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STUDY ON THE MANAGEMENT OF ELECTRICAL EQUIPMENT AND WASTE ELECTRICAL EQUIPMENT WITH PCB CONTENT IN MARAMUREȘ COUNTY, ROMANIA

Irina **SMICAL**[1], Olivian **CHIVER**[2]

[1] Technical University of Cluj-Napoca, North University Centre of Baia Mare, Engineering of Mineral Resources, Materials and Environment Department, 62A Victor Babes str., 430083, Baia Mare, Romania, [2] Technical University of Cluj-Napoca, North University Centre of Baia Mare, Electrical, Electronic and Computer Engineering Department, 62A Victor Babes str., 430083, Baia Mare, Romania

irina.smical@irmmm.utcluj.ro, olivian.chiver@ieec.utcluj.ro

Keywords: Equipment and waste electrical equipment, transformer, capacitor, PCB, contamination

Abstract*: This study highlights the management of electrical equipment and waste electrical equipment with PCB content inventoried in Romania. Because it is mandatory to phase out such equipment with concentrations of at least 50 ppm at a volume of more than 5 dm^3 an assessment of the compliance with the requirements imposed by the specific legislation has been made. The results obtained from the statistical processing and interpretation of the data from the national inventory reveal that in Romania, the elimination process is slow and that are still important stocks of equipment with PCB content that must be eliminated. By the end of 2018, the rate of decontamination and disposal of this equipment and the quantities of oils with PCB content was below 25%. Currently, there is no national or county inventory of fluid-containing equipment with 0.005% to 0.05% PCB relative to fluid weight. In Maramureș County, there is no waste electrical equipment in the inventory with PCB content, but only capacitors in use. By the end of 2019, the rate of decontamination and disposal of these equipments at county level was below 15%.*

1. INTRODUCTION

PCBs belong to a wide family of man-made organic chemicals, known as chlorinated hydrocarbons. They belong to the category of persistent organic compounds and consist of

carbon, hydrogen and chlorine atoms. The number of chlorine atoms and their location in a PCB molecule determine many of its physical and chemical properties [1-2].

The chemical formula of PCBs is $C1_2H_{10-n}Cl_n$, where *n* ranges from 1 to 10. From 209 possible congeners only 130 have been identified in commercial products [3].

PCBs are notable for being extremely persistent, bioaccumulating and transferring to the food chain, easily transported over long distances in the environment, seriously affecting environmental factors and human health. [4-5].

No natural sources of PCBs are known, they are synthetic products. In appearance and condition, PCBs are either in the form of an oily liquid or in solid form or even in volatile form, being present in the air as vapors. The color varies from colorless to light yellow. They have no taste or smell [5].

Due to their high flash points (170–380 °C) PCBs are fire resistant. They are characterized by low electrical conductivity, high thermal conductivity and high resistance to thermal degradation. Thus, they have been used as dielectic isolators in electrical devices [3].

Being used commercially since 1929, after the finding and demonstration of the spread of PCBs in the environment and in living beings in 1966, the production of equipment containing PCBs was banned in 1979 [3], [2]. Thus, many countries have stopped the production, marketing and use of these compounds [3].

In Europe, the production and marketing of PCBs have been severely restricted since 1985 [6]. However, PCB contents continue to exist in old equipment or equipment waste, especially in electrical equipment such as: transformers, capacitors, voltage regulators, circuit breakers, reclosers, insulators; old electrical devices or apparatus containing PCB capacitors [2].

European environmental policy aims at the controlled disposal of PCBs, ie the decontamination or disposal of equipment containing PCBs [7], [1], [8].

Thus, Directive 96/59 / EC requires Member States to draw up registers for equipment containing more than 5 dm^3 of PCBs and to ensure that such equipment has been decontaminated or disposed of by 31.12.2010 at the latest [1].

By the Stockholm Convention (2001), and subsequently under Regulation no. 1021/2019 was established by the end of 2025 at the latest the gradual elimination of the use of polychlorinated biphenyls (PCBs) in equipment (e.g. transformers, capacitors etc). More precisely it is the equipment that contains residual PCB stocks of over 0.005% and in of more than 0.05 dm^3 [6], [8].

In support of the inventory of PCB oils contained in electrical equipment, the Global Environment Facility (GEF) has implemented the project “PCB Elimination in Romania) [9]. Also, by Order no. 1179/2010 was approved the Guide on the Rational Ecological Management of Polychlorinated Biphenyls (PCBs) which has the role of supporting the introduction of a management system for the evidence, monitoring and rational ecological elimination of electrical equipment contaminated with PCBs in Romania [9].

In accordance with the European List of Wastes provided for in Decision 2000/532 / EC and GD no. 856/2002 wastes of electrical equipment containing PCBs are classified as follows [10-11]:

16 02 09* transformers and capacitors containing PCBs

16 02 10* scrapped equipment containing PCBs or contaminated with PCBs, other than those specified in 16 02 09

In Romania, all equipment and waste containing PCBs in concentrations of at least 50 ppm at a volume of more than 5 dm^3 or those containing fluids with 0.005% to 0.05% PCB relative to the weight of the fluid must be inventoried for monitoring, decontamination or disposal [12].

In order to ensure the elaboration, updating and publication of the National Inventory of equipment and materials containing designated compounds, the Secretariat for designated compounds has been established at national level [12-13].

According to the National Plan for the implementation of the provisions of the Convention on Persistent Organic Pollutants, adopted in Stockholm on May 22, 2001, Romania has set as its major objective the elimination of equipment containing PCBs. Correlated with the field of energy distribution, this elimination cannot be done suddenly, but required a staging of the actions, as follows [14]:

1. By 2025, phasing out PCB-containing equipment in operation by replacing it with PCB-free equipment.
2. By 2029, updating inventories of equipment holding PCBs (functional or obsolete).

To fulfill these obligations, both the public environmental protection authorities (central, national, and territorial) and the inspection and control, respectively the economic operators have attributions [14]. For instance, the Electrica Corporation aims as a major objective regarding the protection of the environment the gradual withdrawal from operation, until 2028, of the equipments containing PCB, according to the legal provisions and the national elimination program [15].

Also, the economic operators have the obligation to label equipment in operation or in conservation that contains designated compounds in quantities greater than the minimum quantities [12].

Given the effects and restrictions on the use of PCB oils, solutions are increasingly being sought to replace them with environmentally friendly and safe products for human health. In this regard, Brazilian researchers Da Silva and Sá, (2020) conducted an experiment using natural esters instead of PCB-containing oils. Replacement of PCB oils in transformers with natural or synthetic esters also supported by other experts and researchers [16-21].

The objective of the present study is to identify the current state of waste electrical equipment management in Maramureș County and Romania and the degree of its compliance with the legislative provisions in force.

2. MATERIALS AND METHOD

The conduct of this study is based on information from the specialized scientific literature and on raw inventory data of electrical equipment with PCB content at national and county level. The main source for statistic data is the national inventory of PCB provided by National Environmental Protection Agency.

The method used is that of documentation, data collection, statistical processing and interpretation.

3. RESULTS AND DISCUSSION

3.1 Technical properties of PCBs in electrical equipments

Power transformers are the most important equipment in the electricity transmission chain from producer to consumer. Their role is to change the voltage level so transportation and distribution of the energy be with maximum efficiency. They are made of two main types of active materials: the conductors (Cu or AL) needed for the electrical circuits and the ferromagnetic core, necessary for closing the magnetic flux. In addition to these main materials, insulating materials have a particularly important role. They ensure the insulation between the coil turns but also between the different electrical circuits or between them and the ground.

On the other hand, medium voltage capacitors are used in electrical installations for compensating the power factor. Because the capacitance value is directly proportional with the electric permittivity and the plates surface and inverse proportionally with the distance between plates, it is obviously that dielectric material highly influence the volume of capacitors for an imposed voltage and capacitance.

In the operation of medium and high voltage power transformers, due to the large potential differences between the different active parts as well as between the active parts and the ground, intense electric fields appear that require materials with good insulating properties. Also, during operation, the current in the windings, as well as the variable magnetic flux in the magnetic core, produce electrical losses (proportional to the square of the current and of the voltage respectively) which in time lead to an increase in their temperature. Maintaining a temperature below the limit one, decided by the insulation class, impose the transfer of the heat to the outer surface of the tank and then to the environment. These phenomena (all or some of them) are also valid in the case of other medium or high voltage electrical equipment such as capacitors, switches etc.

PCBs were widely used by manufacturers as dielectric material in power transformers, capacitors, and other electrical apparatus (predominantly in enclosed systems). There are some

main characteristics that recommend the use of PCBs: very good electrical insulating properties, good heat transfer, nonflammability, high boiling point, and chemical stability[22]. Possessing the properties above mentioned, these liquids provide three main functions in electrical devices: offers insulation between active parts at different potentials and also protecting from corrosion of metallic areas; transfers the heat from core and conductors to enclosing container exterior surface; behaves as a healthiness index for equipment. By monitoring the analysis of liquid, the state of electric equipment can be constantly monitored[22].

Of course, the PCBs weren't the first liquids used as dielectric, but they prevailed about fifty years[23] (from 1929) because of high dielectric strength and nonflammability property, from this last point of view being much better than other existing materials at that time. Being not flammable, they were used especially in devices intended to operate at sensitive places, where a fire would have become a catastrophe (hospitals and shopping malls).

The main causes of accidents involving transformers or capacitors with PCBs are arc explosions and fires. Arc explosions are caused by voltage imbalance or resonance in the high-voltage circuit due to harmonic currents [24]. Capacitor banks are normally protected by unbalance relays, but if they are not properly accorded or are defective, the explosion can occur [24]. Fires implying PCBs transformers or capacitors are most often caused by external causes (electric cables and other ignition sources).

3.2 The management of electrical equipment with PCB content at national and county level

Romania, as an EU Member State, has the obligation to follow the provisions of the Directive on the elimination of polychlorinated biphenyls and polychlorinated terphenyls (PCB / TPC) [7].

a) *b)*

Fig. 1. Transformer (a) [25]; b) [26]

Fig. 2. PCBs capacitors in Maramureș county

At national level an inventory was made of equipment and waste electrical equipment with PCB content that focused mainly on the number of capacitors, transformers, the amount of oil with PCB content held by them, the number of functional transformers and capacitors and removed used for decontamination and disposal by incineration, the amount of oil containing PCBs in the inventoried electrical equipment both functional and obsolete, respectively the amount of oil containing PCBs contained in equipment that has been decontaminated or disposed of incineration [27].

Statistical data at national and county level indicate that electrical equipment containing PCBs, both functional and obsolete, continues to be decontaminated and disposed of in order to achieve the goal of total disposal by 2025 [6], [8], [14]. Although efforts have been made in this regard, statistical data indicate a slow pace of disposal of such equipment in use or waste equipment.

From the statistical processing the interpretation of the data from the National Inventory of equipment and equipment waste with PCB content for the period 2016-2018, it results that at national level there are inventories of transformers and capacitors with PCB content both functional and obsolete and at county level Maramureș is only found in capacitors in use. All transformer and capacitor waste was collected and sent for decontamination and disposal [27].

Romania does not currently have an inventory of equipment and equipment waste containing fluids with 0.005% up to 0.05% PCB [27].

As can be seen in *Figure 3*, the number of capacitors in use with PCB content, inventoried in the period 2016-2018 in Romania, is decreasing. If in 2016 their number was about 34000 pieces, in 2018 it reached less than 32000 [27].

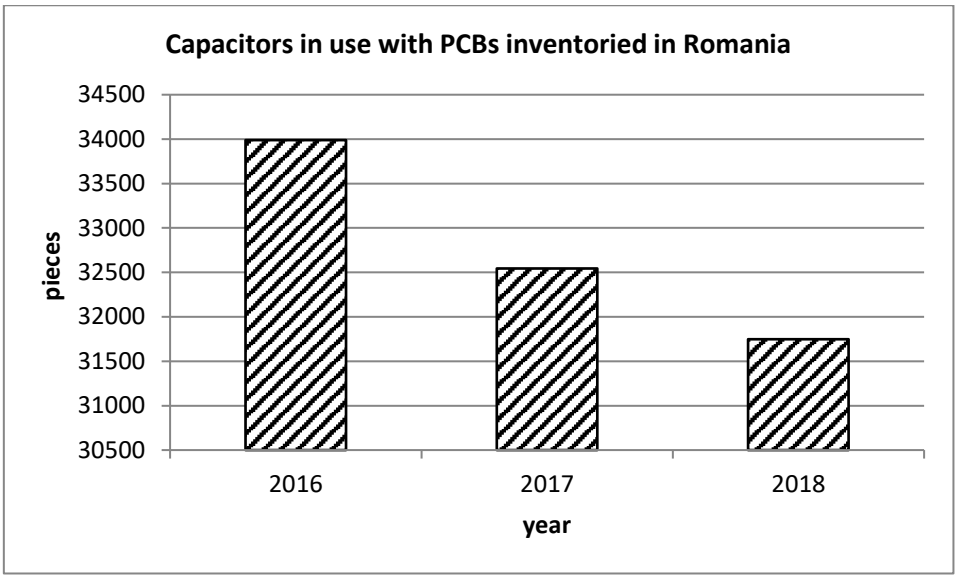

Fig. 3. Capacitors in use inventoried in Romania during 2016-2018 [27]

Regarding the degree of decontamination and incineration elimination of functional capacitors, *figure 4* shows that the highest rate of these processes was recorded for 2018 when 12.41% of the total number of capacitors were decontaminated and eliminated by incineration. The lowest rate of decontamination and elimination of functional capacitors was in 2017 with 2.47% of the total number of functional capacitors inventoried (*fig. 4*).

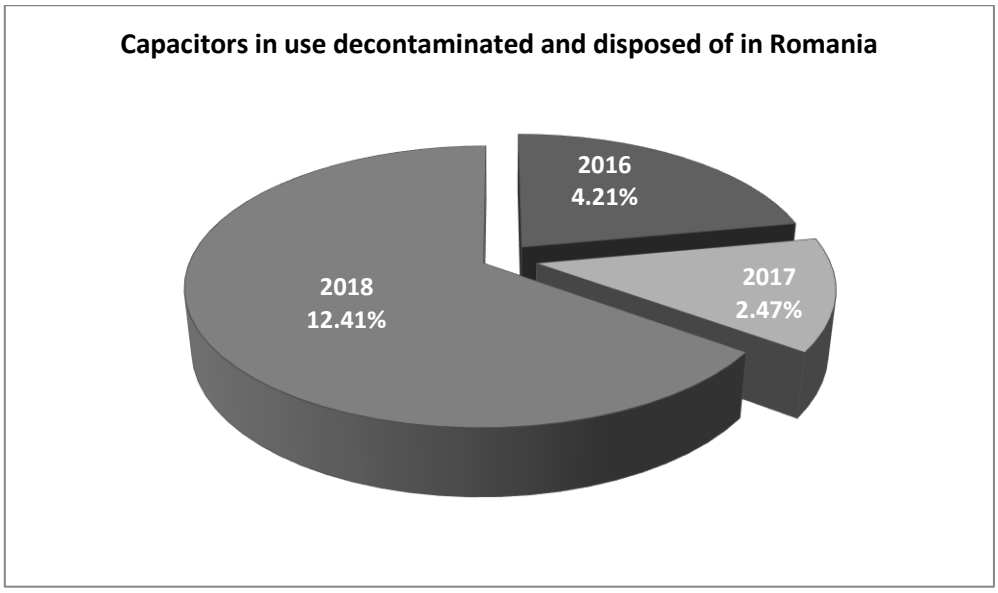

Fig. 4. Capacitors in use decontaminated and disposed of in Romania in the period 2016-2018 [27]

According to the data provided by NEPA (2021), the oil content of PCBs in the capacitors in operation inventoried in Romania in the period 2016-2018 registered a downward trend, following the decrease of the number of capacitors in use, inventoried [27]. The year 2018 recorded the lowest amount of PCB oil contained in the inventoried equipment, below 263000 liters, and the highest amount belongs to 2016 with over 300000 liters (*fig. 5*) [27].

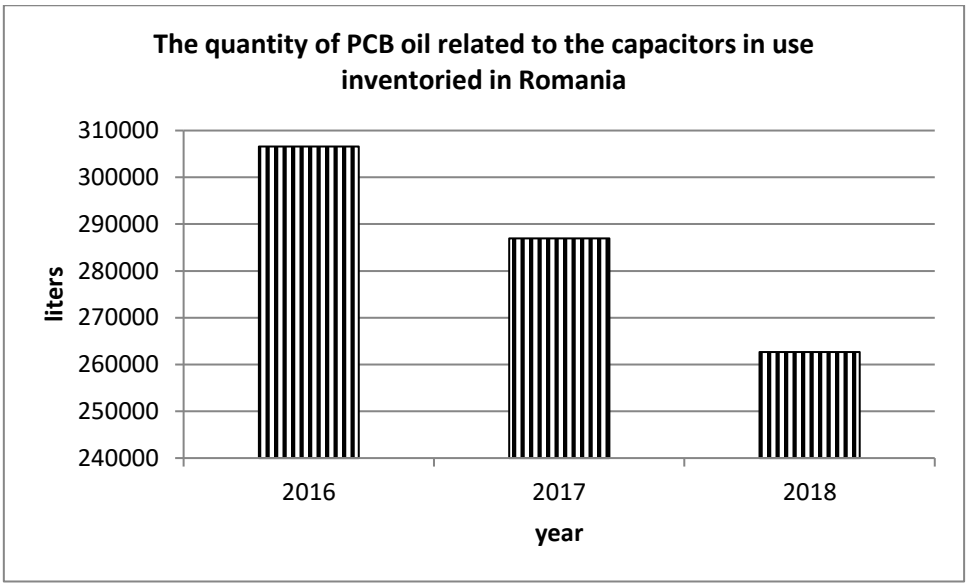

Fig. 5. The quantity of PCB oil related to the capacitors in use inventoried in Romania in the period 2016-2018 [27]

Regarding the oil content with PCBs in the capacitors in use inventoried at national level, the highest amount decontaminated and eliminated by incineration was registered for 2018 of 8.20% and the lowest, in 2017 of 2.41% (*fig. 6*) [27].

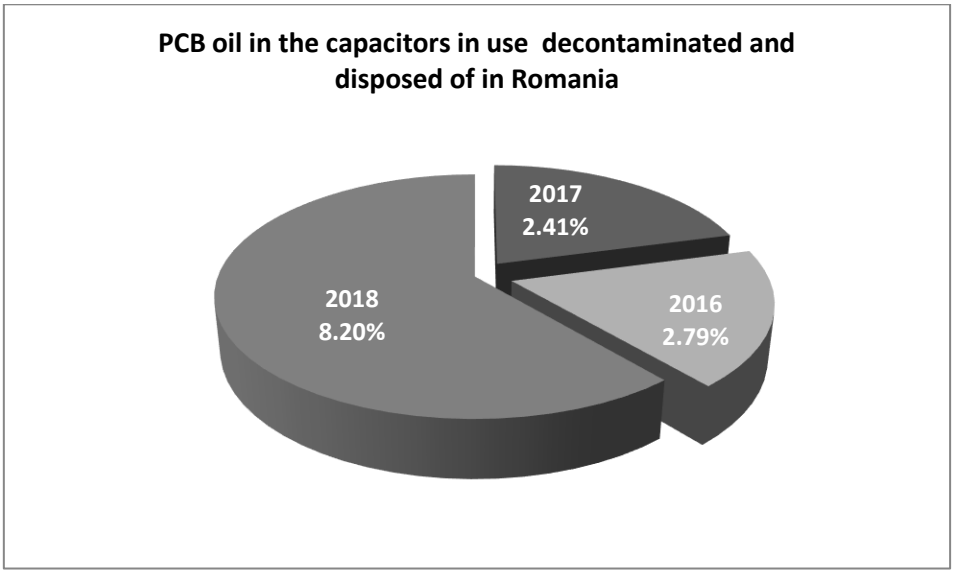

Fig. 6. PCB oil in capacitors in use, decontaminated and disposed of in Romania in the period 2016-2018 [27]

In addition to capacitors, the National Inventory also contains data of electrical transformers with PCB content. Thus, in the case of transformers in use, the statistical data for the period 2016-2018, reflect a decrease in the number of these equipments from over 540 in 2016 to 478 in 2018 (*fig. 7*) [27].

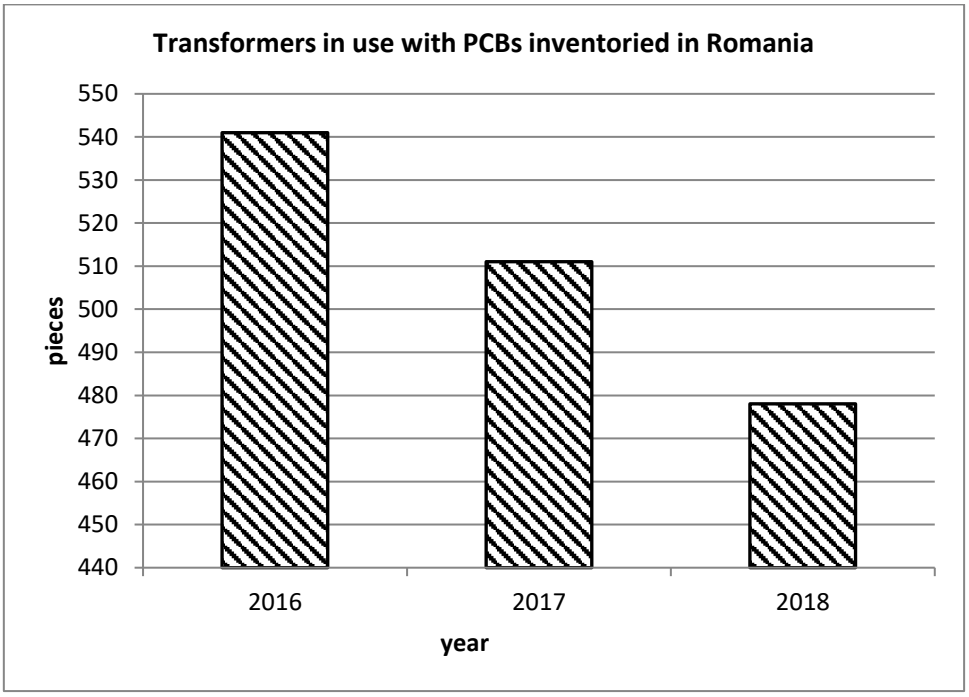

Fig. 7. Transformers in use inventoried in Romania during 2016-2018 [27]

Regarding the decontamination and disposal by incineration of transformers with PCB content in use, the highest rate was recorded in 2018 being 9.41% of the amount of inventories inventoried, respectively the lowest rate in 2017 of 2.74% (*fig. 8*) [27].

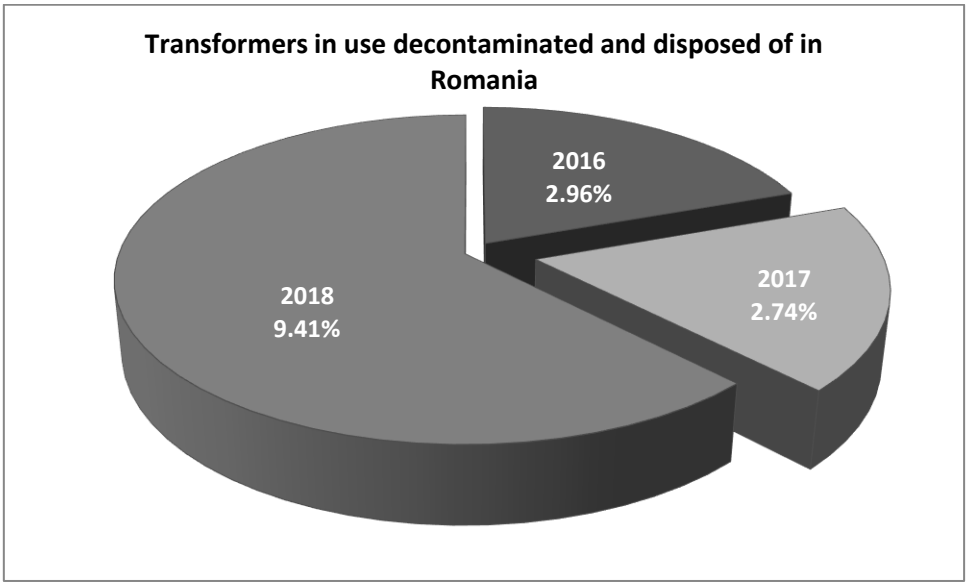

Fig. 8. Transformers in use decontaminated and disposed of in Romania in the period 2016-2018 [27]

As about the quantity of oil with PCB content in the transformers in operation in Romania, there is a decrease in the quantity in a trend very close to that of the decrease in the number of electrical equipment containing this type of oil. The lowest quantity was registered for 2018 with over 613000 liters and the highest for 2016 when 677404 liters were registered (*fig. 9*) [27].

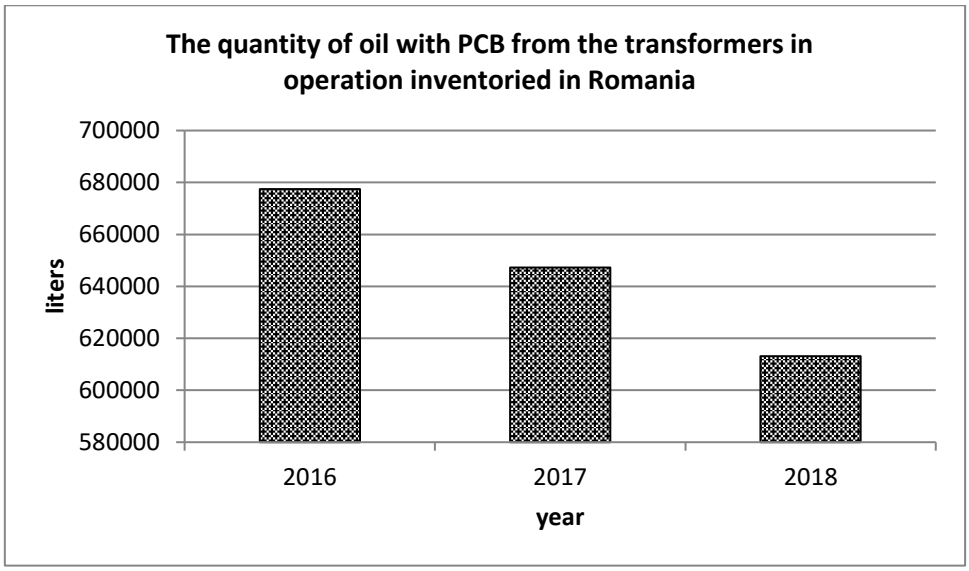

Fig. 9. The quantity of oil with PCB from the functional transformers inventoried in Romania in the period 2016-2018 [27]

Of the total amount of PCB oil inventoried for the transformers in use, the highest amount of PCB oil decontaminated and disposed of by incineration was found to be in 2018 with 11.62% and the lowest in 2017 with 2.25% of the amount of oil containing PCBs in the equipment inventoried in those years (*fig. 10*) [27].

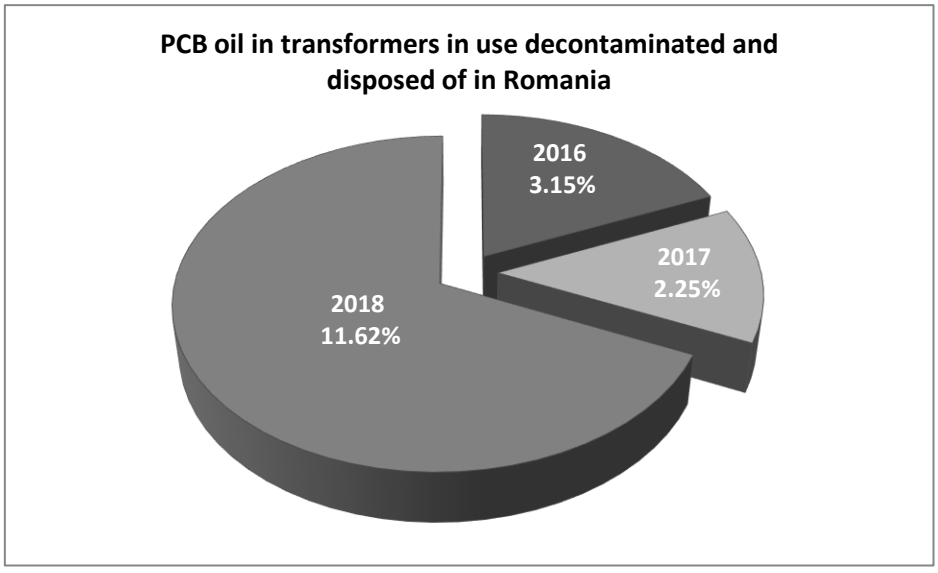

Fig. 10. PCB oil in functional transformers, decontaminated and disposed of in Romania during 2016-2018 [27]

Regarding the waste capacitors, it can be stated that their number is much lower than those in use, which is explained by the fact that the frequency of their collection was much higher. The evolution of the number of discontinued capacitors inventoried in the period 2016-2018 is a descending one, 2018 being the year in which there were the lowest number of such equipment in Romania (*fig. 11*) [27].

