:
Since 2007, 34 patients with CSH requiring surgical treatment have been operated on at the neurosurgery clinic of INN, using endoscopic assistance and minimally invasive access. In all cases, at least 3 weeks elapsed from the moment of injury to the operation.
The initial state of patients before surgery was 7–15 points on the Glasgow Coma Scale (GCS), the volume of hematomas was from 80 to 130 cm3, the displacement of the midline structures was 2–14 mm.
In the course of the research, the possibilities of modern computer information technologies (IT) were used. For this purpose, with the aim of convenient practical use of preoperative CT of the brain in the process of surgical treatment, additional mathematical and informational methods were used to process the computer data of CT. The result of this approach was the creation of a 3D computer model of CSH with its subsequent printing on a 3D printer, which is used when planning the surgical access performed through the trephination hole in the projection of the maximum visualization of the CSH cavity.
In addition, with direct resection and elimination of CSH, the surgeon could visually use a 3-dimensional computer on-line model of the operating field with a hematoma located on it.
Aspiration and hemostasis were performed under the control of 0 ° –30 ° rigid endoscopic optics (Karl Storz, Germany) using soft transparent catheters and flexible electrodes. At the end, closed passive outflow drainage was installed for 24-48 hours.

RESULTS:
The completeness of emptying the CSH was assessed intraoperatively endoscopically, and in dynamics, using CT / MRI imaging (1-3 times / day and according to indications). In 80.3% of cases, hematomas were emptied totally, in 13.0% more than 80% of the initial volume were removed, in other cases about 75% of the CSH volume was emptied.
The study recorded 1 death (against the background of developed coagulopathy), which amounted to 3.1% in the study group.
Minimization of surgical access and 3D modeling led to a faster regression of neurological deficit and a decrease in cognitive impairment in the postoperative period. There were no complications in wound healing; postoperative hematomas were in 3.1% of cases.

CONCLUSIONS:
Preoperative 3D modeling and endoscopic inspection for minimally invasive removal of CSH provide:
• clear visualization of the area of intervention;
• atraumatic and radical removal of CSG contents;
• adequate hemostasis while minimizing the surgical wound;
• reduces cosmetic defect;
• reduces the period of hospitalization- offers a better medico-financial
balance.