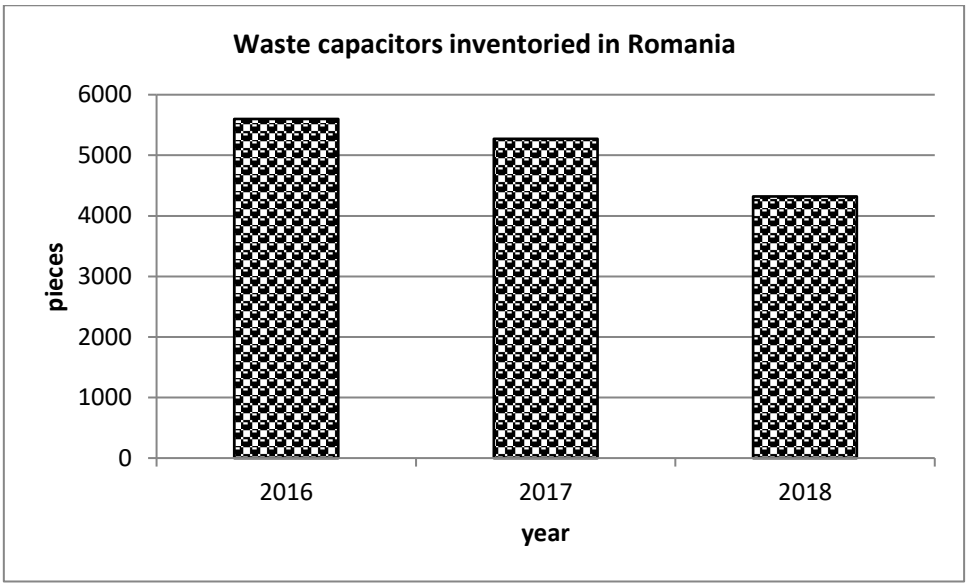

Fig. 11. Waste capacitors decontaminated and disposed of in Romania in the period 2016-2018 [27]

Compared to the number of capacitors with PCB content taken out of use in Romania, the decontaminated and eliminated ones represent a relatively small share. Thus, the highest rate of decontamination and disposal of discontinued PCB capacitors took place in 2017 of 10.28% and the lowest of 3.31% in 2018 (*fig. 12*) [27].

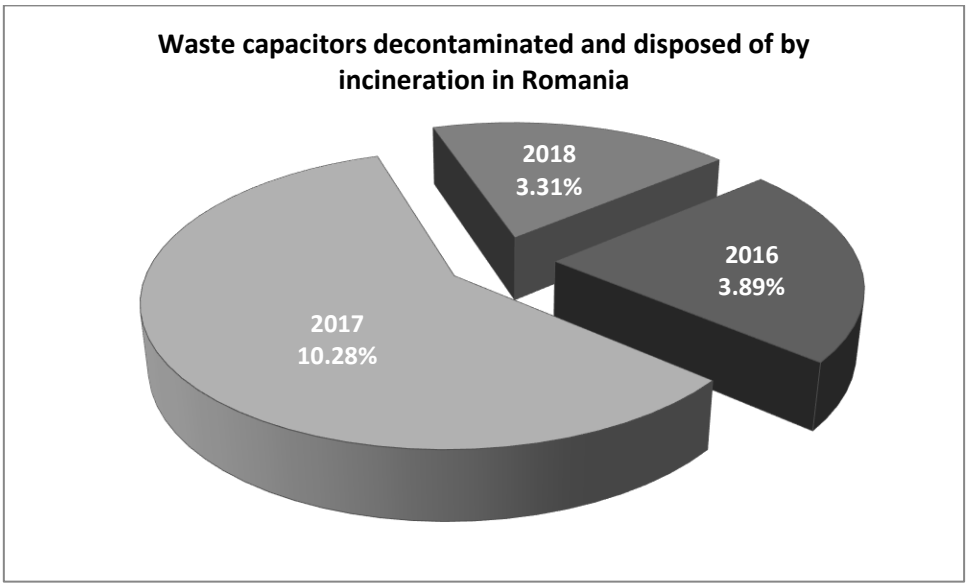

Fig. 12. Waste capacitors decontaminated and disposed of in Romania in the period 2016-2018 [27]

The quantities of PCB oil in the decommissioned capacitors have registered a decreasing trend from 2016, with over 40000 liters, until 2018 when a quantity of 32933 liters was inventoried (*fig. 13*) [27].

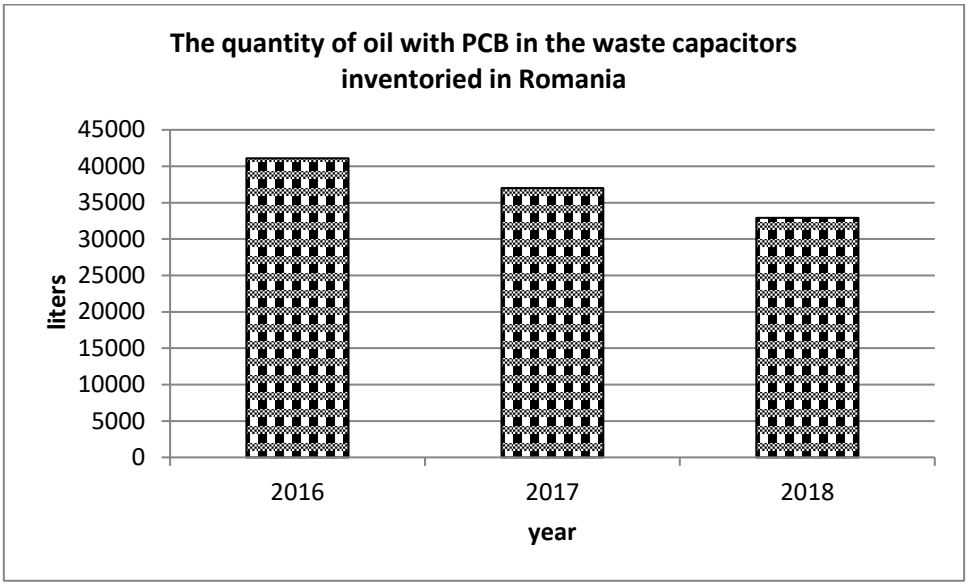

Fig. 13. The quantity of PCB oil in waste capacitors inventoried in Romania in the period 2016-2018 [27]

Some of the oil containing PCBs in the inventoried capacitors was decontaminated and disposed of by incineration in the same time with decontamining and disposing of the waste capacitors. The amount of decontaminated and incinerated oil was highest in 2017 of 8.04% of the inventoried quantity and the lowest in 2018 was 2.96% (*fig. 14*) [27].

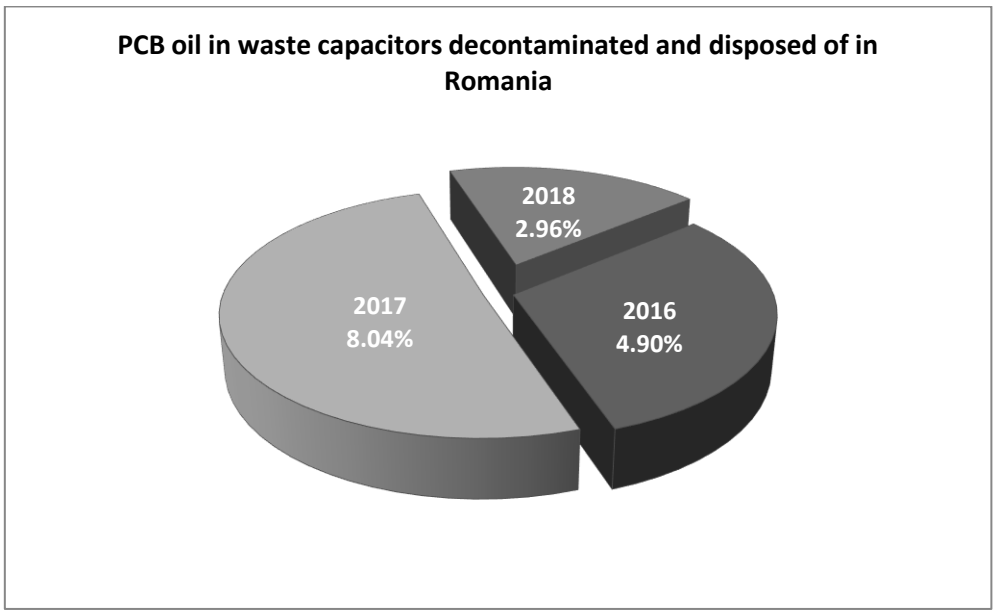

Fig. 14. PCB oil in waste capacitors decontaminated and disposed of in Romania in the period 2016-2018 [27]

In the case of waste transformers, the statistical data indicate an increase in their number in 2017 compared to 2016 and 2018. However, the largest number of transformers inventoried in the period 2016-2018 does not exceed 40 pieces / year (*fig. 15*) [27].

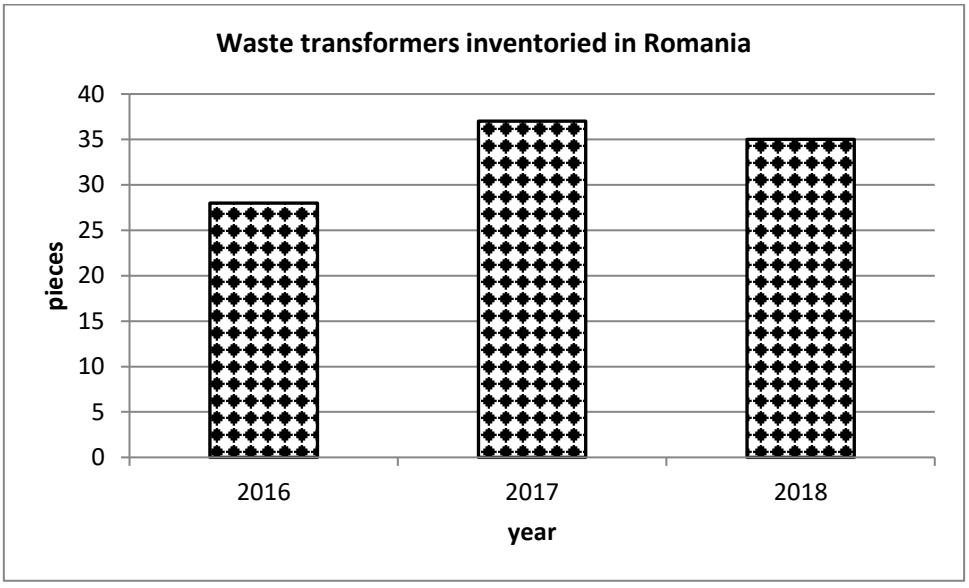

Fig. 15. Waste transformers inventoried in Romania during 2016-2018 [27]

Of the total waste transformers inventoried in Romania for the period 2016-2018, 21.43% were decontaminated and disposed of by incineration in 2016, 24.3% in 2017 and they were no longer decontaminated and disposed of in 2018 although there were 35 of such equipment in stock (*fig. 16*) [27].

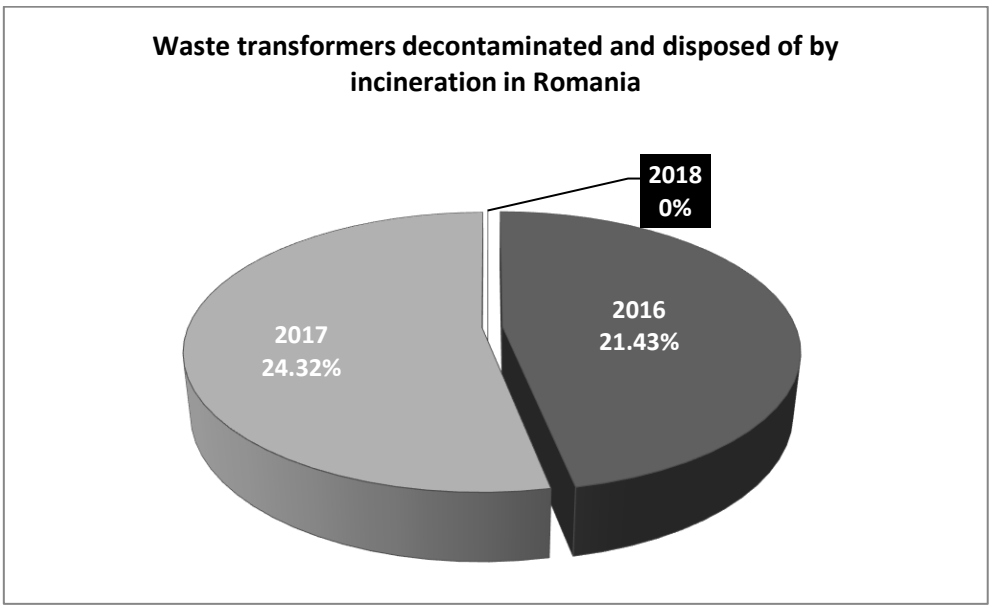

Fig. 16. Waste transformers decontaminated and disposed of in Romania in the period 2016-2018 [27]

Regarding the waste transformers inventoried in Romania in the period 2016-2018, the oil content with PCB registered an increase from over 11500 liters in 2016, to over 18800 liters in 2018 (*fig. 17*) [27].

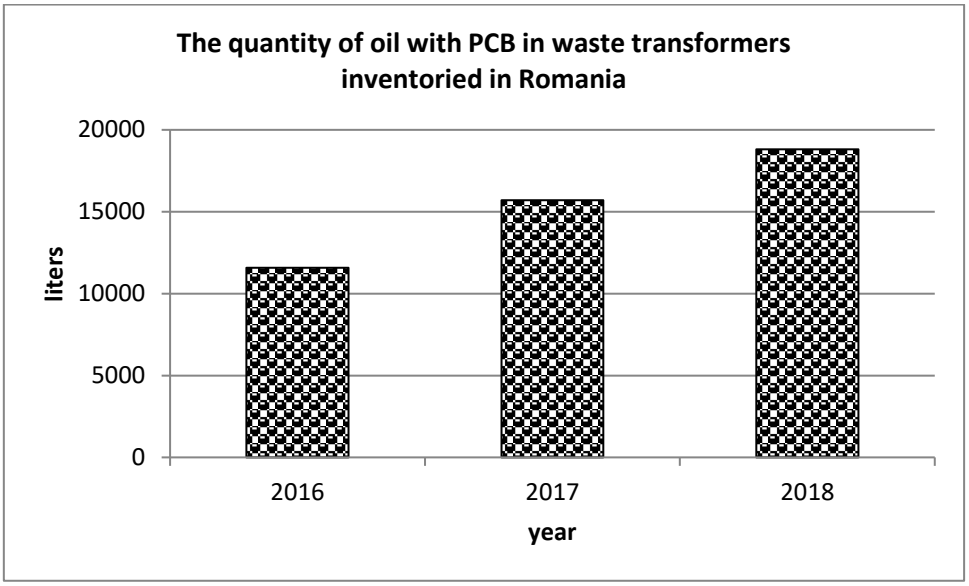

Fig. 17. The quantity of oil with PCB in waste transformers inventoried in Romania in the period 2016-2018 [27]

Of the total amount of PCB oil contained in the inventoried waste transformers, only a part of this was decontaminated and disposed of by incineration together with the decontamination and disposal of this equipment. The highest rate of decontamination and disposal was of 41.17% in 2016, of 3.21% in 2017 and it was not decontaminated and eliminated at all in 2018 (*fig. 18*) [27].

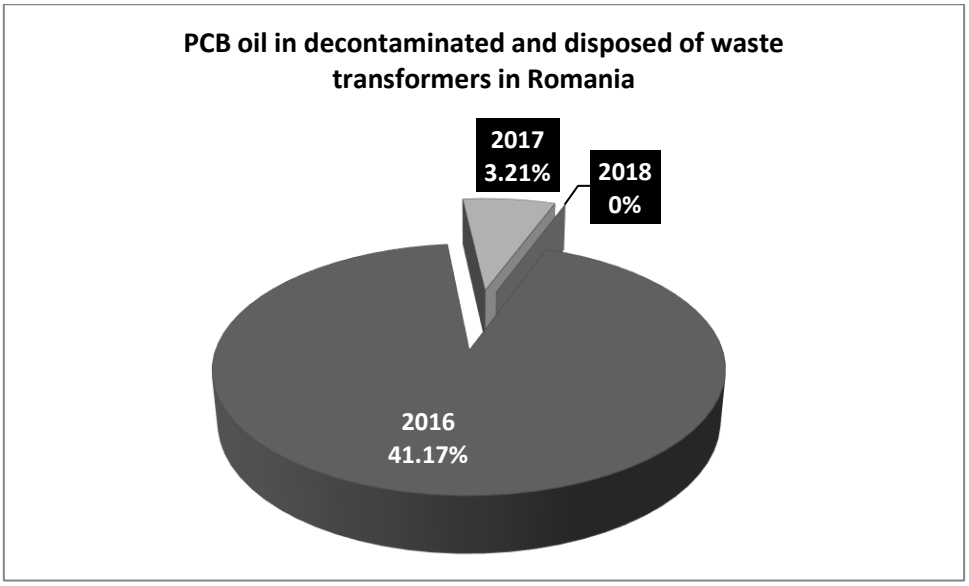

Fig. 18. PCB oil in decontaminated and disposed of waste transformers in Romania in the period 2016-2018 [27]

According to the statistical data presented above, it can be seen that the number of capacitors inventoried in Romania in the period 2016-2018 is much higher than that of transformers inventoried for the same period. This is a normal thing because of the greater number of capacitors used in medium voltage electrical installation.

According to the information provided by APM MM (2021), in Maramures county there were 6 economic operators in the period 2019-2020 that reported information regarding capacitors with PCB content [27].

In 2019, no equipment with PCB content was eliminated and in 2020, 121 capacitors were sent for decontamination, but it is possible that this number will increase because the reporting period has not been ended [27].

The inventory of electrical equipment with PCB content related to Maramureș County has no transformers with PCB content but only capacitors with PCB for the period 2016-2019 [27-28]. As shown in the graph below (*fig. 19*), there is a decreasing trend in the number of functional capacitors with PCB content. The largest number of capacitors of this type was registered with 769 pieces in 2016 getting to 637 pieces in 2019 [27-28].

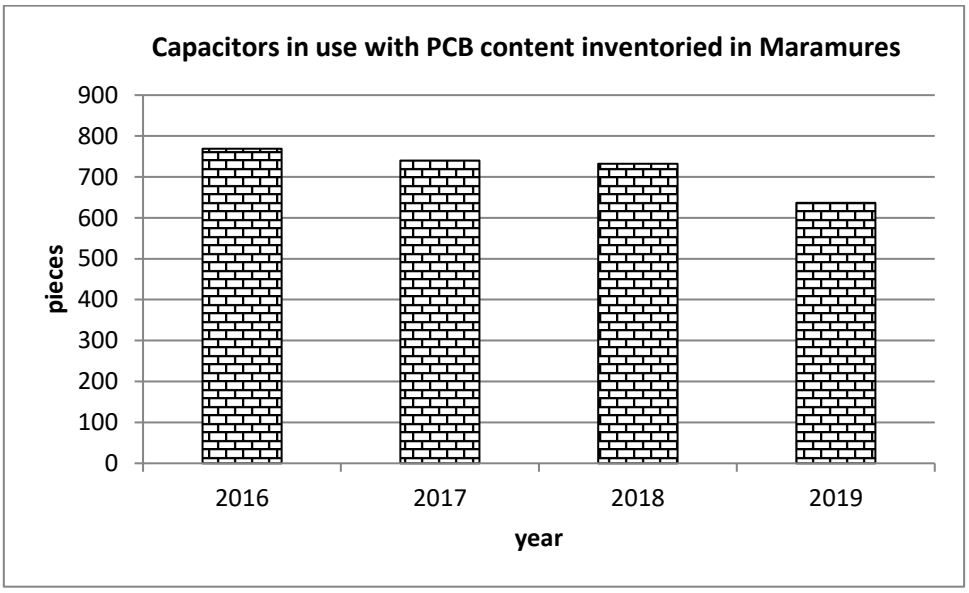

Fig. 19 Capacitors in use inventoried in Maramureș County during 2016-2018 [27-28]

Regarding the quantity of PCB oil in the waste capacitors inventoried in Maramureș County, the largest inventoried quantity was over 12747 liters in 2016 and the lowest, of 11477 liters in 2019 (*fig. 20*) [27-28].

Compared to the amount of oil contained in the capacitors in use in Maramureș County, the inventory data indicate a rate of decontamination and disposal of PCB oils of 6.83% in 2016, of 1.76% in 2018, and of 0.09 % in 2017. (*fig. 21*).

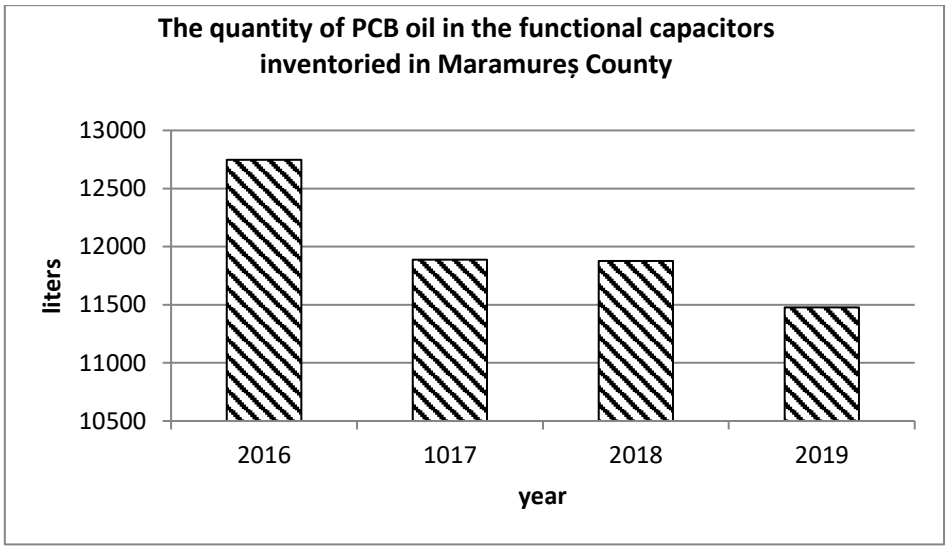

Fig. 20. The quantity of PCB oil in the functional capacitors inventoried for Maramures county in the period 2016-2018 [27-28]

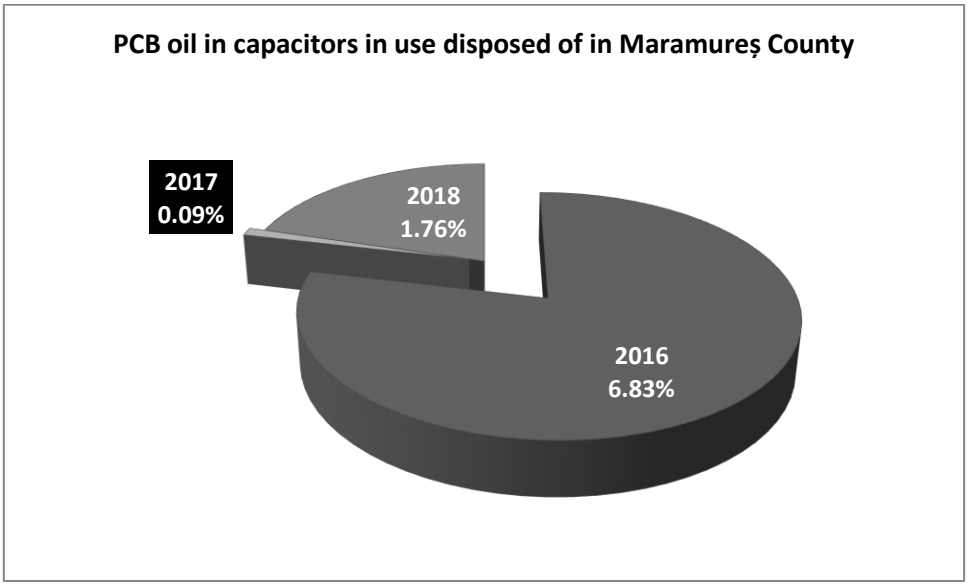

Fig. 21. PCB oil in capacitors in use decontaminated and disposed of in Maramures County in the period 2016-2018 [27]

In the period 2016-2018, the insufficient activity of decontamination and disposal of in use or waste electrical equipment with PCB was noticed both at the national and county level. This might be explained by the fact that there is only one authorized installation for decontamination of this kind of equipment with PCB [27].

3.3 Human health risks caused by PCBs

Like most organochlorine compounds, PCBs are persistent in the environment and accumulate in the food chain with affinity for adipose tissue (WHO, 2000). It accumulates mainly in the kidney, liver, adipose and epithelial cells [26].

The penetration of PCBs into the environment was done until their production was banned, in the form of emissions from industrial processes, or as leaks from the equipment or tanks with which these synthetic products were transported [5].

Many times, PCBs have accidentally ended up in various foods so that the population has been severely affected by them. One such incident occurred in 1968 in the Japanese city of Yusho. Because of the overheating of PCB oil-containing equipment that cooled rice bran oil, the PCB oil entered the edible oil and reached the population's food. Numerous symptoms have been registered such as increased discharge from the eye, lack of appetite, changes in nail color, hair loss, swelling of the limbs, nausea, vomiting, numbness of the limbs, and cutaneous symptoms [26].

Today, as the introduction of PCBs into equipment is not allowed, the danger of environmental contamination is the possible leakage of PCB-containing equipment waste or the decomposition of PCB-containing waste that has been in non-compliant landfills for many years [5].

Exposure of the population to PCBs can be achieved by ingestion with food or liquids; by inhalation or dermal contact. Also important are the dose, the duration of contact between the PCB and living organisms [5].

Studies have shown that air is the main pathway for the spread and dispersion of PCBs in the environment [3].

According to the study published by the WHO in 2003, the exposure of the population to PCBs can be followed by the appearance of many diseases, some of which are irreversible. Of these can be listed as follows [3-4]:

- different forms of cancer, including: cancer of the digestive system, cancer of the liver or melanoma etc
- deficiencies of the reproductive system
- developmental delay
- neurological effects
- immunological changes
- dermatological changes, including chloracnea, disorders of skin pigmentation, nails, gums; nail deformities, drowsiness, headaches and a sore throat

The effects that appear differ from individual to individual depending on the degree of exposure but also on the physical and mental characteristics of each individual.

Even the threshold limit values (TLV's) are not fixed by legislation, however there are some recommendations made in some states such as [4]:

United Kingdom Health and Safety Executive who set the following limits based on chlorine content [4]:

- for 42% chlorine content: long term exposure: l mg/m^3
- for 54% chlorine content: long term exposure: 0.5 mg/m^3

Germany which established through the former Federal Health Office of Germany recommended the following [4]):

- Tolerable Daily Intake (TDI): 1 mg per kg body weight per day
- if level exceeds 3000 mg per m^3 of air - Action should be taken
- level below 30 mg per m^3 of air should be kept as target

4. CONCLUSIONS

PCBs are part of the category of persistent organic compounds with a high capacity for bioaccumulation and significant damage to environmental factors and human health [1], [5]. These compounds have been used over time, due to their good dielectric properties, in various electrical equipment such as capacitors and transformers. Given the fact that there is a program for the gradual elimination of electrical equipment with PCB content that must be completed by 2025, Romania has developed a national inventory of equipment with PCB content that aims to monitor and ensure consistent management and efficient disposal of these categories of equipment and waste equipment.

The results obtained from the statistical processing and interpretation of the data provided by the national inventory of equipment and waste equipment containing PCBs reveal that in Romania the process of disposal is slow and that there are still large stocks of equipment containing PCBs that must be decontaminated and disposed of. By the end of 2018, the rate of decontamination and disposal of this equipment and the quantities of oils with PCBs contained was below 25%. In general, it is observed that the inventoried stocks decreased from 2016 to 2018 except for the waste transformers category which is registered in 2017 with 9 pieces more than the number of equipment registered in 2016 and with 2 more than the one registered in 2018.

Currently, there is no national or county inventory of equipment containing fluids with 0.005% to 0.05% PCB reported to the fluid weight [27].

In Maramureș County, there are no waste electrical equipment with PCB content, but only capacitors in use in the inventory. By the end of 2019, the rate of decontamination and disposal was below 15% [27-28].

The relatively slow pace of decontamination and disposal of electrical equipment, capacitors and transformers in Romania can be attributed to the fact that currently there is only one economic operator authorized to carry out the decontamination of equipment containing PCB/PCT. The oil extracted from this equipment is removed by incineration [27].

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AN ANALYTICAL APPROACH TO AM2 MODEL FOR BATCH ANAEROBIC BIOREACTORS

Abdelouahab **ZAATRI**
Département de Génie Mécanique, Université de Constantine 1, Constantine, Algeria
azaatri@yahoo.com

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Abstract*: The well-known AM2 model is commonly used for simulation of biotechnological processes of two-phases anaerobic digestions. Nevertheless, numerical simulation and graphical results usually obtained by solving the non-linear system of differential equations characterizing this model do not always enable an easy analysis of the processes as well their sensitivity to the variations of the different parameters and the initial conditions. In this paper, as an alternative to simulation, an analytical approach is proposed for batch reactors. It consists of adopting some approximations to reduce the mathematical complexity of the coupled differential equations of the AM2 model. The aim is to derive approximate analytical expressions concerning the dynamical evolution of the substrates and bacterias involved in reactions. The obtained expressions, therefore, permit a relatively easy analysis of the evolution of the main processes and their sensitivity to the different parameters and initial conditions. Moreover, it provides an explicit mathematical expression that enables to estimate the cummulative production of methane. The comparison of the obtained results by this proposed analytical approach to the numerical simulation of the AM2 model shows a satisfying qualitative convergence of the proposed approach to the AM2 model.*

1. INTRODUCTION

A practical mathematical model named AM2 is very useful for simulating and analyzing biological process of anaerobic digestion of two phases. Many authors have used this model to study batch and continuous anaerobic digesters with different substrates in various conditions [1-3]. From the mathematical point of view, the AM2 model corresponds to a set of coupled ordinary differential equations (ODE) of the first order with non linear left hand sides. Because

of this non linearity, explicit analytical solutions about state variables cannot be obtained; so the solutions are only obtained numerically by various numerical integration methods and serve to simulate and visualize graphically the evolution of the state variables. Most of the results obtained by different authors, based on AM2 model, are qualitatively comparable but quantitatively they may differ. Indeed, the results are very sensitive with respect to the change of the parameter values and to the conditions of experiments [4]. This fact expresses the complexity of the phenomenon regarding the limits of this model.

However, while the numerical simulation can graphically present the evolution of the different state variables, it doesn't always enable an easy analysis of the processes as well as the influence of the different parameters involved in the model and the conditions of experiments. In the literature, approaches leading to even approximate solutions of the AM2 model are very few or limited to analyzing the stability of the AM2 model [6]. Most of analytical approaches propose approximate expressions of the output state variable that is usually the production of methane based on simplifications and empirical formulas [5-10].

In this paper, It is intended to solve the AM2 model by using an analytical approach. By adopting some approximations over the equations of the model, this approach led to obtain some analytical expressions concerning the dynamical evolution of the substrates and bacteria during the processes. The obtained analytical expressions enable to have an insight on the complexity of the problem and to perform a detailed analysis of the temporal evolution of the main processes and the influence of the different parameters involved in the mathematical model. The comparison of this analytical approach to the numerical simulation shows qualitatively a satisfying convergence of the former approach and therefore justifies its use within the limits of the adopted approximations.

2. EQUATIONS GOVERNING THE AM2 MODEL

2.1. Mathematical Formulation

The mathematical AM2 model is based on the laws of growth [4]. It involves the following dynamic variables: X_1 is the concentration of the acidogenic bacteria population; X_2 is the concentration of the methanogenic bacterial population; S_1 is the concentration of the substrate of carbonaceous material and S_2 is the substrate concentration of volatile fatty acids. For batch systems, the mathematical model is expressed in the form of a coupled differential equations of the first order system:

$$\frac{dX_1}{dt} = \mu_1 X_1 \tag{1}$$

$$\frac{dX_2}{dt} = \mu_2 X_2 \tag{2}$$

$$\frac{dS_1}{dt} = -k_1 \mu_1 X_1 \tag{3}$$

$$\frac{dS_2}{dt} = k_2 \mu_1 X_1 - k_3 \mu_2 X_2 \tag{4}$$

For the growth process, the function of Monod μ_1 for acidogens bacteria and the function of Haldane μ_2 for methanogens bacteria are adopted and they are respectively:

$$\mu_1 = \mu_{1m} . \frac{S_1}{S_1 + Ks_1} \tag{5}$$

with μ_{1m} the maximal growth rate and K_{S1} the constant of half-saturation; and

$$\mu_2 = \mu_{2m} . \frac{S_2}{S_2 + Ks2 + \frac{S_2^2}{K_{I2}}} \tag{6}$$

with μ_{2m} the maximal growth rate, K_{S2} the constant of saturation and K_{I2}, the constant of inhibition.

The flow of methane which is the end product depends directly on the growth of methanogenic bacteria population $X_2(t)$, according to the relation:

$$Q_{CH4}(t) = k_4 . \mu_2 . X_2(t) \tag{7}$$

The cumulative quantity C(t) of the produced methane can be estimated by:

$$C(t) = k_4 . X_2(t) \tag{8}$$

There are nine parameters involved in this model (μ_{1m}, K_{S1}, μ_{2m}, K_{S2}, K_{I2}, k_1, k_2, k_3, k_4). To mathematically solve this system of differential equations, we must also provide four initial conditions: $S_1(0)$, $S_2(0)$, $X_1(0)$ and $X_2(0)$.

2.2. State Space Model

The system constituted of the differential equations (1), (2), (3) and (4) is a set of coupled differential equations of first order with non linear functions at the right hand side. Its integration provides the temporal evolution of the bacteria and the substrate concentrations. The production of the methane can be deduced from equation (7) and (8). For the implementation, this model can be written in a state space form such as:

$$\frac{dz(t)}{dt} = f(z(t)) = \begin{pmatrix} \overset{*}{X}_1(t) \\ \overset{*}{X}_2(t) \\ \overset{/*}{S}_1(t) \\ \overset{*}{S}_2(t) \end{pmatrix} = \begin{pmatrix} f_1(z) \\ f_2(z) \\ f_3(z) \\ f_4(z) \end{pmatrix} = \begin{pmatrix} \mu_1.X_1 \\ \mu_2.X_2 \\ -k_1.\mu_1.X_1 \\ k_2.\mu_1.X_1 - k_3.\mu_2.X_2 \end{pmatrix} \tag{9}$$

with the state space vector: $z(t) = (X_1(t) \quad X_2(t) \quad S_1(t) \quad S_2(t))^T$
and initial conditions are: $z(t_0) = (X_1(t_0) \quad X_2(t_0) \quad S_1(t_0) \quad S_2(t_0))^T$

This ODE system has been implemented by means of Euler's integration method and has been solved by using the ODE function of SCILAB software [11]. The graphical results obtained by solving this system correspond to a simulation carried out with the following parameter values: $\mu_{1m} = 0.4/\text{day}$; $K_{s1} = 72\,\frac{\text{g}}{\text{l}}$; $\mu_{2m} = 0.4/\text{day}$; $K_{s2} = 18\,\frac{\text{g}}{\text{l}}$; $K_{I2} = 103$ g/l; k_1= 13; k_2= 12; k_3 = 22; and the initial values are: $S_1(0)$ = 10 g/l; $S_2(0)$ = 2 g/l; $X_1(0)$ = 0.4 g/l and $X_2(0)$ = 0.01g/l.

3. ANALYTICAL APPROACH FOR $S_1(t)$ AND $X_1(t)$

3.1. Temporal evolution of substrate $S_1(t)$

To analyze the system of differential equations of AM2 model, consider the differential equations $X_1(t)$ and $S_1(t)$ corresponding to equations (1) and (3). It can be noticed that they are in fact decoupled from equations $X_2(t)$ and $S_2(t)$. Therefore, by combining (1) and (3), it can writen the following equalities:

$$\frac{dS_1}{dt} = -k_1.\mu_1.X_1(t) = -k_1.\frac{dX_1}{dt} \tag{10}$$

by integrating this differential equation, one gets the following linear relationship between $S_1(t)$ and $X_1(t)$ that is:

$$S_1(t) = -k_1.X_1(t) + S_{10} + k_1.X_{10} \tag{11}$$

where X_{10} and S_{10} are respectively the initial values of $X_1(t)$ and $S_1(t)$.

To explicit $X_1(t)$, let's replace μ_1 in (10) by its expression in (1) so that one gets the following relationship:

$$\frac{dS_1}{dt} = -k_1.\mu_1.X_1 = -k_1.\mu_{1m}.\frac{S_1}{(S_1 + K_{S1})}.X_1 \tag{12}$$

replacing $X_1(t)$ by its expression obtained in (11), one gets the following first order non linear differential equation in terms of $S_1(t)$ with respect to the time variable:

$$\frac{dS_1}{dt} = .\mu_{1m}.\frac{S_1}{(S_1 + K_{S1})}.(S_1 - a) \tag{13}$$

with: $a = S_{10} + k_1.X_{10}$

The expression (13) can be written in the following form by separating the variables from both sides:

$$\frac{(S_1 + K_{S1})}{S_1.(S_1 - a)}.\frac{dS_1}{dt} = \mu_{1m} \tag{14}$$

By introducing the initial conditions, one obtains the solution of the differential equation (14) in an analytical inverse form $t=f(S_1)$:

$$t = f(S_1) = \frac{(K_{S1} + a)}{a.u_{1m}}.\ln(\frac{|S_1 - a|}{|S_{10} - a|}) - \frac{K_{S1}}{a.u_{1m}}.\ln(\frac{|S_1|}{|S_{10}|}) \tag{15}$$

It is not possible to express explicitly $S_1(t)$ in a standard form. However, from (15), $S_1(t)$ can be easily computed and graphically represented as shown in *fig.1* by just giving values to S_1 and computing the corresponding time t. Expression (15), $t=f(S_1)$ or $S_1(t) = f^{-1}(t)$ are the analytical functions that contain the model parameters (K_{S1}, μ_{1m}, k_1) and initial values (S_{10}, X_{10}). This enables to study analytically the interaction and the influence of any of the involved parameters (Ks_1, μ_{1m}, k_1) or initial values (S_{10}, X_{10}) on the dynamical evolution of the process $S_1(t)$ that is the concentration of the substrate of carbonaceous material. The profiles of $S_1(t)$

obtained by the analytical function (15) and that obtained by solving the system of differential equations are presented on the same graphic as implemented under Scilab software. They appear superimposed in the graphics of *fig.1* and thus are similar.

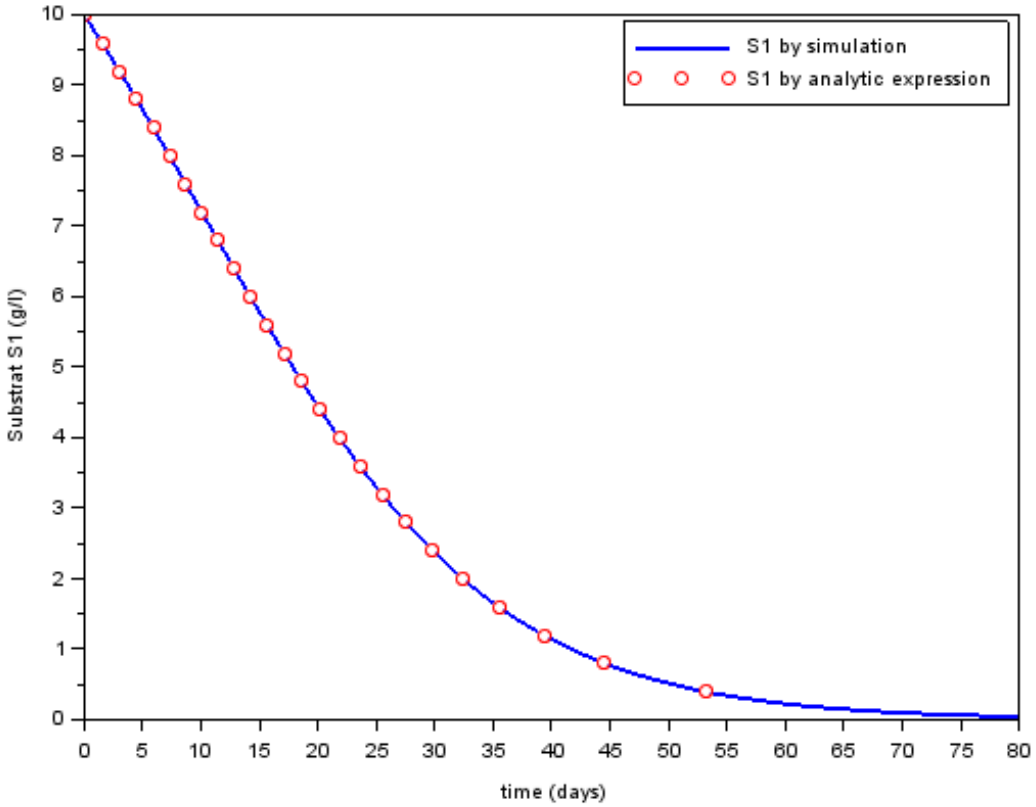

Fig. 1. Temporal Evolution of $S_1(t)$ by simulation and analytically

3.2. Temporal evolution of bacteria $X_1(t)$

The dynamic evolution of bacteria $X_1(t)$ can be derived from relation (11) as follows:

$$X_1(t) = -\frac{1}{k_1}(S_1(t) - a)) \tag{16}$$

Similarity to $S_1(t)$, $X_1(t)$ cannot be written in a standard form but can be expressed in the inverse form: $t = g(X_1)$. Therefore, the analytical expression is the function $t = g(X_1)$:

$$t = \frac{(K_{S1} + a)}{a.\mu_{1m}}.\ln\left(\left|\frac{X_1(t)}{X_{10}}\right|\right) - \frac{K_{S1}}{a.u_{1m}}.\ln\left(\left|\frac{k_1.X_1(t) - a}{k_1.X_{10} - a}\right|\right) \tag{17}$$

The analytical expression (17) includes the model parameters (Ks_1, μ_{1m}, k_1) and the initial values (S_{10}, X_{10}). It enables to analyze the evolution of the concentration of the acidogenic

bacteria population as well as its sensitivity to the related model parameters. By varying the values of X_1, the values of corresponding time are computed and the function $X_1=g^1(t)$ can be drawn. Graphics of $X_1(t)$ obtained by simulation and by the analytical expression (17) are presented in *Fig. 2*. They appear superimposed and thus are similar.

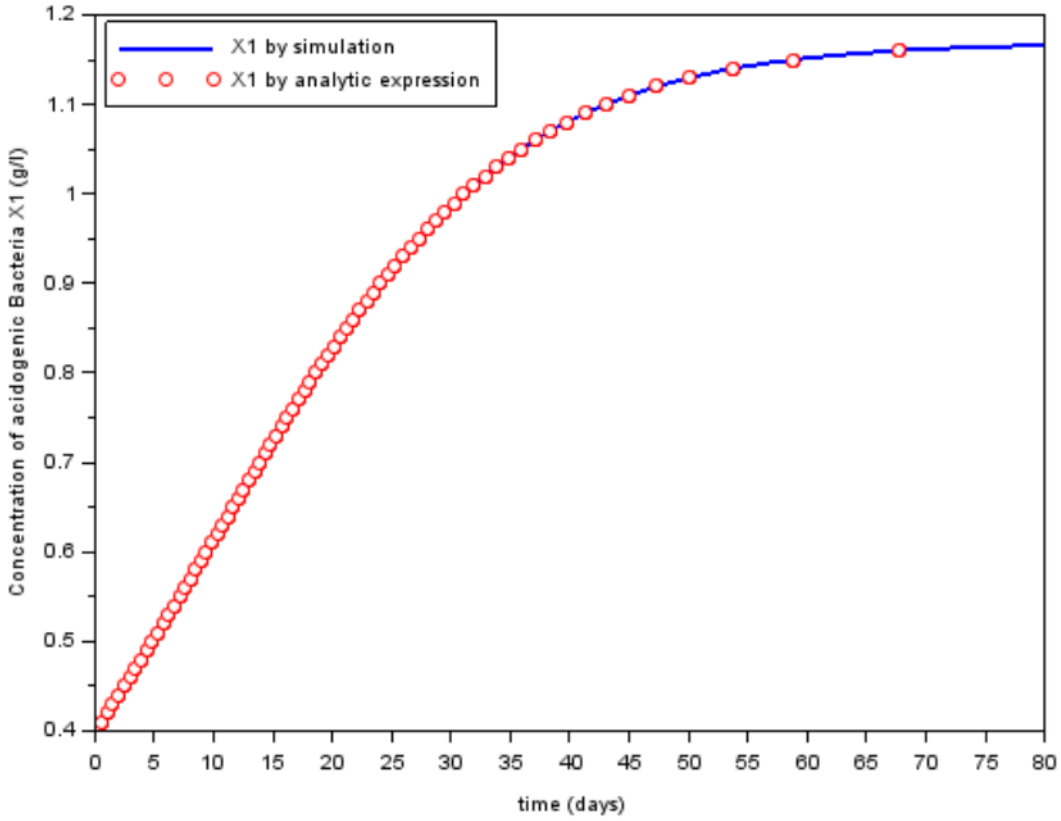

Fig.2. Temporal Evolution of $X_1(t)$ by simulation and analytically

3.3. Some Remarks

3.3.1. Behavior evolution of $S_1(t)$ and $X_1(t)$

Although the equation of *X1(t)* and *S1(t)* are non-linear, there profiles present behaviors like systems whose dynamics are characterized by transient response followed by a steady state one. So, to determine the steady state asymptotic value of $X_1(t)$ which is for large time values, it requires combining (3), (5), (11) and equaling to zero the first derivative of $X_1(t)$:

$$\frac{dX_1}{dt} = \mu_{1m}.\frac{S_1}{(S_1+K_{S1})}.X_1 = \mu_{1m}.\frac{(-k_1.X_1+a).X_1}{(-k_1.X_1+K_{S1}+a)} = 0 \tag{18}$$

This leads to the condition: $-k_1.X_1+a=0$, which consequently leads to the asymptotic steady state value of acidogenic bacteria: $X_1(t) = X_{1S} = \frac{a}{k_1} = X_{10} + \frac{S_{10}}{k_1} \cong 1.17\ g/l$.

Similarly, from equation (11), we can determine the asymptotic steady state value for $S_1(t)$ which is zero. This means that the concentration of the substrate of carbonaceous material will be almost completely consumed at relatively large time durations.

3.3.2. Settling time for $X_1(t)$ and $S_1(t)$

In such systems, it is important to determine the settling time t_{set} which is defined as the time to reach the steady state value up to 5%. For $X_1(t)$, it corresponds to: $X_1(t_{set}) = X_1set = 0.95*X_{1S}$ = 1.11 g/l. By replacing this settling value X_1 set in (12), the settling time *ts* is about 45 days. From equation (11), we can estimate the settling value for $S_1(t)$ which is about 50 days. The comparison of these results is in full agreement with those given by simulation of the system of differential equations composing AM2 model.

3.3.3. Sensitivity analysis

Given the analytical relations (15) and (17), the analysis of the evolution of the substrate $S_1(t)$ and of the bacteria $X_1(t)$ with respect to all involved model parameters as well as their sensitivity can be easily performed analytically from these expressions.

4. TEMPORAL EVOLUTION OF $X_2(t)$ AND $S_2(t)$

4.1. Establishment of differential equations for $X_2(t)$ and $S_2(t)$

From the previous equations (2) and (4), we can write:

$$\frac{dX_2}{dt} = \mu_2.X_2 = \mu_{2m}.\frac{S_2}{S_2 + \frac{S_2^2}{K_{I2}} + K_{S2}}.X_2 \tag{19}$$

On the other hand, by using (1) and (2), equation (4) can be written in the following form:

$$\frac{dS_2}{dt} = k_2 \frac{dX_1}{dt} - k_3.\frac{dX_2}{dt} \tag{20}$$

by integrating this last equation (20), we obtain:

$$S_2(t) = k_2 X_1(t) - k_3.X_2(t) + C \tag{21}$$

which can also be written as:

$$S_2(t) = -k_3 X_2(t) + k_2.X_1(t) + C = -k_3.X_2(t) + f(t) \tag{22}$$

with: $f(t) = k_2.X_1(t) + C$ and $C = S_{20} - k_2 X_{10} + k_3.X_{20}$.

By replacing $S_2(t)$ from (22) into the (19), we can explicit a non linear differential equation of the first order on $X_2(t)$ which depends on $X_1(t)$ via the term $b(t)$:

$$\frac{dX_2}{dt} = \mu_{2m}.\frac{(-k_3.X_2 + f).X_2}{\left[(-k_3.X_2 + f) + \frac{(-k_3.X_2 + f)^2}{K_{12}} + K_{s2}\right]} = g(X_2, X_1) \tag{23}$$

Under this form, the differential equation (23) cannot be solved to obtain an analytical expression. This is only possible in the case where $X_1(t)$ is independent from time which is not the case in our general problem since we know already the profile given by (17). However, we can integrate (23) by numerical methods without the need to solve the system of coupled differential equations. But it requires to provide the values of $X_1(t)$ at each step of integration by tabulation or by integrating the inverse of $X_2(t)$ which is:

$$\frac{dt}{dX_2} = g^{-1}(X_2, X_1) \tag{24}$$

This differential equation contains all the model parameters (μ_{2max}, K_{S2}, K_{I2}, k_2, k_3) that affects the evolution of the methanogens as well as the corresponding initial conditions: S_{20}, X_{20}. The other parameters concerning the acidogenic bacteria with their initial conditions are introduced in (23) by $b(t)$ which is linked to $X_1(t)$. At this level, integrating only (23) instead of solving the set of differential equations of the AM2 model, makes it easier to study and analyze the influence of all parameters and initial conditions on $X_2(t)$. Another easiest way consists of integrating (23) by using a piecewise linear approximation of $X_1(t)$ derived from (17). Further, we will integrate the differential equation (23) using this linear piecewise approximation of $X_1(t)$. The results will be compared to simulation and to those of our analytical approach.

4.2. Approximation of the growth process of Bacteria $\mu_2(S_2)$

To obtain analytical solutions for $X_2(t)$ and $S_2(t)$, it is necessary to make some approximations that simplify the differential equations (22) and (23). That is the only way to make them amenable to expressions that are analytically integrable. To this purpose, we consider a first approximation that concerns $X_1(t)$. One appropriate simple simplification is to

use a piecewise linear approximation by two segments. The first segment corresponds to a linear approximation derived from (17) during the transient response. The second one consists of approximating $X_1(t)$ by a horizontal line corresponding to the asymptotic steady state response. The point of junction between the two segments corresponds to the settling time of $X_1(t)$.

However, even by using a linear approximation of $X_1(t)$ during the transient response, $X_2(t)$ remains still dependant from time, then (23) cannot be solved analytically. To be solvable analytically, it needs to be simplified to the level that the grown law of the process of the methanogenic bacterial population becomes linear of the form:

$$\mu_2 = \frac{u_{2m}}{K_{S2}}.S_2 \tag{25}$$

By adopting these simplifications, (23) can be written as follows:

$$\frac{dX_2}{dt} = \mu_{2m}.\frac{S_2}{Ks2}.X_2 = \mu_{2m}.\frac{(-k_3.X_2 + k_2.X_1 + C).X_2}{Ks2} = \mu_{2m}.\frac{f(t).X_2 - k_3.X_2^2}{Ks2} \tag{26}$$

Now, the differential equation (26) corresponds to Bernoulli's equation [12] can be rewritten to match the standard form of Bernoulli's differential equation for the case where the coefficient $n = 2$; that is:

$$\frac{dy(t)}{dt} + P(t).y(t) = Q(t).y^2(t) \tag{27}$$

Equation (246) structured in the standard Bernoulli's form becomes:

$$\frac{dX_2(t)}{dt} - \frac{\mu_{2m}}{Ks2}(C + k_2.X_1(t)).X_2(t) = -\frac{\mu_{2m}}{Ks2}.k_3.X_2^2(t) \tag{28}$$

with

$$P(t) = -\frac{\mu_{2m}}{Ks2}(C + k_2.X_1(t)) \tag{29}$$

and

$$Q(t) = q_0 = -\frac{\mu_{2m}}{Ks2}.k_3 \tag{30}$$

To solve (27), it is converted into another simpler differential equation of the first order that has a general solution [12]:

$$y(t) = \frac{\exp\int -P(t).dt}{C_0 - \int Q(t).\exp\int -P(t)dt} \tag{31}$$

To explicit the general solution in the form of (31), it requires the provision of *P(t)* which means in our case to provide the profile of $X_1(t)$. Here again, the problem of integrating this function is not obvious in standard analytical expressions. So, in this paper, we will use a piecewise linear approximation for $X_1(t)$ as announced.

5. DETERMINATION OF $X_2(t)$

5.1. Determination of $X_2(t)$ with linear approximation of $X_1(t)$

The linear approximation of $X_1(t)$ to the first order during the transient response is given from (17) by considering:

$$\ln(x) \cong x - 1 \tag{32}$$

By applying this approximation, relation (17) can be written in a linear form such as:

$$X_1(t) \cong X_{10} + u_0.t \tag{33}$$

with:

$$u_0 = \mu_{1m}.\frac{(k_1.X_{10} - a).X_{10}}{(k_1.X_{10} - a - K_{s1})} = \mu_{1m}.\frac{S_{10}}{(S_{10} + K_{s1})}.X_{10} \tag{34}$$

It follows from (29) that *P(t)* is also linear with respect to time:

$$P(t) \equiv -\frac{\mu_{2m}}{Ks2}(C + k_2.X_1(t)) = a_1 + b_1.t \tag{35}$$

with:

$$a_1 = -\frac{\mu_{2m}}{Ks2}.(S_{20} + k_3.X_{20}) \tag{36}$$

$$b1 \equiv -\frac{\mu_{2m}.k_2}{Ks2}u_0 = -\frac{\mu_{2m}.k_2}{Ks2}.\mu_{1m}.\frac{S_{10}}{(S_{10} + Ks1)}.X_{10} \tag{37}$$

and

$$Q(t) = q_0 = -\frac{\mu_{2m}}{Ks2}.k_3 \tag{38}$$

Having determined the expressions of *P(t)* and *Q(t)* according to the general solution (31), we can integrate the expressions in its numerator and in the denominator. The numerator in (31) equals:

$$N(t) = \exp\left(\int_0^t (-P_1(t).dt\ \right) = \exp(-a_1.t - \frac{b_1}{2}.t^2) \tag{39}$$

by introducing the initial value $X_2(0)$ that is X_{20}, (31) becomes:

$$X_2(t) = \frac{X_{20}.e^{-a_1.t-\frac{b_1}{2}.t^2}}{1 - X_{20}.q_0.\int_0^t e^{-a_1.t-\frac{b_1}{2}.t^2}.dt} \tag{40}$$

The integral in the denominator is a special mathematical function that depends on the values of the coefficients (a_1, b_1). Its behaviour depends particularily on the sign of the term $(-b_1)$. In our case, b_1 is negative, thus $(-b_1)$ is positif. Therefore, the corresponding integral leads to a function known as the imaginary errot function *erfi(x)* which is defined as [13]:

$$erfi(t) = \frac{2}{\sqrt{\pi}}.\int_0^t e^{z^2}.dz \tag{41}$$

In case where the coefficients (α, β) are both positive, the integral in the denominator in expression (40) becomes according to [13]:

$$D(t) = \int_0^t e^{.\alpha.t+\beta.t^2}\, dt = -\frac{\sqrt{\pi}}{2.\sqrt{\beta}}.\exp(-\frac{a^2}{4.\beta}).erfi\,(\frac{2.\beta.t+\alpha}{2.\sqrt{\beta}}) \tag{42}$$

Since in our approximation, $\alpha = -a_1$ and $\beta = -b_1 / 2$ then, the final expression of $X_2(t)$ under the set of adopted approximations is finally:

$$X_2(t) = \frac{X_{20}.\exp(-a_1.t - \frac{b_1}{2}.t^2)}{1 - X_{20}.q_0.\frac{\sqrt{\pi}}{\sqrt{-2.b_1}}.\exp(\frac{a_1^2}{2b_1}).erfi(\frac{-b_1.t - a_1}{\sqrt{-2.b_1}})} \tag{43}$$

This expression shows the temporal evolution of $X_2(t)$ during the transient response of the processes. We can observe the presence of all the involved model parameters except K_{12} which has been neglected for the seek of approximations and simplifications. The presence of all the model parameters in expression (43) proves and explains the complex sensitivity and interactivity of biotechnological problems. This explains the sensitivity of the methane production as a final product with respect to all these parameters and conditions.

Expression (43) is mainly valid for the duration of the transient response. After that, it must be approximated by an asymptotic horizontal line corresponding to the steady state response. The steady state value of $X_2(t)$ can be determined from the expression derived from (21):

$$\boldsymbol{X_2(t) = \frac{1}{k_3}(k_2 X_1(t) - S_2(t) + C)} \tag{44}$$

For large values of the time, $X_1(t)$ tends to ($X_{1S} = a / k_1$) and $S_2(t)$ tends to zero; then the asymptotic value of X_{2s} corresponding to the steady state response is:

$$X_2(\infty) = X_{2S} = \frac{1}{k_3}(k_2.\frac{a}{k_1} + C) = \frac{1}{k_3}.\left[\frac{k_2}{k_1}.S_{10} + S_{20} + k_3.X_{10}\right] \equiv 0.52\ \ g/l \tag{45}$$

Fig. 3 represents the temporal evolution of $X_2(t)$ obtained by simulation (blue curve); by the analytical expression (43) and (45) (black curve) and by integration of (23) using the piecewise linear approximation of $X_1(t)$ (red curve) The analytical curves corresponding to expression (43) is limited by its asymptotic value at about $t = 45$ *days* where $X_2(t)$ reaches X_{2S}.

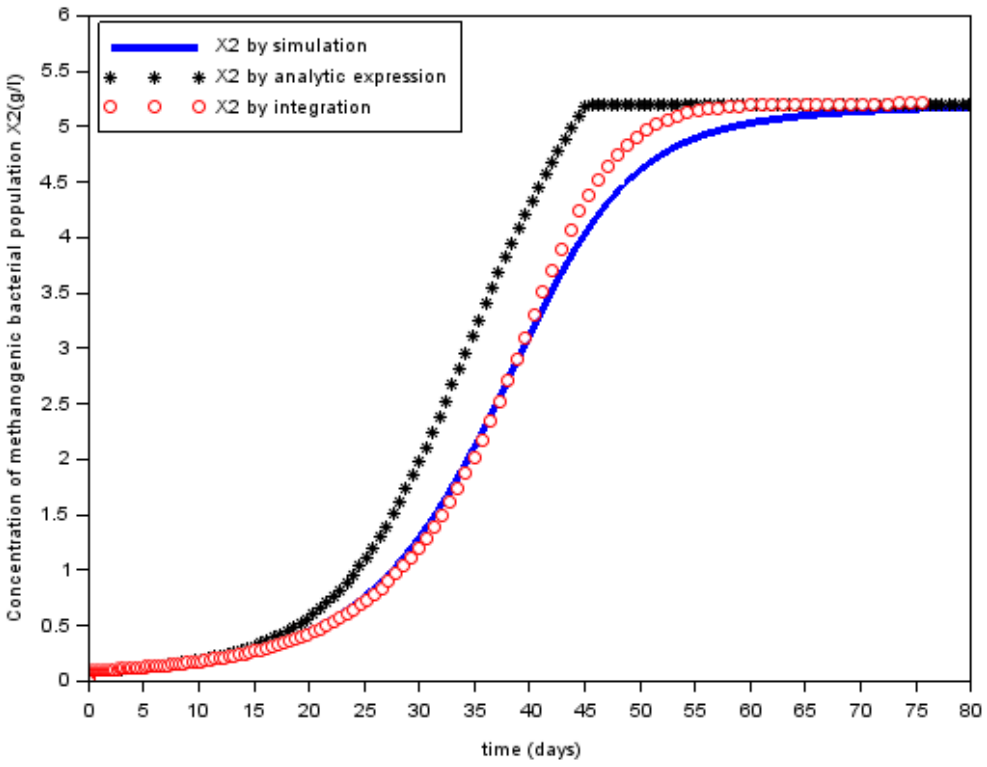

Fig. 3. Temporal evolution of $X_2(t)$ by simulation and analytically

Although, the curve obtained by simulation is considered as the reference, the comparisons of the two other curves to that reference show some difference due to the adopted approximations. However, there is a quanitative agreement during the beginning of the process during about the 15 first days. Then, after that, there is a qualitative agreement. For long durations corresponding to the steady state response, the curves meet and are almost similar.

5.2. Evolution of substrate $S_2(t)$ under linear approximation of $X_1(t)$

By replacing $X_2(t)$ and $X_1(t)$ with their respective expressions in expression (21), we obtain the temporal evolution of the profile of the substrate $S_2(t)$ in the analytical form.

$$S_2(t) = \frac{-k_3.X_{20}.\exp(-a_1.t - \frac{b_1}{2}.t^2)}{1 - X_{20}.q_0.\frac{\sqrt{\pi}}{\sqrt{-2.b_1}}.\exp(\frac{a_1^2}{2b_1}).erfi\,(\frac{-b_1.t - a_1}{\sqrt{-2.b_1}})} + k_2.(X_{10} + u_0.t) + C \tag{46}$$

Fig. 4 represents the temporal evolution of $S_2(t)$ obtained by simulation (blue curve); by the analytical expression (46) (black curve) and by numerical integration derived from (23) using the piecewise linear approximation of $X_1(t)$ (red curve). The analytical expressions $S_2(t)$ contains the parameters involved in the process and reveal their complex interaction with the

biological processes. This expression is an approximation during the beginning of the process that corresponds to the transient responses. At large time duration, $S_2(t)$ vanishes after about 60 days.

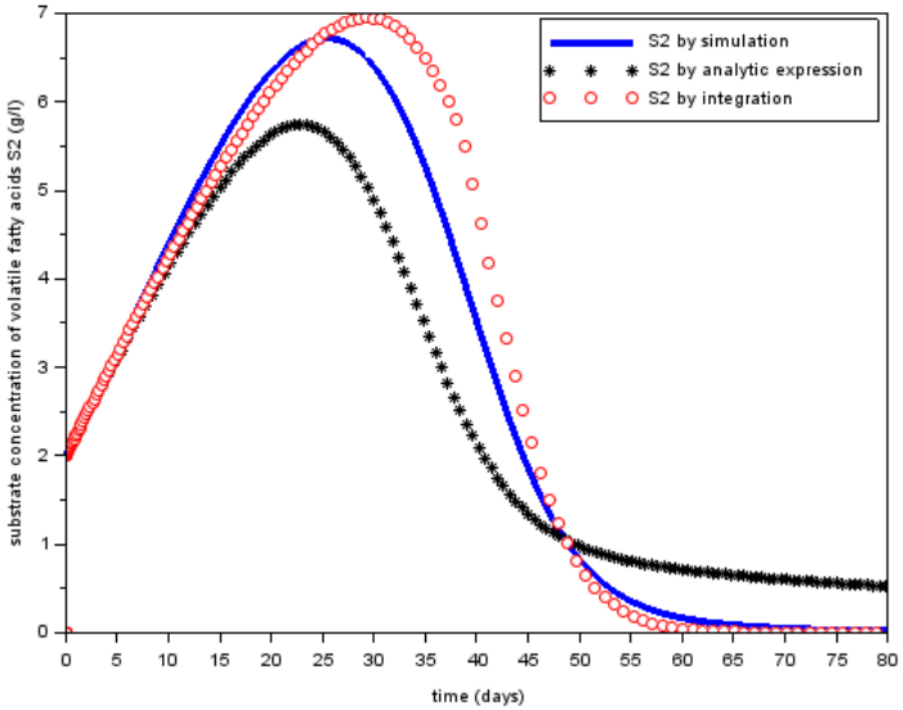

Fig. 4. Temporal evolution of $S_2(t)$ by simulation and analytically

Comparing the other curves to the blue one that constitutes the reference, there curves are in quantitatively in agreement during the 20 first days at the beginning of generation of the processes. After that, there are differences because of the adopted approximations and because of the change on the slope of $S_2(t)$ during the remaining period of the transient response. In this part, the linear approximations of $X_1(t)$ and that of μ_2 in (23) can't hold anymore. Nevertheless, despite the used approximations used, there is a qualitative agreement that enables to analyze the influence of the parameters involved in the processes. Qualitatively, the profile of the analytical expression $S_2(t)$ is roughly reproduced compared to that obtained one by solving the system of differential equations.

5.3. Evaluation of Methane Production

To estimate the methane production from the AM2 model, the literature provides data corresponding to a value of k_4 which is closer to *75* l^2/mg [4]. According to this model, the temporal evolution of methane flow $Q_{CH4}(t)$ is computed from the expression (7) as follows:

$$Q_{CH4}(t) = k_4.\mu_2.X_2(t) = k_4.\frac{dX_2}{dt} \tag{47}$$

The cumulated quantity of methane $C_m(t)$ over a given period is obtained by integrating $Q_{CH4}(t)$ which is proportional to $X_2(t)$:

$$Cm(t) = \int k_4 . \frac{dX_2}{dt} dt = k_4 . X_2(t) \tag{48}$$

The production of the methane depends on the derivative of $X_2(t)$ from the analytical expression (44), we can see the influence of almost all parameters involved in the AM2 model and then the sensitivity of the methane production to them. However, the cumulated quantity of methane depends only on $X_2(t)$. In case of batch reactors, $X_2(t)$ tends after a transient period to a steady state response where $X_2(t)$ becomes constant. It can be evaluated by the expression derived from (45):

$$Cm = k_4 . X_2(\infty) = k_4 . X_{2S} = \frac{k_4}{k_3} . \left[\frac{k_2}{k_1} . S_{10} + S_{20} + k_3 . X_{10} \right] \tag{49}$$

In this expression, one can notice that it does not contain the parameters of bacteria's growth rate which are mainly active during the transient period.

6. CONCLUSION

As an alternative to simulation by solving the system of differential equations characterizing the AM2 model, an analytical approach is proposed in case of batch reactors. It consists of adopting some approximations to reduce the mathematical complexity of the coupled differential equations. Analytical expressions for the state variables have been derived incorporating the model parameters and initial conditions revealing the complexity of the biotechnological systems. The proposed analytic expressions enable thus to perform a relatively easy analysis of the evolution of the main processes as well as the influence of the different parameters and initial conditions. The comparison of the results provided by this analytical approach to the numerical simulation shows a satisfying qualitative convergence of the former and therefore may justify its use under the adopted assumptions. It also opens some perspectives for improving and optimizing the biotechnological processes involved in such models.

Conflict of Interest: The author declares that he has no conflict of interest.

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ANTI-SATURATION CASCADE GENERALIZED PREDICTIVE CONTROL APPLIED IN INDUCTION MOTOR

Khelifa **KHELIFI OTMANE**
Blida 1 University, Department of Automatic and Electrotechnic
B.P 270 Route de Soumâa, Blida, Algeria
khelifi_ot_uhbc@yahoo.fr

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Abstract*: Owing to the physical limitations in the variable speed induction motor drives, the windup phenomenon appears and results in performance degradation when the speed controller output is saturated by the current limiter, this happens often when a large change in the speed reference occurs. This paper's aim is to prevent the undesirable effects of the saturation controller by employing a retuned generalized predictive speed controller based on Youla parametrization. The synthesis of an initial GPC controller based on its polynomial equivalent structure is required in the first step. Then, thanks to the Youla parameterization, this controller is retuned considering these saturation constraints reflected on two specifications. The first is a frequency specification on the quadratic component of stator current response to the speed reference which assures a minimal control action in transient periods. And the second is a time domain constraint on the measured speed response to the speed reference that enforce the output response to be within an imposed envelope. These constraints are stated within a linear convex optimization problem. The simulation results proved the efficiency of the resulting predictive speed controller.*

1. INTRODUCTION

The Generalized Predictive Control (GPC) [1] is a modern technique of process control. It has been successfully implemented in many industrial applications for last two decades [2], it is due to its robustness, optimality and ability to face uncertainty. Therefore, GPC applications to electric drives are developed and become interesting in many research

laboratories [3], [4], [5], [11] and [12]. Some authors use the GPC algorithm in cascade form to control multiple loops of the electric motor [14], also others adopt the multivariable GPC formulation in order to control different variables of the system [15].

Even today, the induction motor (IM) stands out as the motor of choice in wide range of applications especially in industrial drives. This, thanks to its higher efficiency, low cost, lower inertia, high initiate torque, and robust architecture. In high performance drive system, the field-oriented control (FOC) is commonly employed and it is the famous technique used in the speed control of the induction motor. It is due to its unique characteristics like high efficiency, good power factor and perfectly reliable [16]. The FOC method guarantees the decoupling of torque and flux control commands of the induction motor, so that the induction motor can be controlled linearly like a separate excited DC motor by means of the FOC scheme which guarantees the decoupling of torque and flux commands of the induction motor. Usually, VSI (Voltage Source Inverters) and (PWM pulse width modulation) are used to drive IM. Thus, the overall control system consists typically of an outer speed control loop and an inner current control loop in cascade. The studies that employed GPC laws to control induction motors, provide very satisfactory results in terms of robustness, optimality and ability to face uncertainty, compared to the classical regulators such as PI/PID controllers. Therefore, without system constraints, the optimal solution in an analytic (explicit) form can be obtained easily and hence the GPC control laws are pre-calculated off-line. As final step, the GPC controller can be synthetized in its numerical polynomial equivalent structure RST. In practice, the mentioned electrical drive is a difficult engineering problem, especially in high speed control, since it suffers from some limits, such as limits on power inverter's and maximum allowable motor current. If the GPC speed controller is designed in a linear region without regard to any constraint, it can generate an exceeded q-axis current reference for the GPC current controller in dynamic and high speed profiles which leads to an over modulation in the inverter. Also, in reality, this current command is limited to a prescribed maximal value depended on the inverter maximum current limit, the overheating of stator windings, and the magnetic saturation.

Consequently, if the GPC speed controller is saturated, the so-called windup phenomenon arises and the close-loop performance will worsen with respect to the expected linear performance, which leads to a slow settling time, a big overshoot on the speed response, and even an instability in the system. Hence, to safeguard the motor and the power electronics, the control of the IM needs the use of sophisticated control that respects these restrictions, while keeping a simple structure designing.

A classical method to handle the windup problem is to take constraints into account at the phase of control design. Nevertheless, this a priori design method has a high computational cost and the obtained control law can be difficult to implement [2], [4].

Another common design strategy is a two-step paradigm: in the first step, a linear control design is performed in which the nominal performance specifications are satisfied

ignoring the saturation constraints, then a supplementary compensator to the initial controller is achieved to minimize the windup impacts on the closed-loop performance which can take place during saturation [18]. The design based on this second method is not complicated design scheme from the viewpoint that the linear performance recovers when the saturation does not occur.

Based on this second approach, the present work intends to employ an effective and simple technique to prevent the controller saturation by relying on the Youla parametrization and based on to the results provided by P. Rodriguez and D. Dumur [6]. The authors in [6] presents a unified off-line method using the Youla parametrization to re-tune an initial GPC law while keeping its two degrees of freedom form. This parametrization is fulfilled via convex optimization in terms of two free parameters Q1 and Q2 in which a separation is made between the tracking behavior and the closed loop features. As a result, the Q2 can modify only the input-output transfer function without influencing on the closed loop performances. In this paper, we will investigate this feature on our electrical drive to prevent the wind-up phenomenon.

2. SYSTEM MODELING AND GPC LAW DESIGN

By adopting the traditional assumptions of the vector control of the induction machine, the model in the reference axes *d, q* related to the rotating field is presented below [7]:

$$\begin{cases} v_{ds} = (R_s + \sigma L_s s) i_{ds} - e_{ds} \\ v_{qs} = (R_s + \sigma L_s s) i_{qs} - e_{qs} \\ \varphi_r = \left(\frac{L_m}{1+T_r \boldsymbol{s}}\right) i_{ds} \\ C_{em} = \frac{p L_m}{L_r} \varphi_r i_{qs} \\ \Omega = \left(\frac{1}{f_r + J\boldsymbol{s}}\right)(C_{em} - C_r) \end{cases} \quad (1)$$

where:

s	Laplace operator,
v_{ds}, v_{qs}	Stator voltages,
i_{ds}, i_{qs}	Stator currents,
φ_r	Rotor flux,
Ω	Rotation speed,
C_{em}, C_r	Electromagnetic and load torques respectively,
J	Moment of inertia,
L_s, L_r, L_m	Stator inductance, rotor inductance and mutual inductance respectively,

f_r Friction coefficient

$R_s,\ R_r$ The resistance of the stator and of rotor the respectively,

σ Blondel's dispersion coefficient

$T_r = \frac{L_r}{R_r}$ Rotor time constant

and e_{ds}, e_{qs} represent the voltage compensation terms:

$$\begin{cases} e_{ds} = \sigma w_s L_s i_{qs} \\ e_{qs} = -w_s \frac{L.m}{L_r} \varphi_r - \sigma w_s L_s i_{ds} \end{cases} \quad (2)$$

where w_s is the synchronous speed.

We can neglect the electric pole of the induction motor because it is faster than the mechanic pole. Also we consider that the block inverter has neither gain nor dynamics in block scheme of *fig.1*, it is possible to deduce the following transfer functions corresponding respectively to the electric and mechanics modes:

$$\begin{cases} G_i(s) = \frac{1}{(R_s + \sigma L_s s)} \\ G_s(s) = \frac{1}{(f_r + Js)} \end{cases} \quad (3)$$

As the GPC controllers are of discrete type, the transfer functions (3) must be converted into a discrete time transfer functions. Thus, using the ZOH (Zero Order Hold) discretization method, the z-transform of the system transfer functions (3) can be given as follows:

$$\begin{cases} G_i(q^{-1}) = \frac{q^{-1} A_i(q^{-1})}{B_i(q^{-1})} \\ G_s(q^{-1}) = \frac{q^{-1} A_s(q^{-1})}{B_s(q^{-1})} \end{cases} \quad (4)$$

The transfer functions derived above are the models used in the GPC controllers design for the speed and currents respectively. *Fig. 1* illustrates the block diagram of the induction motor drive based on the FOC scheme. The field weakening guarantees that the flux reference diminishes when the motor speed exceeds its nominal value. Using the Park's transformation, the *abs=>dq* block get the i_{as}, i_{bs} et i_{cs} motor stator currents, and the *dq =>abs* block makes the reverse Park's transformation.

In both cases (speed loop or current loops), Tthe GPC control strategy uses for the prediction the CARIMA model (Controlled Autoregressive Integrated Moving Average):

$$A(q^{-1}) y(t) = B(q^{-1}) u(t) + \frac{\xi(t)}{\Delta(q^{-1})} \quad (5)$$

where $u(t)$ is the control signal, $y(t)$ is the process output, $\xi(t)$ is the zero mean white noise, $\Delta(q^{-1}) = 1 - q^{-1}$, and *A* and *B* are polynomials in backward shift operator q^{-1} derived from (5). The predicted output in the *j-th* prediction step over the costing horizons $N_1 \leq j \leq N_2$ is done by:

$$y(t+j) = \underbrace{F_j(q^{-1})y(t) + H_j(q^{-1})\Delta u(t-1)}_{\textbf{free response}} + \underbrace{+G_j(q^{-1})\Delta u(t+j-1) + J_j(q^{-1})\xi(t+j)}_{\textbf{forced response}} \quad (6)$$

F_j, G_j, H_j are polynomials determined from solving iteratively Diophantine equations.

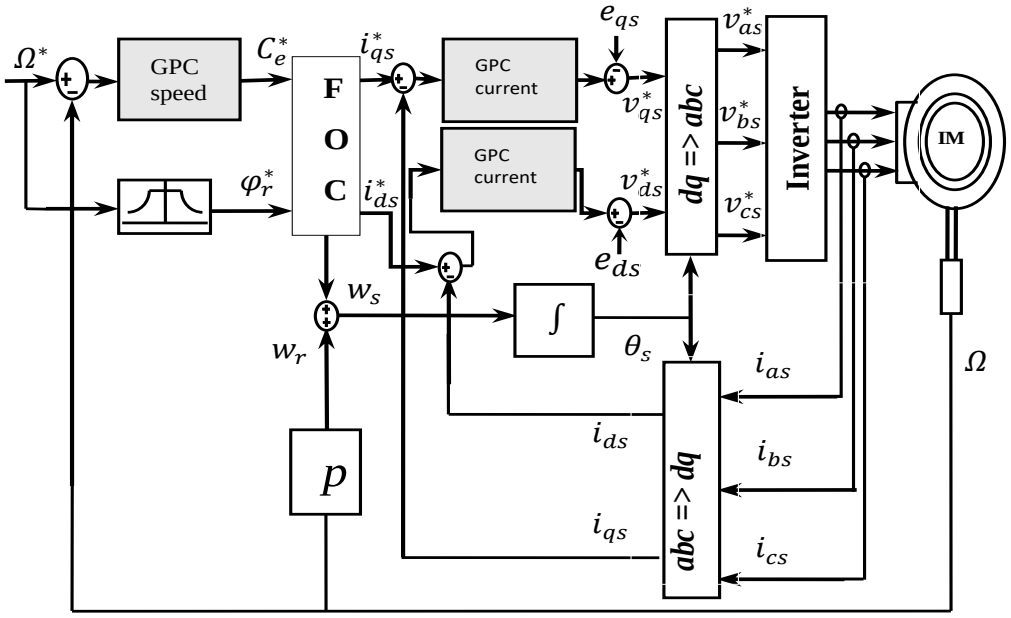

Fig. 1 Block diagram of an induction motor drive based on GPC controllers

The GPC control law is obtained by minimizing the cost function given by:

$$J(N_1, N_2) = \sum_{j=N_1}^{N_2} [\hat{y}(t+j) - w(t+j)]^2 + \lambda \sum_{j=1}^{N_u} [u(t+j-1)]^2 \quad (7)$$

$$\Delta u(t+j) = 0 \text{ for } j \geq N_u$$

where λ is the control weighting factor, *w* the set-point, N_1 and N_2 are the minimum and maximum costing horizons, and N_u is the control horizon.

The obtained GPC control law can be transformed to a two degrees of freedom *RST* structure that given as:

$$S(q^{-1})\Delta(q^{-1})u(t) = -R(q^{-1})y(t) + T(q)w(t) \quad (8)$$

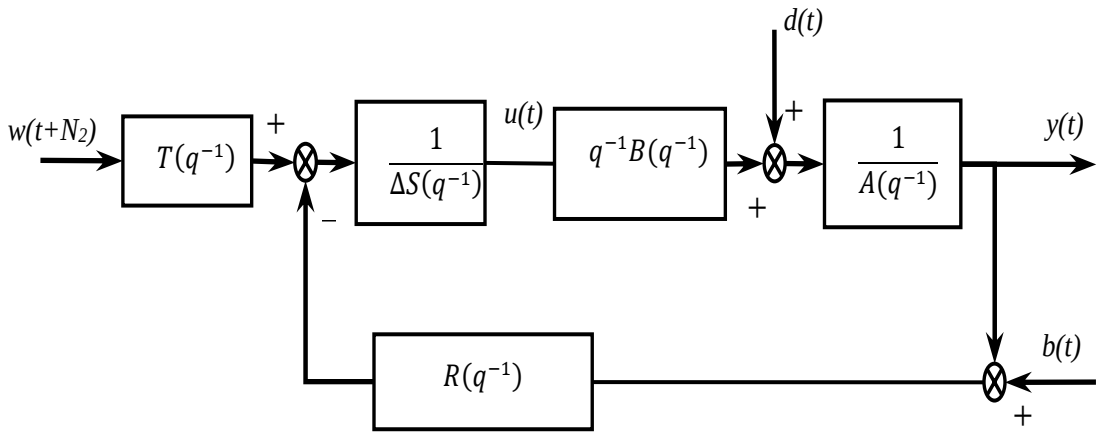

Fig. 2. GPC Equivalent polynomial RST controller

So, three GPC-RST controllers will be synthetized, one for the outer speed control loop denoted (GPC speed) and a pair for the inner current loops denoted (GPC current).

Assuming the design of the initial GPC speed controller has been performed with R_0, S_0, T_0 and N_1, N_2, N_u, λ are tuned to satisfy certain closed loop performance. We notice in the Fig. 1, that the GPC speed controller does not have output magnitude limiter, and therefore, the reference of the electromagnetic torque C_{em}^* , subsequently the current command i_{qs}^* can take values relatively large in transient regimes, especially, in high speed profiles, and, as a consequence, the system drive can be damaged by the large control action. The main goal of this work is to avoid the over values of the currents without incorporating a limiter at the output and without losing the close loop performance obtained by the initial GPC speed controller. It will be carried out by retuning the initial controller based on Youla parametrization. the resulting controller must respect the prescribed limits.

3. RETUNED GPC SPEED USING YOULA PARAMETERIZATION

According to the work presented in [6], The Youla parameterization of the initial GPC speed controller (R_0, S_0, T_0) leads to the following stabilizing polynomials:

$$\begin{cases} T(q^{-1}) = T_0(q^{-1}) - A_0(q^{-1})Q_2(q^{-1}) \\ R(q^{-1}) = R_0(q^{-1}) + \Delta A(q^{-1})Q_1(q^{-1}) \\ S(q^{-1}) = S_0(q^{-1}) - q^{-1}B(q^{-1})Q_1(q^{-1}) \end{cases} \quad (9)$$

where $Q_1$and $Q_2$are stable transfer functions. The corresponding block diagram is shown in *fig. 3.*

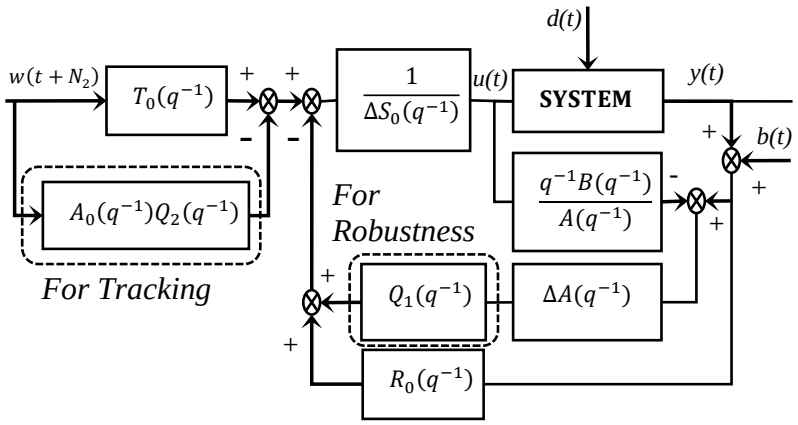

Fig. 3 GPC RST controller with Youla parameterization

From the diagram of the *Fig.3*, we can conclude that the parameter Q_1 modifies the closed loop features preserving the input-output transfer unchanged, whereas the parameter Q_2 modifies only the input-output transfer function [18]. In the following we set $Q_1$to zero since the closed loop performance is fulfilled by the initial controller design, then Q_2 will be used to retune this initial controller modifying the input-output behavior in order to prevent the undesired high control signal at the output of the GPC speed controller.

Q_2 is designed to satisfy two types of specifications: time-domain and frequency specifications. Where the signals *w, y,* and *u* are correspond receptively to the speed reference Ω^*, measured speed Ω , and the current command i_{qs}^*.

3.1. Time-domain specifications

Starting from the *Fig. 3*, let define the close loop transfer function between the input reference *w* and the output *y:*

$$H_{yw} = \frac{y}{w} = \frac{T_o q^{-1} B}{A_o A_c} - \frac{q^{-1} A_o B}{A_o A_c} Q_2 \tag{10}$$

$A_o A_c = \Delta A S_0 + q^{-1} B R_0$ represent the closed loop characteristic polynomial partitioned into an observer polynomial A_o and a control polynomial A_c.

Let *s*(*t*) be the step response of H_{yw} to the input reference *w*(*t*). The main objective of the retuned controller is to make *s*(*t*) constrained inside in an imposed template. This template is chosen according to some requirements on the set point response signal. The template is specified by the minimal amplitude $s_{min}(t)$ and maximal amplitude $s_{max}(t)$. Hence, the set of all Q_2 parameters that satisfy this constraint is:

$$C_{env} = \{Q_2 \,/\, \Phi_{env}(Q_2) \leq 0\} \tag{11}$$

with:

$$\Phi_{env}(Q_2) = \max\left(\max_{t\geq 0}\left(s(t) - s_{max}(t), s_{min}(t) - s(t)\right)\right) \tag{12}$$

The time-domain specifications are convex in Q_2 [9] because there is a linear dependency between the transfer function H_{yw} and the Youla parameter Q_2 as given in equation (10).

3.2. Frequency specifications

Let H_{uw} be the transfer function between the input reference *w* and the control signal *u*:

$$H_{uw} = \frac{u}{w} = \frac{T_0 A}{A_o A_c} - \frac{A A_o}{A_o A_c} Q_2 \tag{13}$$

The frequency specifications lie in the minimization of the effort control in transient response, these specifications are also convex in Q_2. This is carried out by minimizing an H_∞ norm of the transfer function H_{uw} weighted by a transfer function W.

In the steady state, the output *y* must equal the reference *w*. To ensure that, it is necessary to validate the following relation:

$$\frac{y}{w} = \frac{T_0 q^{-1} B}{A_o A_c} - \frac{q^{-1} B}{A_c} Q_2 \Big|_{q=1} = 1 \tag{14}$$

It is thus necessary that $Q_2 = 0$ for $q = 1$. This can be obtained simply by forcing in Q_2 a term $\Delta = 1 - q^{-1}$ in the numerator:

$$Q_2 = \Delta . Q_2' \tag{15}$$

Finally, the Q_2 design is achieved by a H_∞ norm minimization of the transfer control/set-point under constraints imposed by the time-domain specifications (11):

$$\min_{\substack{Q_2' \epsilon \mathcal{RH}_\infty \\ \Phi_{env}(Q_2) < 0}} \left\| \left(\frac{T_0 A}{A_c} - \frac{A \Delta}{A_c} Q_2' \right) W \right\|_\infty \tag{16}$$

Where RH_∞ is the space of all stable and proper transfer functions. This convex optimization problem leads to a Q_2 parameter varying in an infinite dimensional space. A sub-optimal solution of this optimization problem is obtained by considering a finite dimensional sub-space generated by an orthonormal base of discrete stable transfer functions such as a polynomial or FIR (Finite Impulse Response) filter. In this manner, the time-domain constraints and the H_∞ norm minimization can be approximated by a minimization under linear inequality constraints [6].

4. SIMULATION TESTS

In the next, the retuned GPC predictive controller has been applied on the induction motor drive. The induction machine is a squirrel-cage type of 1.1kW and 1500 rpm.

As a first step, three initial GPC controllers have been designed, one for the outer speed control loop (GPC speed) and two for the inner current loops (GPC current) *fig. 1*. The inner system is sampled at $T_i = 0.05\text{ms}$, and the outer system is sampled at $T_s = 1\text{ms}$. According to the rules given in [8], the following tuning parameters are selected:

$$N_1 = 1\ , N_2 = 30\ , N_u = 1 \text{ for the speed loop;}$$

$$N_1 = 1\ , N_2 = 5\ , N_u = 1 \text{ for the current loop.}$$

Using the simplified model (4), the simulation shows that the GPC speed controller gives a fast tracking response but the control action is very high (reaches about 400% for the nominal value), which is unacceptable in electrical drives. This inconvenient justifies to redesign the initial controller in order to make it able to reduce the control action in the transient response. For that purpose, minimization problem (16) must be solved considering, as temporal specifications, a time domain template for which the system preserves the time response obtained with the initial controller. We chose $N_t = 200$ the number of points of the temporal response taken into account by the template (i.e. horizon of *0.2s*). In order to give more weigh to high frequencies, a high pass filter is chosen as weighting fundion:

$$W = \frac{1-0.8q^{-1}}{0.2} \tag{17}$$

The research of the Q_2 parameter has been accomplished with *180* points for the transfer norm calculus and with *100*-order polynomial. The resulting polynomial is then approximated by a transfer function [10].

Fig. 4 shows the step response of the simplified model connected to both the initial and modified controller and it also shows the template which must be respected.

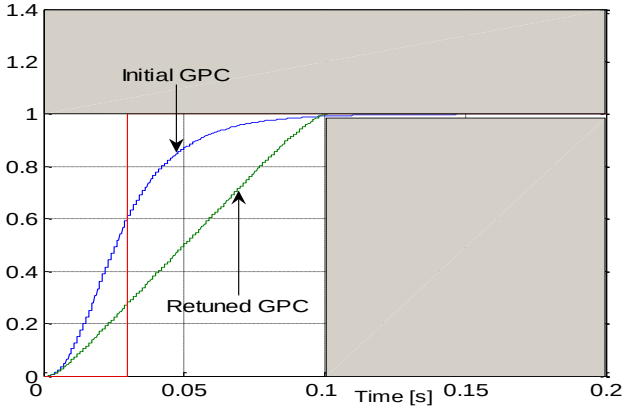

Fig. 4 Step response and time domain template

The temporal response to a step input and to the perturbation at *0.2s* is shown in *fig. 5*. And *fig. 6* depicts the control signal where the results obtained with the initial controller are superimposed in comparison. We note that the dynamic of the disturbance rejection remains unchanged. In addition, the transitory command is reduced and the dynamics of the input/output behavior respects the imposed template.

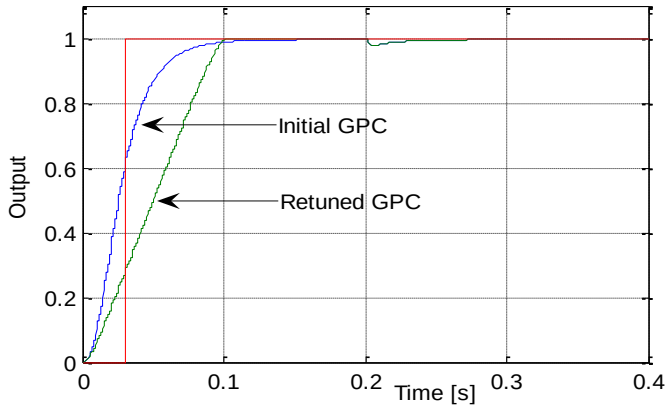

Fig. 5 Temporal response of the system connected to the initial and retuned GPC

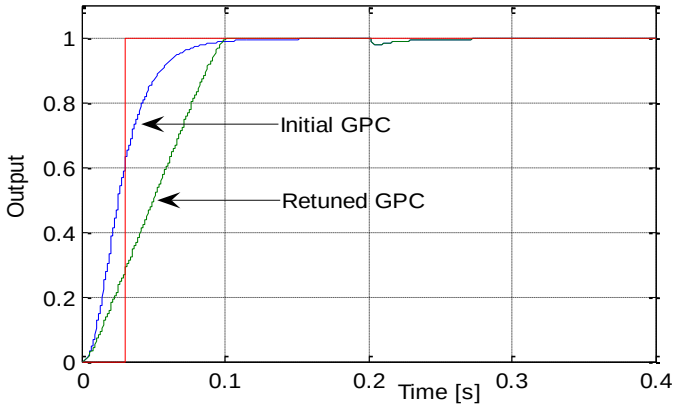

Fig. 6 Control signal of the system connected to the initial and retuned GPC

Now, let's examine this procedure on the complete drive system shown in *fig 1* under various situations. The drive system parameters are given in the Appendix. A rectangular form of motor speed set-point is chosen. Initially, the motor operates under unload conditions with a speed rotor equals *150 rd/s*. Between $t = 0.3s$ and $t = 0.8s$, in order to examine the impact of the load condition the load torque is stepped to *5 Nm*. The speed is reversed from*150 rd/s* at *1s* to *-150 rd/s* at *2s.* After that, the motor is stopped.

Figure 7 illustrates the rotor speed and *figure 8* depicts the quadratic component of the stator current i_{qs} that represents the control signal. It is easier to see that i_{qs} is minimized in the transient response thanks to the retuned GPC regulator, while this controller preserves the same time response of the system with zero steady-state error. Moreover, it has no effects on the disturbance rejection dynamic obtained by the initial GPC controller. These results prove that

the proposed design is efficient compared the conventional methods with anti-windup scheme that use a limiter in the output of the controller with compensators.

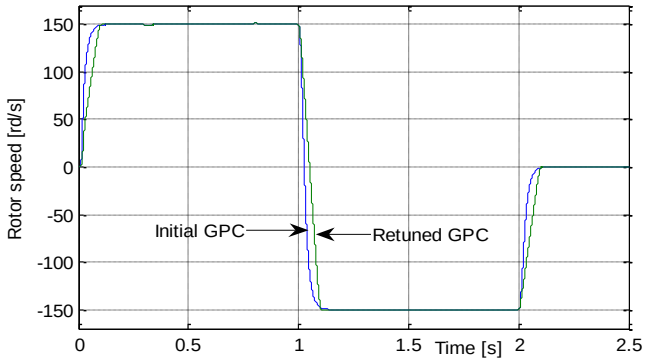

Fig. 7 Rotor speed of the induction motor drive

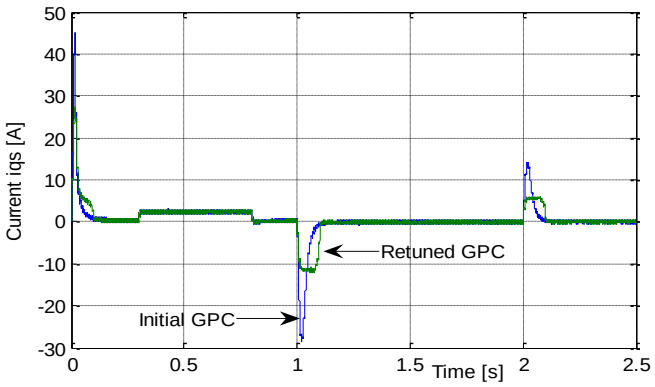

Fig. 8 quadratic component of stator current i_{qs}

5. CONCLUSION

This paper has stated the effect of the high transient current control of an induction machine generated by a GPC speed controller caused by the fast and large step change in the speed reference. For that, three generalized predictive controllers are used to drive the machine, two inner ones to control the currents and an outer one to control the speed. Then, by means of the Youla parameterization, the outer controller has been retuned such that both time-domain and frequency constraints are satisfied. These constraints are formulated as a convex linear optimization framework. We conclude that the resulting controller has two advantages. Firstly, it can minimize the current command in the transitory response, and secondly, it keeps the time response of the system obtained before the modification without changing the closed loop behavior. These results are validated by simulations.

Appendix (*Motor parameters)*:

1.1 kW, 1500 rpm, 220/380 V, 3.5 A, 1.14 Wb, 7 Nm,

$R_s = 8.1\ \Omega,\ R_r = 3.2\ \Omega, L_s = L_r = 0.48\ H, L_m = 0.46\ H, J = 0.006 Kg.m^2$

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AN IoT BASED SMART HOME APPLIANCES SCHEDULING MANAGEMENT SYSTEM

Md Murshadul **HOQUE**, Mithun **CHAKRABORTY**, Joy **RUDRA**, Md Arif Iftekhar **MAHMOOD**

Department of Electrical and Electronic Engineering, University of Chittagong, 4331 Chittagong, Bangladesh,

m.hoque@cu.ac.bd

Keywords: Smart scheduling, demand response, time of use, home energy management, IoT, home appliances.

Abstract*: This paper proposes a smart home appliance scheduling management (HASM) system based on demand response. An IoT based HASM system is developed to provide an efficient electricity consumption scheme to residential consumers for scheduling their appliances in a cost-effective way and smartly throughout a day. This smart load scheduler takes residential electricity users' preferences to shift the appliances with deferrable characteristics at cost effective periods considering the user is aware of dynamic tariff information. The user interaction to the scheduling of loads provides maximum comfort level as well as saving of total electricity bill, and the effective utilization of demand response strategies to reduce peak hour electricity consumption. The results of this development indicate a reduction of daily energy consumption confirming the consumer comfort.*

1. INTRODUCTION

The demand of electricity is increasing day by day with our standard of living. The production of electricity cannot keep the pace with the ever-increasing demand of electricity. As fossil fuels' demand increases, they are becoming scares and are responsible for emission of various greenhouse gases. Researchers investigate new research areas such as integration of renewable energy, discovering new energy sources and energy saving programs by encouraging customers through demand side management (DSM) and demand response (DR)

programs in order to meet the ever-increasing energy demand. Utilities participate in DSM programs to improve power system stability where end users participate in DR programs to minimize their electricity bills [1,2].

The DR program is defined as variations in electricity usage of end-use customers from their regular consumption patterns in accordance with variations in electricity price. DR-based load shifting is helpful in reducing the electricity cost of end users, at the cost of user comfort. Similarly, the utility-based direct load control technique improves power system stability [1], while disturbing user comfort. Thus, both cost reduction and comfort maximization cannot be achieved at the same time. Previous research highlighted that the use of DR is essential to improve home energy management system (HEMS) in the domestic sector [2]. For efficient HEMS system with DR, a variety of consumer electronic devices must be controlled using the internet and the home network for remote management so as to reduce peak demand that may lead to reduce risk of outages at transmission and distribution networks [3-5]. The operation of the home appliances schedule was proposed according to the ever-changing real time prices and the tariff rate-based DR program [6,7]. The dynamic pricing is a method of DSM, which could be a very important factor for including electricity consumers to reduce their energy consumption. This strategy also provides opportunities to customers to reduce their monthly electricity bill. The peak load reduction is considered an immediate outcome of using variable electricity prices. A number of dynamic pricing strategies, such as Real time pricing (RTP), Time of use (TOU) pricing, Critical peak pricing (CPP), Critical peak rebate (CPR) and so on [8,9].

The most popular one for the residential electricity user and the electricity distributor is TOU pricing [10]. In the country like Bangladesh, the electricity distributor companies do not practice with such pricing techniques. As the demand for electricity rises, the price increases, and as it decreases, so does the price. So, using the various appliances with high power rating increases the peak hour electricity demand as well as electricity bill. Shifting these appliances at the non-peak hour helps to reduce both the problems but it affects the user's comfort. Achieving the reduction in peak hour electricity demand as well as electricity bill with maximum user comfort level became one of the major challenges in the scheduling of the appliances.

In this proposed development the standard TOU pricing system is considered [10]. The proposed IoT based smart load scheduler takes residential electricity users' preferences to shift the appliances with deferrable characteristics at cost effective periods considering the user is aware of dynamic tariff information. The user interaction to the scheduling of loads provides maximum comfort level as well as saving of total electricity bill, and the effective utilization of demand response strategies to reduce peak hour electricity consumption. It is more flexible, compatible and adjustable to any home applications.

The rest of this paper is organized as follows. In Section 2, we introduce the system overview of our proposed system. Section 3 covers the procedure of system design and mobile

application development for HASM. In Section 4, the description of operational flow, the IoT based implementation in mobile app and the implementation of DR program with TOU pricing information are presented. In Section 5, the results of DR analysis are illustrated and discussed. Finally, we conclude this paper in conclusion section.

2. SYSTEM OVERVIEW

The proposed HASM system basically consists of a mobile application, communication device, appliance scheduling operation controller and the appliances that are needed to be scheduled. The block diagram of the HASM system is illustrated in *figure 1*. The system is designed in such a way that a user can set his household appliances to a certain period of time at Off-Peak hours using the home appliances scheduling mobile application. The mobile app is connected to a database where all the user preferences are stored. The controller consists of Arduino, relay board and nodeMCU ESP8266. The nodeMCU ESP8266 allows the controller to be connected to internet through a communication device such as router so that it can receive the scheduling information from database and operates accordingly [9]. Appliances to be scheduled have the following characteristics: 1) high power rating, 2) user interaction no longer required during their operations, 3) can be operated at any time throughout a day and 4) does not affect the user comfort.

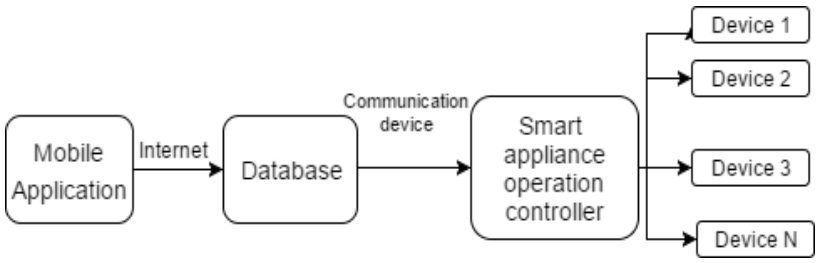

Fig. 1. System Overview of HASM System

3. DESCRIPTION OF DESIGN

This section describes the designing of the HASM System, which can be divided into two parts such as system design and HASM Mobile app development.

3.1. HASM system design

The system design of the HASM system involves using a microcontroller and interfacing the system with appliances or loads through relays as the block diagram is shown

in *figure 2.* The smart appliance scheduling operation control overview is also found in *figure 2*. The commands to the microcontroller are given through a nodeMCU module. The description of hardware used in this development are given below.

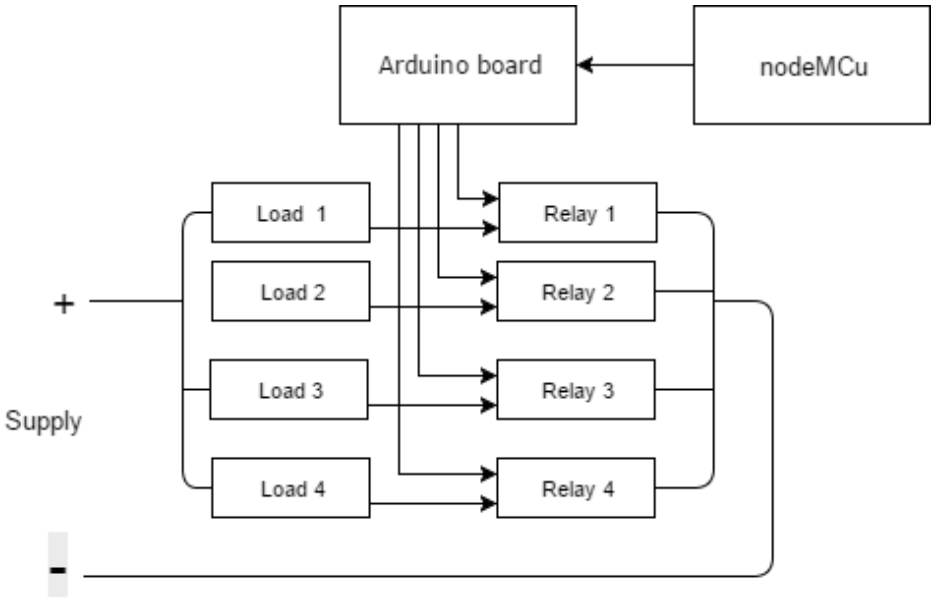

Fig. 2. Block Diagram of the Appliance Operation Controller

3.1.1. Arduino Board

Arduino shown in *figure 3* is an important component of the smart controller. It is connected to the nodeMCU and relay board. Arduino takes inputs through nodeMCU and operates the relay switches. The switching operations of HASM system are performed by Arduino [11].

3.1.2. Relay

The relays are used to accomplish switching opearation of the load connected to the controller as in *figure 3*. It is an electromechanical switch that turns from its normally closed position to its normally open position when the coil of the relay is excited by a voltage.

3.1.3. NodeMCU ESP8266 Wi-Fi Module

NodeMCU ESP8266 Wi-Fi module plays a vital role in this developed system. An ESP8266 Module receives commands from mobile application wirelessly through the internet (see in *figure 3*). According to the commands the home appliances are scheduled based on the proposed control algorithm.

3.1.4. Circuit Diagram of HASM

The HASM controller is designed to perform the load scheduling automatically. It includes a power supply unit, a controller, relays, Wi-Fi module and driving part as shown in

figures 2 and *3*. All parts including smart controller are powered by the power supply unit so that it can operate independently. A DC current supply is required to the digital parts such as a microprocessor. The driving part is connected inside the electric load of the home through the relay circuit. *Figure 4* shows the pin connections of the HASM controller.

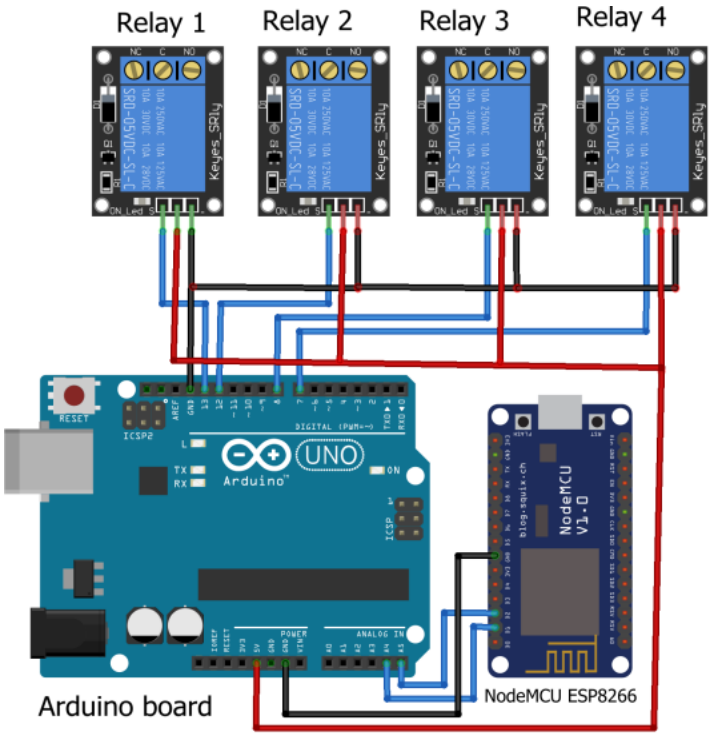

Fig. 3. Pin connections of HASM Controller

3.2. HASM mobile application development

The major part of this system is the appliance scheduler application, which is developed using Android studio. Android Studio is the official Integrated Development Environment (IDE) for Android application (app) development, based on IntelliJ IDEA [9,12]. The application designed has the options to schedule the household appliances and set their duration of operation of the particular appliance. This application acts as user interface (UI) of the Home energy management system. *Figure 4* shows the layout of HASM system in mobile app. User has provision to make a preferable schedule by using the HASM mobile app by giving a starting time, off time and the duration of operation for particular appliances. The app is designed in such a way that it sends the 'duration' information given by user only when the mobile operating system time matches with the 'starting time' of any particular appliances in the HASM app. The database receives the information and holds it till the 'off time' matches with the system time.

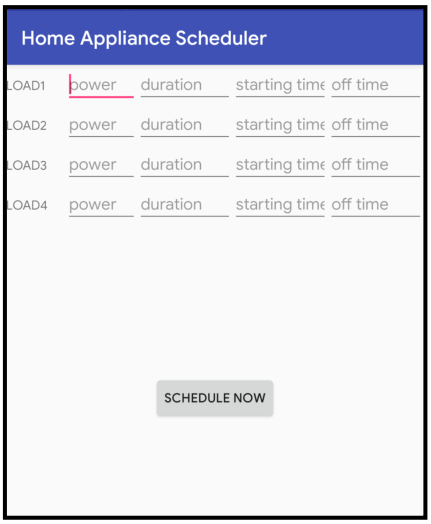

Fig. 4. HASM App Layout

4. SYSTEM OPERATION AND IMPLEMENTATION

The working flowchart for the overall HASM system is shown in *figure 5* where the input is taken by the mobile app. The app checks the operating system time (T.sys). The app sends the duration information to the database when T.sys matches with the start time (T.start) set by user. The nodeMCU continuously checks the database for appliances operation information. When information arrives at database the nodeMCU sends the information to Arduino. Arduino process the information and turn on the appropriate relay till the duration value exceeds.

In the proposed system, for DR program, TOU pricing information is used as presented in Table 1. The demand periods are considered according to daily load profile of residential house in Bangladesh. The typical daily load profile for a residential household is used in this implementation as depicted in *figure 6* [13]. A total day is divided in four demand periods to matches with the pricing technique provided where varying TOU rates according to the demand is considered. During the evenings, on weekends and on holidays the demand is low where the loads are powered as a baseload from sources like large hydroelectric stations and nuclear generators. As daytime begins, more people turn on their lights and appliances, and businesses ramp up their operations for the workday. The demand becomes high that to be scheduled smartly by using this proposed system.

Table 1. TOU pricing information

Periods	**Demand Load**	**Pricing Information ($/kW)**
7 AM – 10 AM	On-Peak	0.132
10 AM – 5 PM	Mid-Peak	0.094
5 PM – 11 PM	On-Peak	0.132
11 PM – 7 AM	Off-Peak	0.065

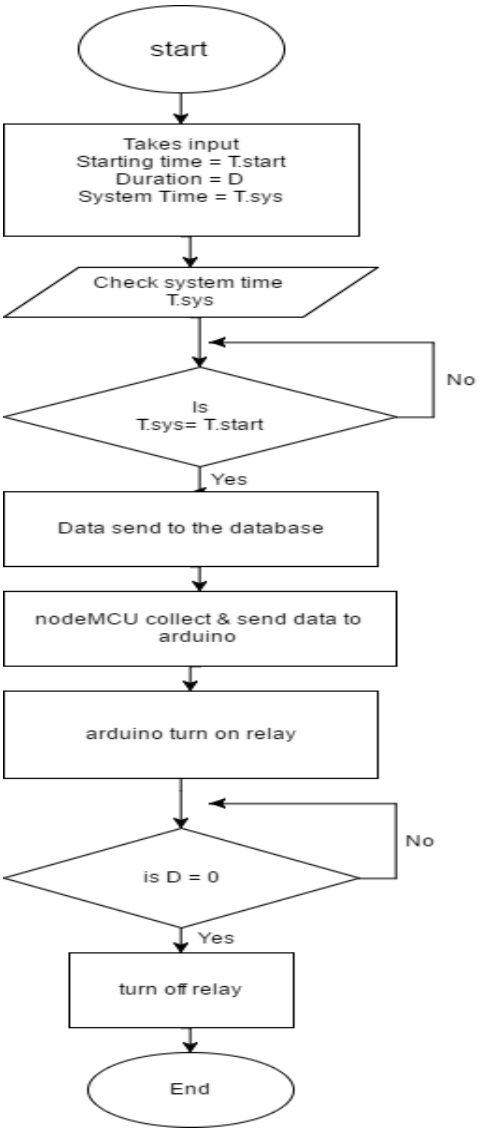

Fig. 5. Flowchart of HASM algorithm

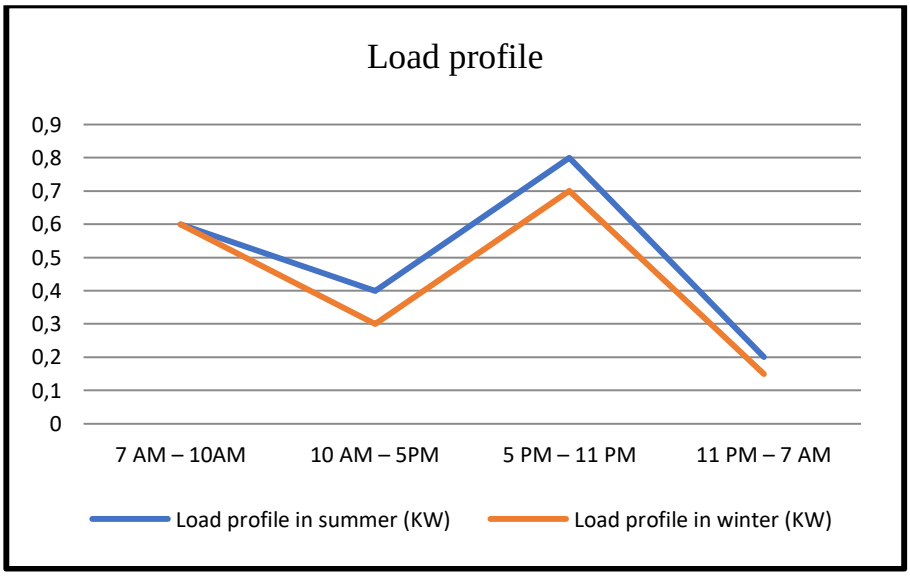

Fig. 6. Typical daily load profile

5. RESULTS AND DISCUSSIONS

The results of the proposed development are given in this section that includes the results of data transfer from the HASM app to database, DR analysis and the results obtained from scheduling appliances at low tariff periods by using HASM system.

5.1. Data transfer

The Data consists of duration information of scheduled appliances are transferred to the database through internet. The HASM app and HASM controller are connected to internet. From *figure 7* it can be seen that a user scheduled multiple appliances at 1:30 (GST) (Off-Peak period). When mobile system operating time matches with the starting time 1:30 (GST) the HASM mobile application send a signal to the database. Database receives the information as shown in *figure 8*. This information is then sent through nodeMCU Wi-Fi module connected to the Arduino board and processed into control signal to turn on the relay connected to the appliances and turn off the relay when the time duration exceeds for scheduling operation of that particular appliance.

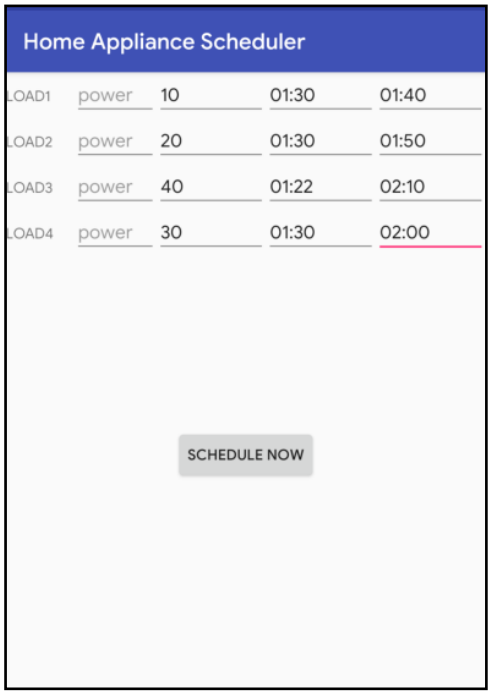

Fig. 7. Home appliances scheduling

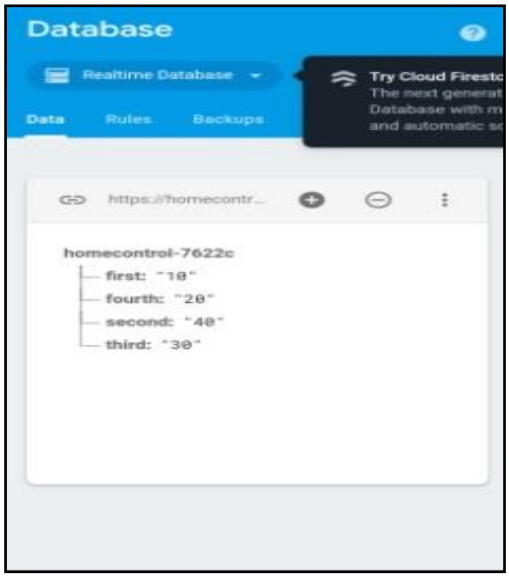

Fig. 8. Database with the duration information

5.2. DR Analysis

The DR analysis consists of typical and scheduled load profile verses TOU pricing system of Table 1 which is applied to develop the algorithm for the shifting of appliances. Table 2 shows typical electricity usage pattern of household appliances of high-power ratings. The data are obtained from a survey on electricity usage pattern of household appliances on 40 dwellings. Based on the proposed algorithm the typical load pattern is shifted from On-Peak to Off-Peak or somewhat Mid-Peak to Off-Peak and load distribution among the periods is accomplished accordingly. The scheduling is configured maintaining consumer comfort and balanced distribution. Table 3 shows usage pattern of appliances after scheduling the deferrable appliances at the Off-Peak period based on demand response.

Table 2. A typical usage pattern of household appliances

Appliances	**Periods**			
	7 AM – 10AM	10 AM – 5PM	5 PM – 11 PM	11 PM – 7 AM
	On-Peak	Mid-Peak	On-Peak	Off-Peak
Water Pump 750 W	-	-	(2 hr) 1500 Whr	-
Iron 1200 W	(1 hr) 1200 Whr	-	-	-
Washing Machine 800 W	(2 hr) 1600 Whr	-	-	-
Fridge 180 W	(2.5 hr) 450 Whr	(5.8 hr) 1044 Whr	(5 hr) 900 Whr	(6.6 hr) 1188 Whr
TV	(1 hr)	(3 hr)	(4 hr)	-

90 W	90 Whr	270 Whr	360 Whr	
Desktop PC 200W	(1 hr) 200 Whr	-	(3 hr) 600 Whr	-
Oven 1000W	(15 min) 250 Whr	-	-	-
Lights (8x 22W) 176W	88 Whr	50 Whr	1056 Whr	50 Whr
Total	3.88 kWhr	1.36 kWhr	4.42 kWhr	1.24 kWhr

Table 3. A scheduled usage pattern of appliances

Appliances	**Periods**			
	7 AM – 10AM	10 AM – 5PM	5 PM – 11 PM	11 PM – 7 AM
	On-Peak	Mid-Peak	On-Peak	Off-Peak
Water Pump 750W				(2 hr) 1500 Whr
Iron 1200 W	(1 hr) 1200 Whr			
Washing Machine 800 W		(2 hr) 1600 Whr		
Fridge 180 W	(2.5 hr) 450 Whr	(5.8 hr) 1044 Whr	(5 hr) 900 Whr	(6.6 hr) 1188 Whr
TV 90 W	(1 hr) 90 Whr	(3 hr) 270 Whr	(4 hr) 360 Whr	
Desktop PC 200W	(1 hr) 200 Whr		(3 hr) 600 Whr	
Oven 1000W	(15 min) 250 Whr			
Lights (8x 22W) 176W	88 Whr	50 Whr	1056 Whr	50 Whr
Total	2.3 kWhr	2.96 kWhr	2.92 kWhr	2.74 kWhr

Scheduling of deferrable appliances at Off-Peak period reduces the On-Peak electricity demand which can be seen from the load profile comparison in *figure 9*.

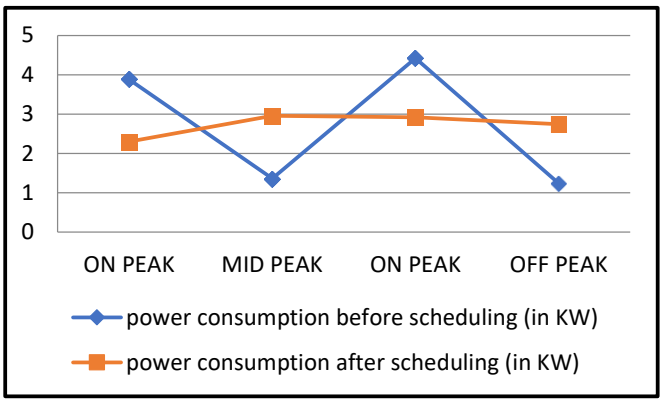

Fig. 9. Load comparison profile per period

As the electricity consumption is shifted, the electricity usage bill according to the periods reduces significantly as illustrated in *figure 10*. When the deferrable appliances are shifted from their typical using periods to the off-peak period significant reduction in electricity usage bill can be observed in *figure 11*. The shifting of appliances reduces the demand of electricity at the On-Peak period significantly as the analysis presented in *figure 12*. Thus, it is shown that the proposed HAMS system has a good home appliances management capability smartly with efficient utilization of energy and significant reduction of electricity bills.

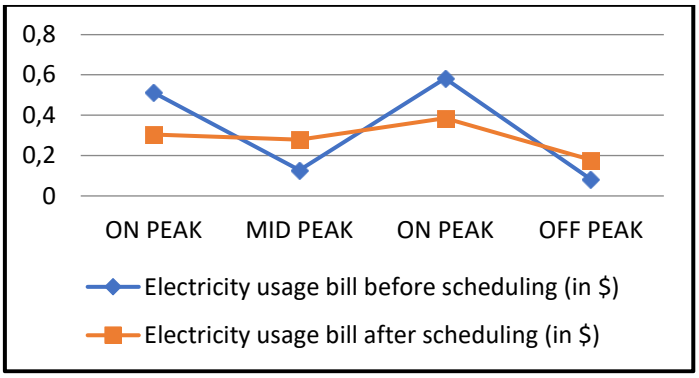

Fig. 10. Electricity usage bill comparison per period

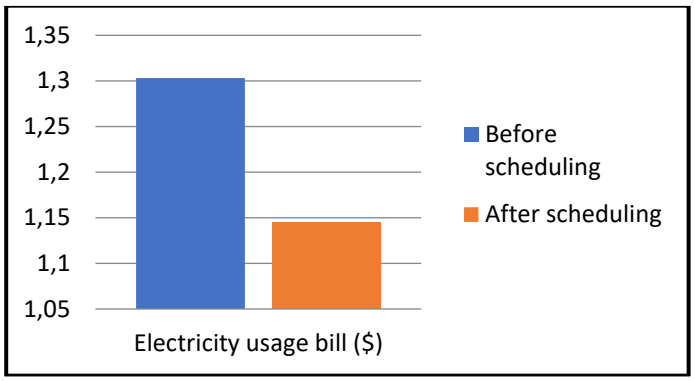

Fig. 11. Total electricity usage bill comparison for a day

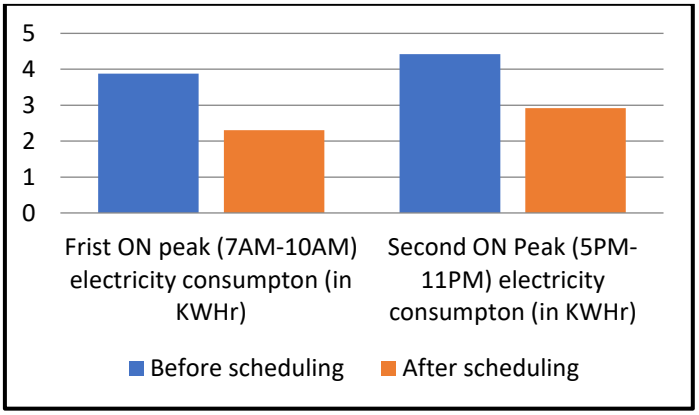

Fig. 12. Peak-hour electricity demand reduction

6. CONCLUSION

A smart home appliance scheduling management system based on IoT for residential household appliances is proposed in this paper. Dynamic pricing system TOU is discussed and used from Bangladesh perspective for obtaining DR analysis. The proposed HASM system is implemented in mobile app based IoT control platform that operates by receiving a user's input through the home appliance scheduling application and schedules the appliances at the preferred time. The scheduling operation and demand response analysis results show that this developed system is capable to reduce On-Peak period electricity demand and electricity usage bill. It is a very convenient and economical solution for home energy management keeping the household user comfort level high. This system can be modified to manage loads with larger ratings.

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THE ENERGY ASSESMENT OF THE BUILDING SERVICES FACULTY OF CLUJ-NAPOCA

Calin **CIUGUDEANU**
Lighting Engineering Laboratory, Technical University of Cluj-Napoca, Romania
calin.ciugudeanu@insta.utcluj.ro

Keywords: energy consumption, energy efficiency, LED lamps, sustainable lighting, green buildings.

Abstract*: Lighting Engineering Laboratory – LEL - is one of the major lighting independent consultants in the north-west side of Romania. The laboratory is affiliated to the Building Services Faculty of the Technical University of Cluj-Napoca. Over the past few years, the Lighting Engineering Laboratory carefully mapped the university's energy use. To estimate the actual level of energy efficiency at our faculty we compared previous consumption data to obtain the trends of energy consumption. The paper presents the energy consumptions recorded for the Building Services Faculty of Cluj-Napoca. This should be the very first step to achieve the most appropriate energy efficiency solutions for the university's buildings. Some lighting refurbishments were also tested as case studies. A new design for an active educational building that will produce more energy that it consumes - was proposed. The present paper tries to determine the detailed aspects of the building energy consumption, proposing at the same time some energy efficiency solutions economically viable for the most educational buildings in the Eastern Europe.*

1. INTRODUCTION

The European Commission released in 14.07.2021 a proposal for a Directive of the European Parliament and of the Council on Energy Efficiency (recast). With the adoption of the European Green Deal in December 2019, the Commission set out "a new growth strategy that aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in

2050 and where economic growth is decoupled from resource use [1]. In March 2020, the Commission tabled a proposal for a European Climate Law to decarbonize Europe by 2050.

In its Climate Target Plan (CTP) [2], the Commission proposed to raise the Union's ambition on reducing greenhouse gas emissions to at least 55% below 1990 levels by 2030, which is a substantial increase compared to the existing 40% target.

Energy efficiency is a key area of action, without which the full decarbonization of the Union economy cannot be achieved [3]. The Energy Efficiency Directive has led to the Union's current energy efficiency policy to capture the cost-effective energy saving opportunities. In December 2018, the Energy Efficiency Directive was amended as part of the 'Clean Energy for All Europeans package', in particular to include a new headline 2030 Union energy efficiency target of at least 32,5% (compared to projected energy use in 2030), and to extend and strengthen the energy savings obligation beyond 2020.

In the same context Romania adopted in April 2020 the Integrated National Plan for Energy and Climate Change 2021-2030. The main energy and climate targets for the year 2030, are as follows [4]:

- Target on reducing domestic greenhouse gas emissions by at least 40% by 2030 compared to 1990;
- The target for renewable energy consumption of 32% in 2030;
- The target for improving energy efficiency by 32.5% in 2030;
- The objective of interconnecting the electricity market at a level of 15% up to 2030.

Therefore, Romania targets a primary energy consumption of 32.3 Mtoe, respectively one final energy consumption of 25.7 Mtoe, thus obtaining energy savings of 45.1%, compared to the primary consumption for 2030, respectively 40.4% for final consumption compared to the PRIMES 2007 baseline scenario.

For the educational buildings, the Romanian Integrated National Plan for Energy and Climate Change 2021-2030 reveal the next scenario – Table 1.

Table 1. Detailed refurbishment scenario – educational buildings

Building type	Total Surface	Buildings	Investment	Energy reduction	CO_2 reduction
	[MM sq m]	[No]	[MM EUR]	[MM toe]	[MM t]
Education	4.24	4361	874.84	0.03	0.14

For the total number of 4361 of educational Buildings in Romania the proposed refurbishment scenario leads to a total 0.03 MM toe energy reduction and 0.14 [MM t CO_2].

2. UNIVERSITY ENERGY CONSUMPTION

The Technical University of Cluj-Napoca (UTC-N) financed for the year 2012-2013 - [5] and 2014 - [6] an internal lighting efficiency project aiming to determine the actual energy consumption of the university buildings as well as to identify the best techno-economical energy efficiency lighting solution.

A detailed measurement of the current consumption of the Faculty of Building Services – UTC-N, with a total area of 4775.98 sq. m was performed. The electricity and natural gas bills for the year 2012 were analyzed - Table 2.

Table 2. Current annual energy consumption 2012 – UTC-N – Faculty of Building Services

Building Services Energy Consumption 4776 sq. m				
	[euro/month]	[euro/year]	[kWh/month]	[kWh/year]
ELECTRIC CONSUMPTION 0.155 [euro/kWh]	1 064	12 770	6 865	82 385
NATURAL GAS CONSUMPTION 0.0382 [euro/kWh]	1 752	21 020	45 856	550 262
TOTAL	**2 816**	**33 790**	**52 721**	**632 647**

A total energy (electrical and natural gas) consumption of 132.46 [kWh / (sq. m*year)] was identified for the year 2012, based on the utility bills [7].

The main energy consumers of the building can be spited in two main categories, using: electricity or natural gas. The heating central system is the only gas consumer. Meanwhile electricity is used for - lighting, general use sockets, air ventilation / cooling systems. The building is geared with HVAC installations for just two rooms and the main building 300 persons amphitheater. Even if the AC installations are main electricity users – their share in the general electricity consumption is very small due to the university reduced activity during summer. The main consumers are the old conventional T8 fluorescent luminaires. Unfortunately, the old electric installations didn’t give us the opportunity to individually monitor the lighting vs socket electricity consumption.

In the last years LEL installed different lighting retrofit solutions. The starting point was in 2013 - the lighting refurbishment success of the greatest lecture hall by replacing the old 4*18 W fluorescent luminaires by new LED ones and a new DALI lighting control system, get 70% savings in lighting electricity consumption. For 2014 the hallways existing 2*36 W fluorescent luminaires were geared with electronic ballasts and motion sensors. In the same year the faculty outdoor lighting LED system controlled by daylight/time sensors was installed. In 2015 the classic fluorescent recessed 4*18 W fluorescent luminaires were

retrofitted using 4*14.4 W LED modules. The overall luminous efficacy of the retrofitted luminaires was around 55 lm/W. In the last year a new emergency lighting system powered from a smart central battery unit was installed. In another class 2*36 W fluorescent lighting system was completely replaced with 37 W LEDs and a modern PLC dimmable control system able to maintain a certain user defined lighting level on the desk working area. In 2020 two main lighting manufacturers equipped experimentally tow student classrooms with the state-of-the-art lighting equipment's.

The electricity consumption of the building was evaluated based on the readings recorded by an electronic meter. The hourly readings were recorded over a period of 3 years, namely 2014, 2015 and 2016 [8]. The total annual consumption was different over the years. Due to the installation of a new cooling system in the faculty main amphitheater an increase of 11237 kWh/year, from 82375 kWh/year in 2012 to 93612 kWh/year.

Afterwards, a decrease from 93612 kWh/year in 2014 to 86190 kWh/year in 2015 and 68901 kWh/year in 2016 was recorded (*fig. 1*), due to the new LED lighting system installed, which meant a general reduction of more than 25%, from 2014 to 2016.

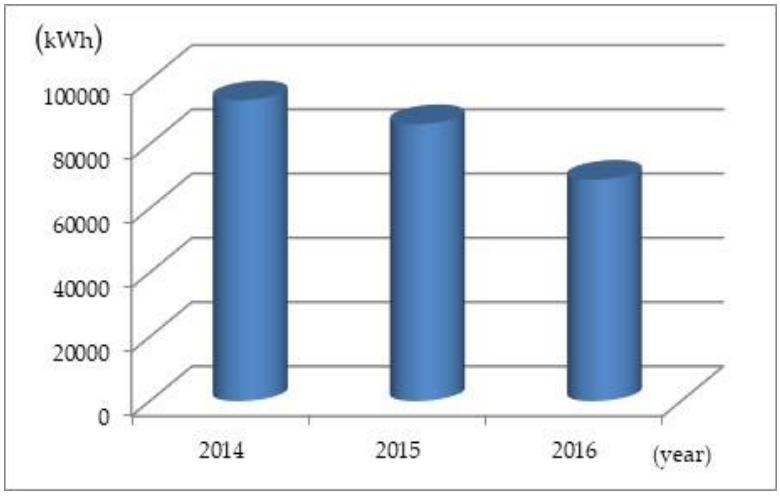

Fig.1. UTC-N Faculty of Building Services yearly electricity consumptions

The recorded monthly average electricity consumption is detailed in Table III. Mainly the 2015 values are lower than the values recorded in 2014. The reason for this might be the energy efficiency lighting retrofits implemented for some classrooms. The existing fluorescent T8 luminaires were replaced by LED luminaires / sources. The exception from May to July are not relevant while the university auditorium is also used by other faculties from the Technical University of Cluj-Napoca, so the running ours are different from one year to another. Also, in those months the installed chiller is used for cooling the amphitheater indoor air.

Using the university adopted lighting retrofit solutions as case studies, circular economy aspects were identified [9]. For a LED retrofitted recessed luminaire T8 4 × 18 W,

the previous study [10], showed a major reduction of the installed power, a correct lighting distribution, but also revealed some issues: lack of certification of the retrofit luminaire, necessity of qualified personnel, high workforce costs, etc.

A consumption pattern was also identified for the year 2014 electrical consumption. *Figure 2* shows the daily electricity consumption in the first eight months of the year 2014. The graph shows the consumption variations after classes/semesters. All the measurements were made in the same day of the week (Thursday) in order to compare theoretically the same class schedule. For the first four months, the electricity consumption is higher (over 20 kWh) from 6.00 AM to noon. For the next three months, the electricity consumption is more constant during the day (over 10 kWh) from 6.00 AM to 2.00 PM. August readings show constantly low electricity consumption (3 kWh) for the holydays, when usually the university building is close.

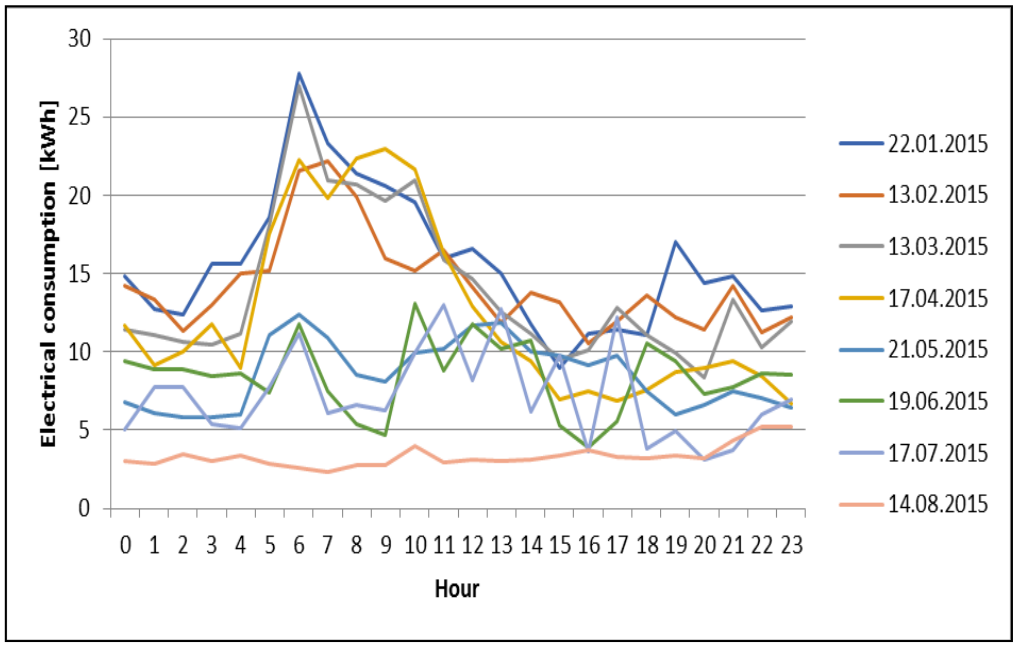

Fig. 2. UTC-N Faculty of Building Services daily electricity consumption in the first eight months (first semester) of the year 2014

The recorded monthly average electricity consumption is detailed in Table 3. Mainly the 2015 values are lower than the values recorded in 2014. The reason for this might be the energy efficiency lighting retrofits implemented for some classrooms. The existing fluorescent T8 luminaires were replaced by LED luminaires / sources. The exception from May to July are not relevant while the university auditorium is also used by other faculties from the Technical University of Cluj-Napoca, so the running ours are different from one year to another. Also, in those months the installed chiller is used for cooling the amphitheater indoor air.

Table 3. Monthly average electricity consumption UTC-N – Faculty of Building Services – 2014, 2015

Electricity Consumption [kWh]		
Month	**2014**	**2015**
1	12317.68	12162.93
2	10042.38	8973.10
3	9655.28	9952.89
4	7504.10	7427.34
5	6358.32	5342.16
6	6372.00	3269.86
7	5510.50	2710.12
8	2686.86	2135.34
9	3461.92	3416.39
10	8340.45	9093.93
11	11469.51	10534.71
12	11362.39	11173.46
Total	**95081.38**	**86192.23**

The faculty building recorded electricity consumption recorded for the years 2014 and 2015 is showed in *fig. 3* and *fig. 4*. The daily average consumption values are indicated in *fig. 3*. The lowest consumption is in August for bought 2014 and 2015, when usually the building access is restricted to few people due to the holydays.

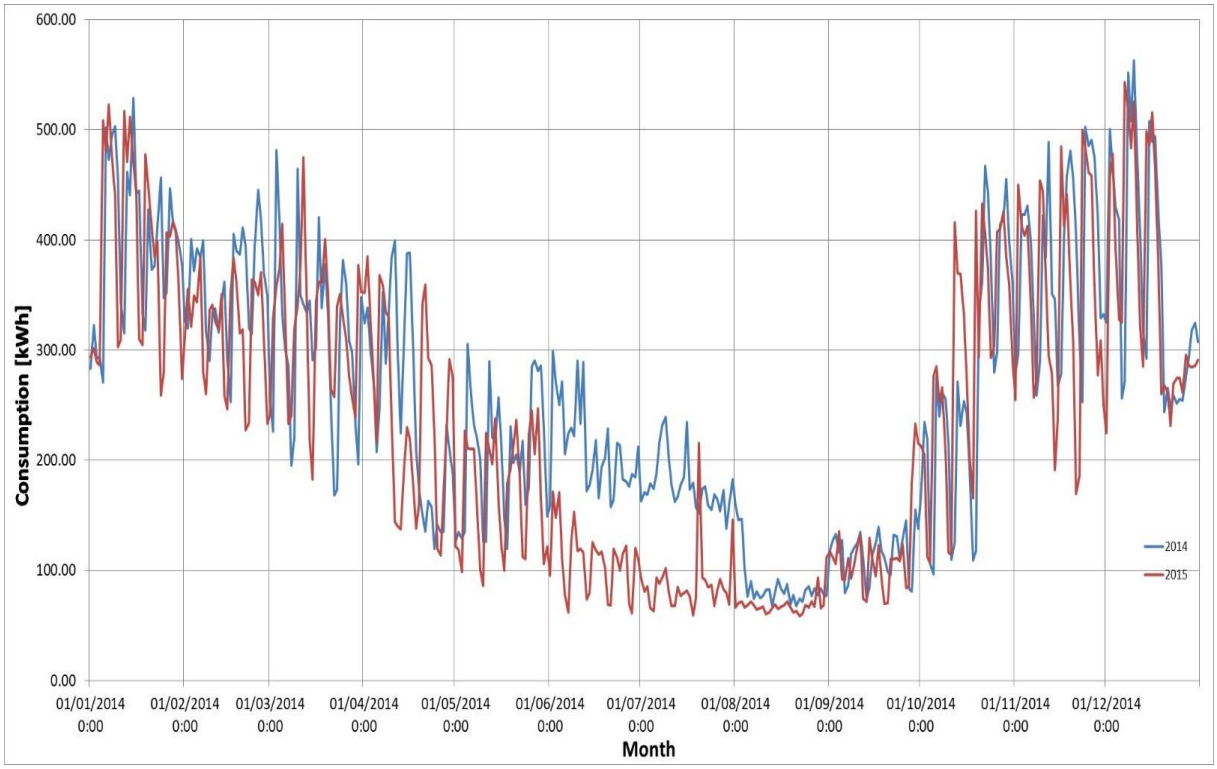

Fig. 3. UTC-N Faculty of Building Services daily electricity consumptions, 2014, 2015

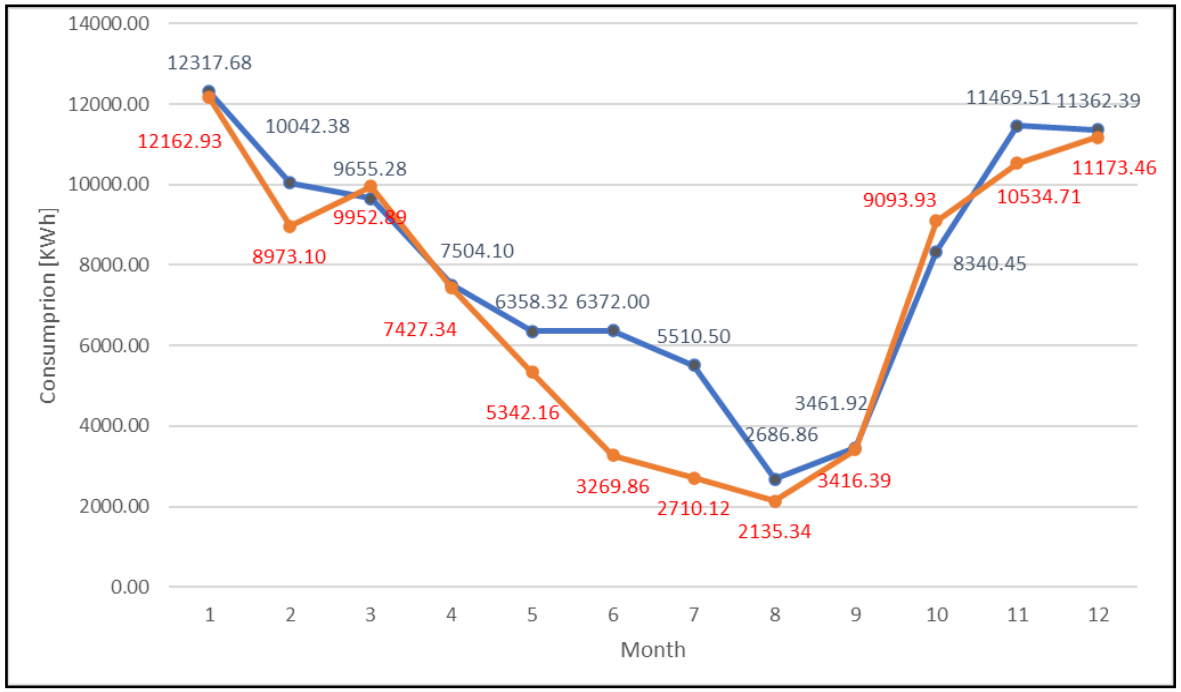

Fig. 4. UTC-N Faculty of Building Services monthly average electricity consumptions, 2014, 2015

3. LIVING BUILDING LAB - CASE STUDY

The Living Building Lab Project (LBL) presumes a holistic approach and includes young architects, constructors and building services engineers, starting with vernacular architecture (traditional), passing through traditional materials (straw, wool, hemp) and reaching modern technologies. Without these technologies the user's comfort cannot be achieved, nor a small energy consumption or the transformation into active buildings (Buildings Management Systems - BMS). Among the practical results of this project the most important will be to build the first Romanian green building (Living Building Lab), using traditional materials combined with the latest technologies, educational - purpose space, where these solutions are to be tested in real conditions. The building process will be supported by volunteers (project members, PhD researchers and students). The private/public sector interest will be involved by new sponsorships contracts (specialized services, materials, equipment) and only partially for some uncovered costs, the university funds. The present achievements of the project are presented. The project member's main goal is to achieve an active building and a very low carbon footprint. Up to this point a draft architectural design was finalized and waits for feedback from the structural/building services team specialists, *fig. 5*. To obtain a low carbon footprint and achieve a practical low-cost building example, simple, bio and locally available construction materials are needed. Building structure will be made from wood having a metal pylon foundation to avoid the Portland cement use. The thermal isolation will be made of bales of straw and wool. As for the exterior building

envelope, wood and clay plasters will be used. The proposed building has two floors and a total area of 220 sq m. The southeast side of the building will have vertical green walls. For the roof area an isolation study was performed, considering the LBL location and the surrounding buildings. To get the largest photovoltaic roof exposition, the final solution was half terrace and half pitched roof, facing south. A total photovoltaic area of 71 sq. m was reached.

Fig. 5. Living Building Lab architectural design

The photovoltaic system will be designed to power the building facilities and the old faculty building consumers. Natural and heat recovery ventilation systems will be used as well as a Canadian well and a heating pump. The interior lighting system will use besides the traditional windows, tubular daylight guidance systems [11] and LED luminaires. The rainwater will be used for the water supply of the building and the plants irrigation system. To ensure a minimal ecological impact, an eco-water purification plant will be installed. An advanced building management system – BMS will be used to achieve the best energy efficiency and to constantly monitories the building's consumptions.

The Living Building Lab Project – UTC-N should be an example of how to change the annual energy requirement of the old university buildings (135 [kWh / (sq. m*year)] to a close to zero energy consumption green facility.

The present paper is just the beginning of the first Romanian green building model for educational/exhibition proposes. Just the first design steps are presented to discus and get feedback from the scientific society and previous experiences. The Living Building Lab Project aims to develop a green model for an active house built up using eco, locally available and low-cost construction materials with a very low carbon footprint. The public should see that everyone can afford those eco building technologies (straw, wool, clay etc.) that combined with the latest energy efficient technologies can actually consume close to zero energy and have a minimal impact on the environment.

4. CONCLUSIONS

The ongoing lighting refurbishment solutions already prove their economic viability and the conclusions are clear and detailed. Starting from those case studies, The Technical University of Cluj-Napoca financed the Living Building Laboratory Project – meant to be an example of how to change the annual energy requirement of the old university buildings (132 [kWh/sq. m/year] to a close to zero energy consumption green facility – *fig. 6*.

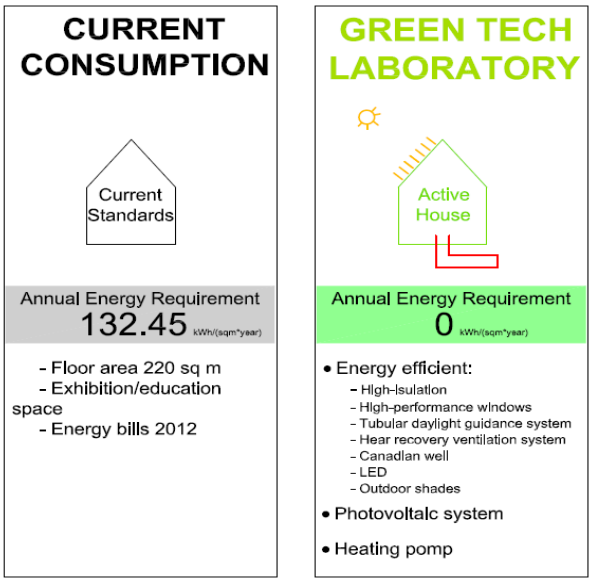

Fig. 6. Living Building Lab goal

The present paper is just the beginning of the first Romanian green building model for educational/exhibition proposes. Just the first design steps are presented to discuss and get feedback from the scientific society and previous experiences. The Living Building Laboratory Project aims to develop a green model for an active house built up using eco, locally available and low-cost construction materials with a very low carbon footprint. The public should see that everyone can afford those eco building technologies (straw, wool, clay etc.) that combined with the latest energy efficient technologies can actually consume close to zero energy and have a minimal impact on the environment.

The Living Building Laboratory Project presumes a holistic approach and includes young architects, constructors and building services engineers, starting with vernacular architecture (traditional), passing through traditional materials (straw, wool, hemp) and reaching modern technologies. Without these technologies, the user's comfort cannot be achieved, nor a small energy consumption or the transformation into active buildings that will produce more energy that it will consume.

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HYBRID EQUIVALENT CIRCUIT GENERATION

Mihaela **GRIB**, Ionela **VLAD**, Ovidiu Dorin **LĂUDATU**,
Alexandru Radu **GRIB**, Mihai **IORDACHE**
University Politehnica of Bucharest, Romania
mihaelagrib@yahoo.com, ionela.vlad@gmx.com, ovidiu.laudatu@yahoo.com,
AlexandruRGrib@eaton.com, mihai.iordache@upb.ro

Keywords: Hybrid equivalent circuit, model H ~ nullified, polarization process, single-port and multi-port networks.

Abstract*: The main objective of this paper is to correctly define the hybrid equivalent circuits. These circuits allow the separation of the linear portions of electronic circuits from the nonlinear ones and in this way the polarization process of electronic devices becomes much more efficient. When linear and/or nonlinear analyzed circuits have a small number of nonlinear circuit elements, their analysis, synthesis, and simulation are performed more efficiently if the nonlinear part of circuit is separated from the linear one. A new modeling technique, called H ~ modeling, is introduced for multi-port networks. It is shown that H ~ models are more dynamic compared to equivalent Thevenin or Norton circuits and have the ability to describe port behavior more accurately. A special type of model H ~ is also introduced, called model H ~ nullified, or simply model H ~ and many properties of H modeling are investigated, including circuit energy management. It is shown that the H models are not limited to single-port networks, but also cover multiport. A major property of H modeling is the local polarization of transistors. It separates the nonlinear components from the linear portion of circuit for faster and more efficient polarization of circuit. Here a designer can take advantage of H-modeling and bias individual transistors (or in combinations) with no need to perform the normal circuit biasing. The proposed strategy separates linear and nonlinear portions of an analog circuit and takes more control of nonlinear portions. This separation of portions (components) of circuit is achieved by introducing a new port model that cancels the ports of nonlinear devices. In turn, this leads to a new technique for polarizing nonlinear components. This separation of portions (components) within the circuit is accomplished by introducing a new port modeling that nullifies the ports of nonlinear devices.*

1. INTRODUCTION

Due to the rapid development of technology, analog and mixed signal integrated circuit technology has an important and decisive role in communications and signal processing. In particular, the rapid development of CMOS technology has made analog circuit designers very interesting, [1–11], for this technology. Other evolutions of technology, such as: low supply voltages, low power consumption, performance complexity and high number of transistors have led to a substantial increase in the demand for new design methodologies and techniques.

A major difficulty in approaching the analog circuits is the DC polarization - obtaining the desired operating points through a fast convergence procedure; and the problem worsens with the advancement of technology, which is due to the increase in the size and complexity of the circuit. The analysis can even lead to multiple DC operating points, or to the instability of these operating points due to positive reactions. In the SPICE circuit simulator [1, 2, 6, 7, 9-22], for example, methods such as Newton-Raphson iteration techniques are used to treat circuit nonlinearities; sometimes the major difficulty is to make the circuit analysis procedure converge in a limited number of iterations. Schemes such as the addition of minimum conductance (GMIN), shunt resistors, changing the tolerance values for results and the feed step are usually adopted in a simulator to make convergence possible.

Usually, a poor selection of the initial conditions or the adoption of large and irregular calculation steps causes the instability of the calculation process or may even lead to this process diverging. Another difficulty may result from a fixed topology of the fixed supply circuit throughout the polarization process. With such a pre-set of conditions, the operating points are found naturally through long and timely iterations. All this adds to the design task and the useful processing time. We need a more guided design procedure; a procedure that helps a designer go through a top-down and piece-by-piece design strategy.

The main objective of this paper is to correctly define the hybrid equivalent circuits. These circuits allow the separation of the linear portions of the electronic circuits from the non-linear ones and in this way the polarization process of the electronic devices becomes much more efficient. In general, H models are used in various analyzes and applications of analog circuits such as: transformation of sources, analysis in DC, analysis in AC (frequency or phasor and s-domain), [1, 2, 4, 9].

Section 2 defines the hybrid equivalent circuits, specifying the necessary and sufficient conditions for a one-port linear circuit to be replaced by an equivalent hybrid circuit. Section 3 sets out the necessary and sufficient conditions for the one-port linear circuit to be replaced by a Nullified Equivalent Hybrid Circuit. Thévenin, Norton and hybrid equivalent circuits are used in the construction of Nullified Hybrid equivalent circuits.

Equivalent Thévenin, Norton, hybrid and null hybrid circuits are used in the local polarization of analog circuits, [1 - 18]. Several illustrative examples are presented that highlights the veracity of the elaborated procedures.

2. HYBRID EQUIVALENT CIRCUIT

Considering a linear resistive circuit containing resistors, independent voltage and/or current sources and all four types of two-port controlled sources. We extract from the terminals (nodes) A and B of the circuit the resistor with resistance R_{AB}, as in *fig. 1*. The left circuit of nodes A, B in *fig. 1* must satisfy the conditions of equivalence of this circuit with the equivalent Thévenin circuit and respectively with the circuit Norton equivalent. In order for a resistive linear circuit to be substituted, in relation to the terminals A, B, with an equivalent Thévenin circuit, the voltage U_{AB} must exist and be unique for any value J of the current of an ideal independent current source, when the R_{AB} resistor is replaced by such a source. Similarly, if the R_{AB} resistor in *fig. 1* is replaced by an ideal independent voltage source with e.m.f. E, the resistive linear circuit to the left of terminals A, B can be replaced by an equivalent Norton circuit if the I_{AB} current exists and is uniquely determined for any value E of the ideal independent voltage source, [1, 2, 9, 14].

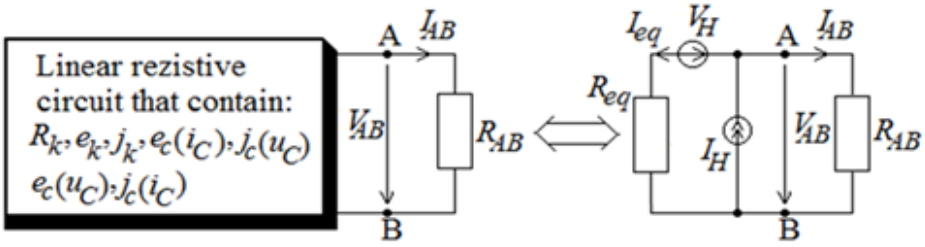


Fig 1. Hybrid equivalent circuit

A Hybrid equivalent circuit, or simply an H~model, of a two-terminal network is a generalized version of Thévenin or Norton equivalent circuit; for resistive circuits it consists of a voltage source V_H, a current source I_H and an equivalent resistance, R_{eq}, which is identical with the Thévenin or Norton model (*fig. 1*). Apparently here one source, V_H or I_H, can be selected arbitrarily and the other source is found through eq. (3).

We assume that the circuit to the left of the R_{AB} resistor in *fig. 1* satisfies the conditions of existence of the equivalent Thévenin and Norton circuits. According to Thévenin's theorem, the I_{AB} current has the expression:

$$I_{AB} = \frac{V_{Th}}{R_{AB}+R_{eq}}, \tag{1}$$

Where is the voltage at terminals A, B of the active circuit, when $I_{AB} = 0$, and the equivalent resistance of the passivated circuit in relation to terminals A, B ($I_{AB} = 0$). Applying the Kirchhoff's laws to the hybrid equivalent circuit in *figure 1*, it follows:

$$\text{KCL: } I_{eq} = I_H - I_{AB} = I_H - \frac{U_{Th}}{R_{AB}+R_{eq}}$$

$$\text{KVL: } V_H = R_{AB}I_{AB} - R_{eq}I_{eq} = R_{AB}\frac{U_{Th}}{R_{AB}+R_{eq}} - R_{eq}\left(I_H - \frac{U_{Th}}{R_{AB}+R_{eq}}\right) \quad (2)$$

It follows from equations (2):

$$I_H = I_{sc} - \frac{V_H}{R_{eq}} \text{ or } V_H = V_{Th} - R_{eq} \cdot I_H \quad (3)$$

where $I_{sc} = I_{ABsc} = \frac{V_{Th}}{R_{eq}}$.

It can be seen that, as with the Thévenin or Norton models, only two measurements are required here to determine all the parameters of the H model. For example, for a selected value of I_H and two measurements of V_{Th} and $I_N = I_{sc}$, eqs. $R_{eq} = U_{Th}/I_{sc}$ and (3) can be used to obtain the R_{eq} and V_H parameters of the model. Now, considering two circuits N_1 and N_2 connected by the gate j (V_j, I_j), as shown in *figure 2*, there are two types of H models for the one-port linear circuit N_1. The 1 H model (1 H ~ model) is shown in *fig. 3. (a)*. To find this model first open the port where $I_j = 0$. Taking into account *fig. 3. (a)* and of equation (3) we have:

$$V_j = V_H + R_{eq}I_N = V_{Th}. \quad (4)$$

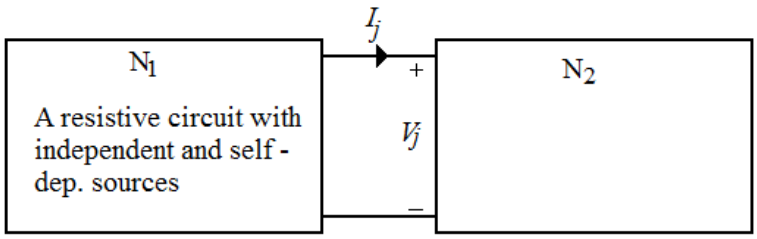


Fig. 2. Two networks N_1 and N_2 connected through a port j (V_j, I_j)

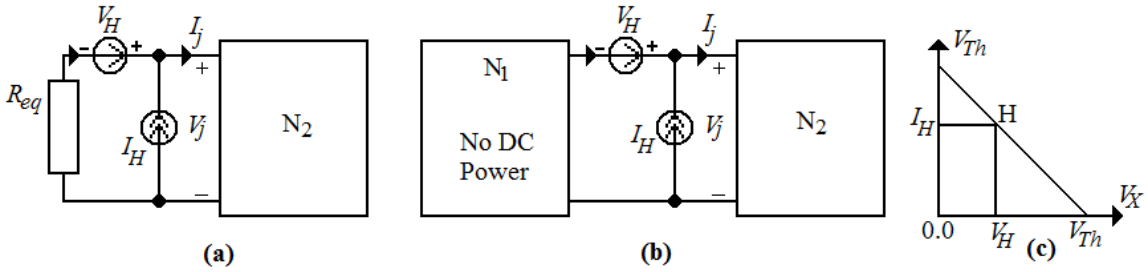


Fig. 3. A two-terminal Hybrid equivalent circuit for N_1; (a) Type 1 representation; (b) Type 2 representation; (c) The location on the port's characteristic curve

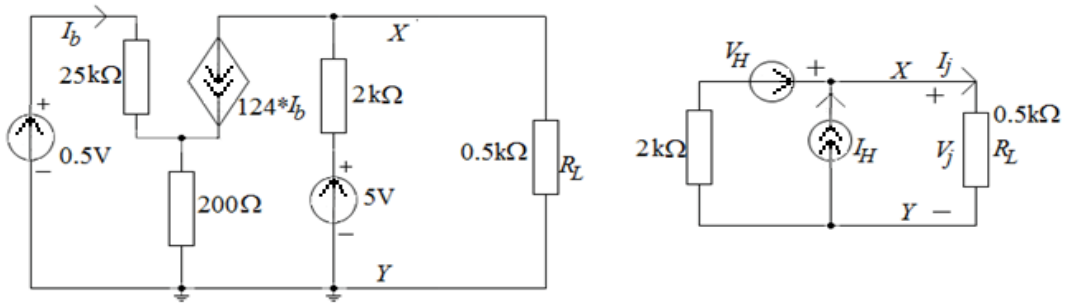
From eq. (4) it results:

$$V_H = V_{Th} - R_{eq} I_N = V_{Th} - R_{eq} I_{sc} \tag{5}$$

In the Type 2 H ~ model, however, the sources remain the same as in Type 1, but instead of calculating the equivalent resistance R_{eq}, we let N_1 unaltered, except that all its DC power sources are removed, as shown in *figure 3. (b).* The term "DC power removed' means that all DC sources are removed from the N_1, including charges on the capacitors and currents through the inductors. Type 2 H~model is useful in several applications, such as moving the DC sources in a circuit to its port terminals without disturbing the internal structure (topology) of the network.

Note that, because of having two sources instead of one, an H~model represents an axis of freedom that acts as a tool in dynamic modeling of a port. As indicated in *fig. 3. (c),* an H~- model covers a full and continuous range of equivalent circuits for a two-terminal network. It is evident from Eq. (2) and *fig. 3. (c)* that both the Thévenin and Norton models are two special cases of an H~-model.

Example 1: A simplified small signal equivalent circuit of a single stage BJT amplifier with load is represented in *fig. 4. (a)*, the X-Y port is connected to a load R_L. Here we would like to have: i) an H~-model for the two-terminal circuit, on the left of X-Y, so that the power consumption on both sides of the port are equal; and ii) modify the H~-model in part i) so that the power consumption in the two terminal circuit (the left of X-Y) becomes zero.



(a) *(b)*

Fig. 4. (a) A simplified small signal equivalent circuit of a single stage BJT amplifier with load; (b) An H~-model of the amplifier.

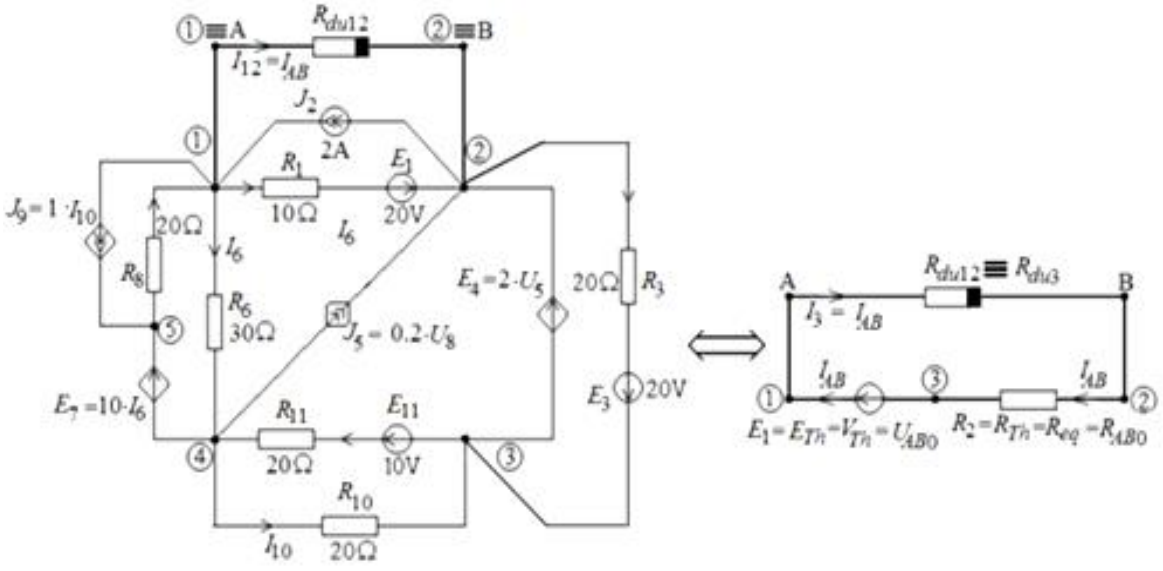
Solution: We first find an H~-model representation for the two-terminal circuit as depicted in *fig. 4. (b)*, with the source values, V_H and I_H, unspecified. Second, to make the power consumption on both sides of port j equal we need to have:

$$R_L I^2_j = R_{eq} (I_H - I_j)^2 \tag{6}$$

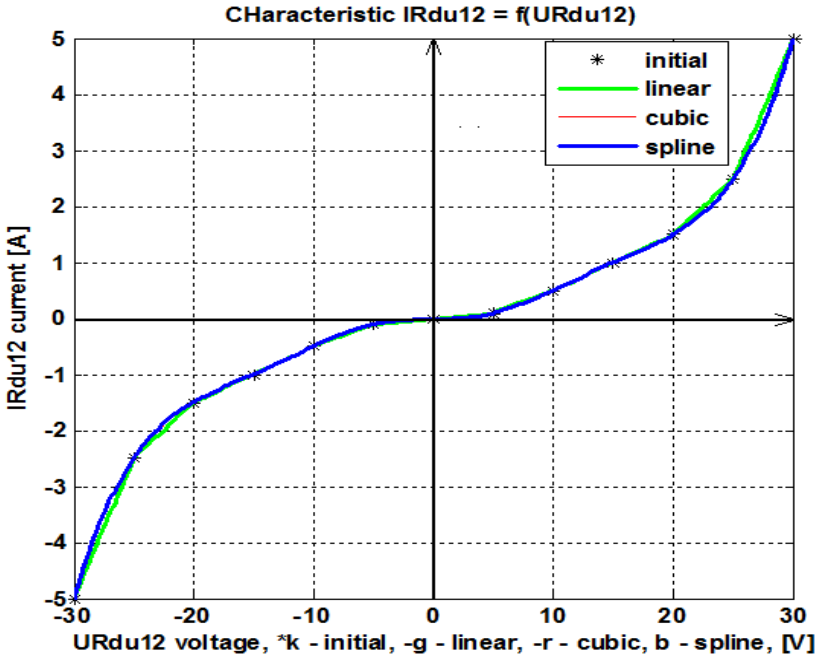
By using eq. (3) and knowing that V_{Th} = 2.52 V and R_{eq} = 2 kΩ we get I_j = 1.008 mA, I_H = 1.512 mA, V_H = −0.504 V, and the power consumed for each side is $P_j = R_L*(I_j)2$= 0.508 mW. For part ii), because the situation for the load R_L is not changed we still have I_j = 1.008 mA, V_j = 0.504V, and P_j = 0.508 mW. Now, to make the power consumption to the left of X – Y zero we must have $R_{eq}(I_H - I_j)^2 = 0$; or simply $I_H = I_j$ = 1.008 mA, and as a result $V_H = V_j$ = 0.504 V. This concludes the solution with the fact that in the part ii) the total power consumption is reduced to half, i.e., from 1.016 mW to 0.508 mW.

Universality is an important characteristic of an H~model. H~models can be accurately applied to all possible cases of linear two-terminal networks, regardless of the port impedances; whereas both Thévenin and Norton equivalent circuits lose their sensitivity in some specific cases when port impedances take extreme low or extreme high values. For example, consider measuring the Thévenin (open circuit) voltage of a two-terminal network N_1 that has the equivalent resistance of R_{eq} = 2 MΩ. Suppose the measuring voltmeter has the input impedance of R_M = 20 MΩ and the measured open circuit voltage displayed is V_M = 3V. Apparently selecting $V_{Th} = V_M$ = 3V as the Thévenin voltage for the port carries an error of 10%. Whereas an H~-model with $V_H = V_M$ = 3V and $I_H = I_M$ = 136 nA represents an exact H~- model for the port. Note that there is no need for any extra measurement to find I_M, because we can simply get it from $I_M = V_M/R_M$.

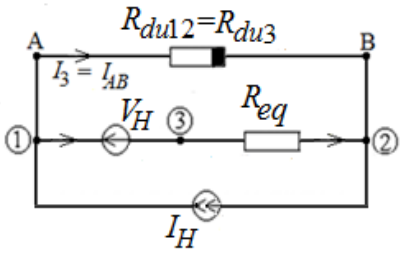
Example 2: In *figure 5. (a)*, is presented a nonlinear resistive circuit containing a voltage-controlled nonlinear resistor (R_{du12}). The numerical values of the circuit parameters in *fig. 5. (a)*, are shown in the figure, and the nonlinear characteristic $I_{Rdu12} = f(U_{Rdu12})$, given by points, is shown in *fig. 5. (c).* The purpose of this example is to show that in the analysis of a nonlinear circuit it is particularly efficient to replace the linear part of the circuit with an equivalent Thévenin, Norton or Hybrid circuit.



(a) *(b)*



(c)



(d)

Fig. 5. (a) Diagram of the nonlinear resistive circuit containing a voltage-controlled (v.c.) nonlinear resistor (Rdu12); (b) Linear part of the circuit in Fig. 5. (a) is substituted by a Thévenin equivalent circuit; (c) Characteristic $I_{Rdu12} = f(U_{Rdu12})$; (d) Hybrid equivalent circuit.

Solution: First we analyze with ACAP - Analogue Circuit Analysis Program, [3, 18], the nonlinear resistive circuit in *fig. 5. (a)* and obtain, for the nonlinear resistor R_{du12}, the solution U_{Rdu12} = -0.50813 V and I_{Rdu12} = -0.010163 A. Then, replace the nonlinear resistor with an ideal independent current source with the intensity of the current jo (oriented from node n_2 to node n_1) and simulate, using the CSAP program - Circuit Symbolic Analysis Program, [3], in the full-symbolic form the circuit thus obtained. In this way the expression of the Thévenin voltage $U_{Th} = U_{AB0} = -U_{Jo}$ and the expression of the equivalent resistance $R_{eq} = R_{Th} = R_{AB0} = U_{Th\_cir\_passive} / j_o$ are determined, where $U_{Th\_cir\_passive}$ is the Thévenin voltage of the passivated circuit (all independent sources in the analyzed circuit are canceled, except for current source j_o).

Finally, the circuit parameters are replaced with their numerical values and the numerical values of the Thévenin equivalent circuit parameters $R_{Th} = R_{eq}$ = 4.6667 Ω and U_{Th}

= E_{eq} = -0.5556 V and those corresponding to the equivalent circuit Norton G_{eq} = 1 / R_{eq} = 0.2143 S and I_{sc} = U_{Th} / R_{Th} = -0.11905 A and thus the circuit of *fig. 5.(a)* is equivalent to that of *fig. 5. (b).* Analyzing, with the program ACAP, [3], the circuit of *fig 5. (b)* the same solution is obtained for the nonlinear resistor R_{du12}, U_{Rdu12} = -0.50813 V and I_{Rdu12} = -0.010163 A. Obviously, the nonlinear circuit in *fig. 5. (b)* is much simpler than the one in *fig. 5. (a). Figure 5. (d)* shows the equivalent hybrid circuit in which the parameters have the values: R_{eq} = 4.6667 Ω, I_{sc} = -0.11905 A, V_H = 1 V (value considered arbitrary) and I_H = I_{sc} - V_H / R_{eq} = -0.333334 A. Obviously, for the nonlinear resistor R_{du3} we consider the *characteristic* I_{Rdu3} - U_{Rdu3} from *fig. 5. (c).*

Simulating, by the ACAP program, the circuit from *figure 5. (d),* we obtain the same solution for the nonlinear resistor R_{du3} = Rd_{u12}, U_{Rdu3} = U_{Rdu12} = -0.50813 V and I_{Rdu3} = I_{Rdu12} = -0.010163 A. Obviously, even in this case, the nonlinear circuit in *figure 5. (d)* is much simpler than the one in *figure 5. (a).*

Example 3: Consider the circuit of *fig. 6. (a),* where two sections of a circuit are connected through a port j(V_j, I_j). Let the MOS diode be characterized by $i = K\,(V\text{-}1)^2$ mA for V > 1 V and let K = 0.5 mA/V^2. The analysis shows that port j is not a null port because I_j = 1 mA and V_j = 3 V. Next, we increase port j of N_2 by two current and voltage sources I_j = 1 mA and V_j = 3 V and then remove the supply sources of 5 V and 1 mA from N_1. As a result a new null port k(V_k, I_k) is created, as shown in *fig. 6. (b).*

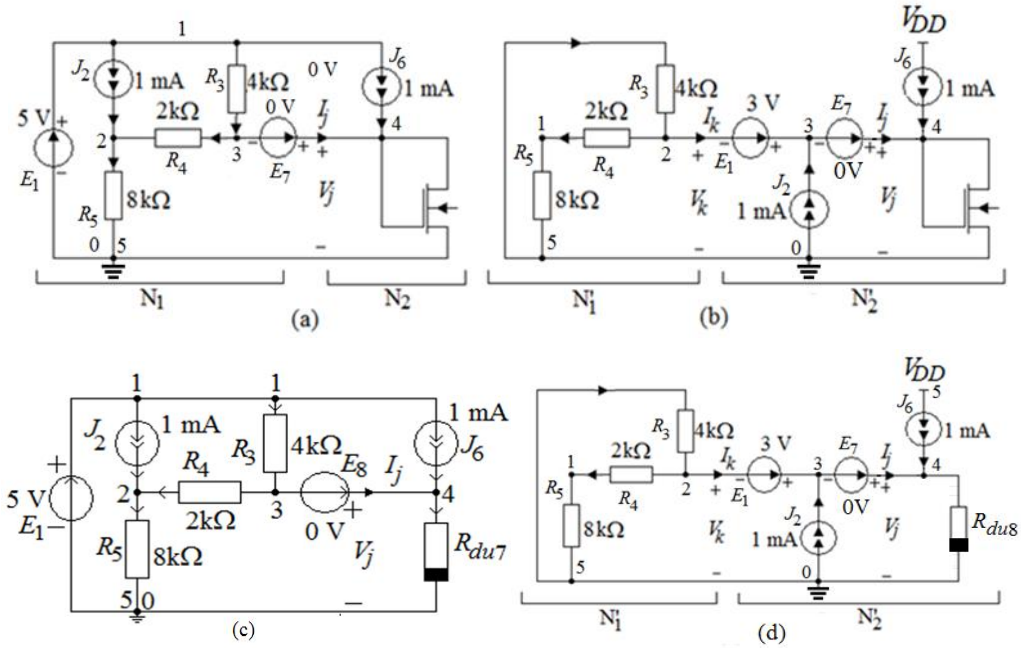


Fig. 6. (a) Example of two networks N1 and N2 separated by a port j; (b) Creation of a null port k in an H-modeling representation; (c) The MOS diode from Fig. 6. (a) was replaced by the voltage-controlled nonlinear resistor R_{du7} with the characteristic $I_7 = k \cdot (V_7 - 1.0)^2$ with k = 0.5 mA/V^2 and $V_7 > 1$; (d) The MOS diode from fig. 6. (b) was replaced by the voltage-controlled nonlinear resistor Rdu8 with the characteristic $I_8 = k \cdot (V_8 - 1.0)^2$ with k = 0.5 mA/V^2 and $V_8 > 1$.

The numerical values of the Thévenin equivalent circuit parameters in respect of the n_2 - n_0 nodes of the circuit in *fig. 6. (a)* are: $R_{Th} = R_{eq} = 2.8572$ kΩ and $U_{Th} = E_{eq} = 8.7143$ V, and those corresponding to the Norton equivalent circuit $G_{eq} = 1 / R_{eq} = 0.35$ S and $I_{sc} = U_{Th} / R_{Th} = 3.05$ mA. The equivalent hybrid circuit of the circuit in *fig. 6. (b)* in respect of the n_2 - n_0 nodes, as one of the two quantities V_H and I_H can be considered arbitrary, the parameters of this circuit can take the values: $V_H = 3.0$ (value considered arbitrary), current, according to relation (2), has the value $I_H = I_{sc} - V_H / R_{eq} = 2.0$ mA and if the current $I_H = 1$m A is considered arbitrary, the voltage, according to relation (2), results $V_H = V_{Th} - R_{eq} \cdot I_H = 5.8572$ V. If at the circuit terminals in *figs. 6. (a)* and *(b)*, we connect, instead of the transistor, a nonlinear voltage-controlled resistor R_{dvc}, with current-voltage characteristic $I_{dvc} = K (V_{dvc}-1)^2$ mA for $V_{dvc} > 1$ V, and let K = 0.5 mA/V^2, we obtain the circuits shown *in figs. 6. (c)* and (*d)*.

The left side of the circuits in *fig. 6. (c)*, respectively *fig. 6. (d)*, are replaced in turn, with respect to terminals n_2 - n_0, by: the equivalent circuit Thévenin (*fig. 6. (c)*) and the two variants of the Hybrid equivalent circuit (see *fig. 6. (b)*). Analyzing all five types of circuits, thus generated, by the ACAP program, [3, 18], it is obtained the same operating point for the voltage-controlled nonlinear resistor R_{dvc} ($V_{Rdvc} = 5.0833$ V, $I_{Rdvc} = 1.2708$ mA).

Obviously, the structure of the circuits in *figs. 6. (c)* and *(d)* are much simpler.

3. NULLIFIED HYBRID EQUIVALENT CIRCUIT

An equivalent canceled hybrid circuit, called model H, is a special case of a model H ~; where, the values of the voltage and current sources in the model are identical to the voltage and current values corresponding to the port, which means that the sources in a model H represent the polarization situation of the corresponding port. For example, taking the case of *fig. 2*, where the network N_1 supplies the voltage V_j and the current I_j to polarize the network N_2. The two models for this example are shown in *figs. 7. (a)*, and (*b)*.

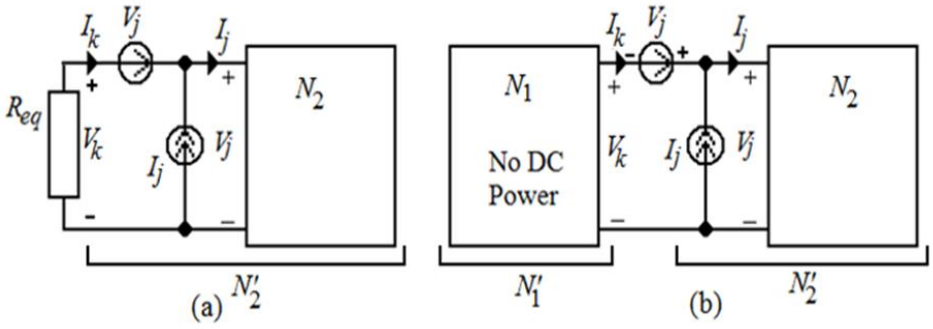


Fig. 7. An H-model for a two terminal N1: (a) Type 1 representation; (b) Type 2 representation.

Note that *Figs. 7. (a)* and *(b)* are identical to *Figs. 3. (a),* and *3. (b),* except that here, the model sources represent the port values. Note also from *figs. 7* that, as a result of modeling H, another port, k (V_k, I_k) (see *fig. 7*) is created in N_1, where both V_k and I_k are zero. Port k(V_k, I_k) is called "null" port, and the process of creating it is called "port cancellation", as will be discussed shortly.

Theorem 1 introduces an important property of a model H that deals with the distribution of electricity in a network [13]. It adds an extra dimension to power analysis and segmentation of power in a network.

Theorem 1: Considering an N_2 network connected to another N_1 network through a port (through a gate) j (V_j, I_j), as shown in *fig. 2*. Replacing N_1 with type H or type 2 models reduces the energy consumption in N'_1 to zero, while the energy consumption in N_2 remains unchanged.

Proof: Consider the model H ~ in *fig. 3. (a)* or *3. (b).* Both sources, I_H and V_H, supply power to the N_1 and N_2 networks. The power delivered to N_2 is fixed and is calculated with the relation $P_2 = V_j \cdot I_j$; whereas in model 1 of type H ~ the power consumed by the network N_1 (*fig. 3. (a)*) is $P_1 = R_{eq} \cdot (I_H - I_j)^2$. Therefore, the power P_1 in N_1 becomes zero if $I_H = I_j$ which results in $V_H = V_j$. However, for model H type 2, we observe from *fig. 3. (b)* that N'_1 does not have a direct current source from which to obtain energy, plus its port is also canceled. Therefore, all currents and voltages inside N'_1 must be zero, resulting in zero power consumption.

Port cancellation (Nullification): Consider an N_2 network connected to another N_1 network through a port j (V_j, I_j), as shown in *fig. 2*. One way to cancel Port j is to enlarge the port on both sides (N_1 and N_2) by power sources: the current I_j and the voltage source V_j. The result is the creation of another port k (V_k, I_k) which, by definition, is a null port, meaning both I_k and V_k are zero.

However, there is an alternative method of creating a null port when two networks N_1 and N_2 are connected through a port j (V_j, I_j), shown in *fig. 2*. Here we can simply replace N_1 with its model H (type 1 or type 2) and create the null port k (V_k, I_k), as shown in *fig. 7*. As a result of the port cancellation procedure, N'_2, is created, which contains the N_2 circuit plus the sources belonging to the H model. Similarly, another N'_1 network is created, on the left side, when the H model loses its sources. As will be seen later, these extended networks have a particular importance in polarizing the circuit. It is observed that the characteristic curves of ports j and k are identical, except for the displacements of *v* and *i*, the coordinate axes, from the origin to the point $Q_j(V_j, I_j)$. This causes the operating point $Q_j(V_j, I_j)$ to fall on the origin, creating a new operating point $Q_k(0, 0)$ for the port k, shown in *fig.8*. This simply means that for any pair of networks, N_1 and N_2, connected via a port j, it is always possible to cancel the port and change N_1 and N_2 to N'_1 and N'_2, where N'_1 and N'_2 are identical to N_1 and N_2, except for the *v* and *i* coordinate axes which move at the port operating point. This is mentioned in Characteristic 1.

Characteristic 1: Consider two networks N_1 and N_2 connected through a port j, as in *fig.3*. If port j is null, then the characteristic curve *i-v* of the port, searching (looking at us) through any network, passes through the origin and the origin is the operating point of that port. If port j is not null, it is always possible to cancel the port to obtain the corresponding networks N'1 and N'2 with a null port k, as shown in *figure 8*.

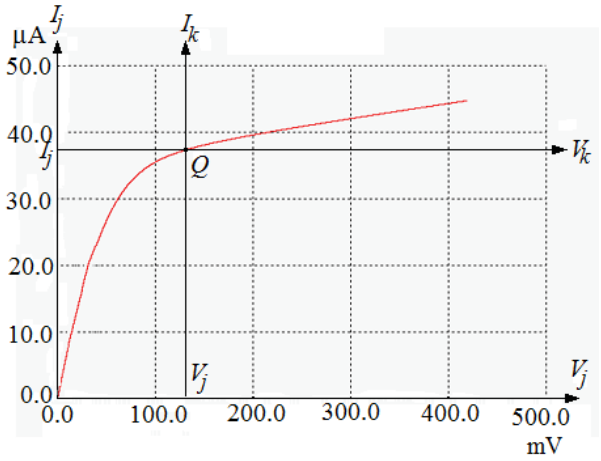


Fig. 8. The i-v coordinate axis moved from (0, 0) for the j port to a new position, $Q_j(V_j, I_j)$, for the k port.

4. CONCLUSIONS

The paper presents the necessary and sufficient conditions to be met by one-port or multi-port linear circuits to be replaced by equivalent Hybrid circuits. These circuits are widely used in the analysis of analog circuits.

A new modeling technique, called H ~ -modeling, is introduced for multi-port networks. It is shown that H ~ models are more dynamic compared to equivalent Thevenin or Norton circuits and have the ability to describe port behavior more accurately. A special type of model H ~ is also introduced, called model H ~ nullified, or simply model H ~; and many properties of H modeling are investigated, including circuit energy management. It is shown that the H models are not limited to single-port networks, but also cover multiports. A major feature of H modeling is the local polarization of the transistors. It separates the nonlinear components from the linear portion of the circuit for faster and more efficient polarization of the circuit. Here a designer can take advantage of H-modeling and bias individual transistors (or in combinations) with no need to perform the normal circuit biasing. The proposed strategy separates linear and nonlinear portions of an analog circuit and takes more control of nonlinear portions. This separation of the portions (components) of the circuit is achieved by introducing a new port model that cancels the ports of nonlinear devices. In turn, this leads to a new technique for polarizing nonlinear components.

The paper presents the necessary and sufficient conditions to be met by one-port or multi-port linear circuits to be replaced by equivalent Hybrid circuits. These circuits are widely used in the analysis of analog circuits.

The main advantage of Hybrid's theorem is that it allows us to replace any part a circuit which forms a linear resistive one-port (but which is of no interest in a given situation) by only two circuit elements without affecting the solution of the solution of the remainder of the circuit.

Thévenin, Norton and Hybrid equivalent circuits are used in the construction of Nullified Hybrid equivalent circuits. Equivalent Thévenin, Norton, hybrid and null hybrid circuits are used in the local polarization of analog circuits.

Based on the paper can introduce a guided design procedure for biasing of the electronic circuits.

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PASSIVE TUBULAR DAYLIGHT GUIDANCE SYSTEMS ENERGY SAVING POTENTIAL FOR THE RESIDENTIAL BUILDINGS IN ROMANIA

Calin **CIUGUDEANU**, Dorin **BEU,**
Lighting Engineering Laboratory, Technical University of Cluj-Napoca, Romania
calin.ciugudeanu@insta.utcluj.ro

Keywords: sunpipe, energy efficiency, daylight guidance systems, sustainable lighting, daylight.

Abstract*: Traditional vertical window can provide adequate daylight within about six meters of the window. Daylight levels decrease asymptotically with distance from the window so that a disproportionate amount of daylight/solar gain must be introduced into the front of the room to achieve small increases in daylight at the back. Tubular daylight guidance systems (TDGS) are linear devices that channel daylight into the core of a building. These consist of a light transport section with, at the outer end, some device for collecting natural light and, at the inner end, a means of distribution of light within the interior. The nature of the systems and the factors influencing the costs and various benefits that contribute value are identified. Lighting systems in residential buildings, lit by electric lighting and daylight guidance, were surveyed. Data on the physical characteristics of the systems and lighting conditions achieved were collected. The results formed the input to a cost and value analysis which permitted the economic limits of the systems to be evaluated. Some estimations were made about the energy savings and the environmental benefits of those lighting systems.*

1. GENERAL OVERVIEW

The visual effect of lighting is an important part of the total living or working environment. Although every building has different functions, it is compelling to use daylight as a primary or a secondary light source for the benefits of energy, productivity, and health [1]. Although it is becoming increasingly difficult to provide the light required for various activities from daylight alone due to the increased building density, partial use of daylight

can still significantly reduce lighting and cooling loads and improve occupants' preferences, visual relief, and pleasing effects [2].

The most effective daylighting strategies could be to optimize building orientation and form as well as to optimize window size and placement. Due to overcrowded urbanization, however, it is increasingly difficult to use strategies that let natural light penetrate deep into the interior space. Fortunately, emerging technologies are available that allow sunlight into the core interior of multistore buildings, although optical sun lighting systems as a remote illumination source can be traced back as far as the late 1800s [3]. Several recent developments in optical lighting systems offer renewed opportunities for reliable optical daylighting sources with broad applicability and high effectiveness. And due to developments in renewable materials, the use of optical daylighting systems for active lighting control can be simple, reliable, and relatively inexpensive.

A few systems exist to redirect daylight into areas of buildings that cannot be lit by conventional glazing. One major generic group is known as 'beam daylighting' - redirects sunlight by adding reflective or refracting elements to conventional windows. The second major group is known as 'tubular daylight guidance systems TDGS.

Tubular daylight guidance systems are linear devices that channel daylight into the core of a building. They consist of a light transport section with, at the outer end, some device for capturing natural light and, at the inner end, a means of distribution of light within the interior. The light capture device may be located at roof level of a building enabling light from the zenithal region of the sky to be gathered. Alternatively, light may be gathered from a device mounted on the building facade. Zenithal openings allow intensive use of daylight but may cause glare or overheating due to penetration of direct solar radiation especially during summer. For a horizontal aperture the quantity of solar flux entering through a facade mounted collector depends on facade orientation and season and these systems are more likely to be influenced by external obstruction than zenithal systems. Collectors may be either mechanical devices that actively focus and direct daylight (usually sunlight) or be passive devices that accept sunlight and skylight from part or whole sky hemisphere. The transport element is usually a tube lined with highly reflective or prismatic material or may contain lenses or other devices to redirect the light. Light is distributed in an interior space by output components, commonly diffusers, made of opal or prismatic material.

There has been a considerable research effort on TDGS over the last decade. Initially, this concentrated on light transport materials and devices, but latterly, a number of methods of predicting light delivery and/or distribution within a building interior have been developed. They form the basis of CIE173:2006 Tubular Daylight Guidance Systems – technical report. The report describes mostly the passive zenithal systems. These are, by far, the most commercially successful types of tubular daylight guidance, being manufactured and installed in large numbers in numerous countries. The design methodology presented in this report relates to passive zenithal systems only. The Report includes reviews of the technology of all

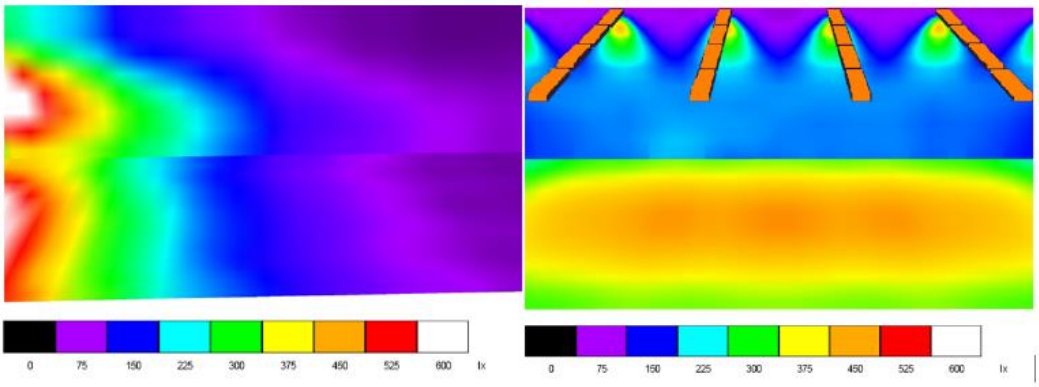
generic types of daylight guidance systems and includes case-studies. The sections on performance indices, photometry of components and systems, design methods, cost and benefits, human factors and architectural issues relate to passive zenithal systems [4].

Our previous research [5], [6] presents results of an experimental study on the performance of a passive tubular daylight system, under the climatic condition of Cluj-Napoca, Romania. A light pipe with flat collector and light-distribution diffuser was installed in a residential building. The performance of the light pipe was tested. The CIE173:2006 suggested methods of prediction are tested against measured data from the installation survey.

2. TUBULAR DAYLIGHT GUIDANCE SYSTEMS (TDGS)

Conventional vertical window can provide an adequate daylight within about six meters deep inside the room. Daylight levels decrease asymptotically with distance from the window so that a disproportionate amount of daylight/solar gain must be introduced into the front of the room to achieve small increases in daylight at the back. While this can increase energy savings over a larger room area by offsetting electric lighting energy, the corresponding increase in cooling due to solar heat gain, and/or heating due to structural heat loss, can negate these savings. The use of glazed areas on other parts of the building envelope including atriums, skylights and roof monitors may light some areas remote from windows but these are of limited use in lighting deep core areas 1.

The estimated lighting level was simulated with Dialux 4.6 Software for a room (6*12 m) situated in Bucharest. The room has the windows orientation NE on the 6 m wall [6]. In *fig. 1* it can be seen the limited amount of daylight inside a 12 m deep room. The same figure illustrates the lighting level when there are used fluorescent 36 W lamps. A dimmed artificial light scene was also simulated in order to obtain a better lighting uniformity.



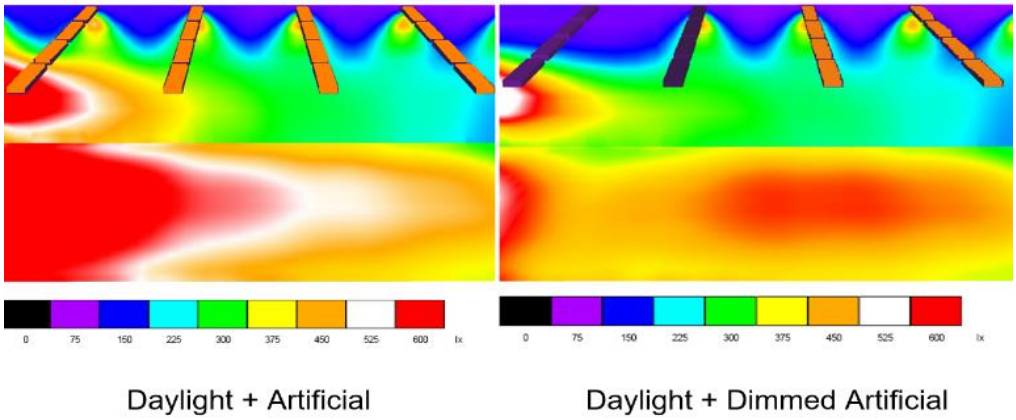


Fig.1. Lighting levels for a room (l=6 m, L=12 m, windows on the left side NE, simulation for a building situated in Bucharest, summertime).

TDGS consist of a light transport section with, at the outer end, some device for collecting natural light and, at the inner end, a means of distribution of light within the interior – *figure 2*.

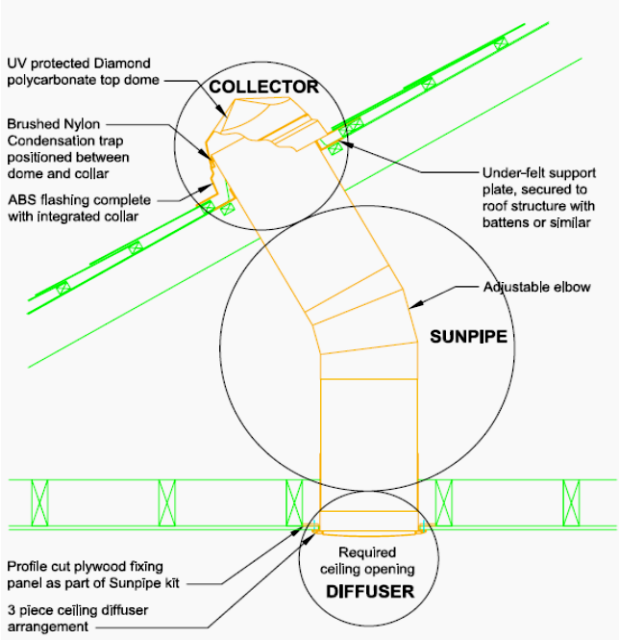


Fig. 2. Tubular daylight guidance system with passive collector [7]

Collectors may be mechanical devices that actively direct daylight (usually sunlight) or be passive devices that accept sunlight and skylight from part or whole sky hemisphere and may be located at roof level gathering light from the zenith sky or on the building façade. Zenith openings capture light from the brightest sky region but may cause glare or overheating due to direct solar penetration. Orientation is a major determinant of collection efficacy in façade mounted collectors. The transport element is usually a tube lined with highly reflective silvered or prismatic material and may contain lenses or other devices to redirect the light. Light is distributed in an interior by emitters which differ little from conventional luminaires.

Light transport is the feature that sets tubular guidance systems apart from other daylight redirection methods. The principal function of transport elements is to deliver light from the collector to the point of exit, but some may additionally act as emitters. Recently considerable research effort has been directed at transport systems, a major factor being the availability of new low-cost light redirection materials. Usually there are four different transport methods, namely, beam/lens systems, hollow mirrored pipes, hollow prismatic pipes, and solid core systems.

The light pipe, lined with highly reflective material, is used to guide sunlight and daylight into occupied spaces (*figure 2*). Highly reflective materials include anodised aluminium and coated plastic film such as Silverlux, which have reflectance greater than 95%. Commercial light pipes are available from a number of manufacturers, in straight and bend sections for on-site assembly and installation. They allow the light pipe to go through complex roof spaces to reach rooms that are not easily accessible to skylights. A light pipe is normally fitted with a clear top dome which removes harmful UV radiation and prevents the ingression of rainwater and dust. A diffuser fitted to the bottom of the light pipe ensures that light is distributed around the room it illuminates. Compared to skylight or windows, the light pipe transmits less solar heat on to the illuminated surfaces. This is particularly valuable in summer for preventing inhabitable hot spots in a building. In winter, a light collector (e.g., a sun-scoop) could be mounted above the top opening to allow significantly more sunlight from low angles to be collected.

A passive TDGS was evaluated – under real conditions. The device was installed in a residential house from Cluj-Napoca, Romania. A light pipe produced by the Velux Company was mounted inside a 4 x 4 m room on the first floor of the building, as shown in *fig. 3*.

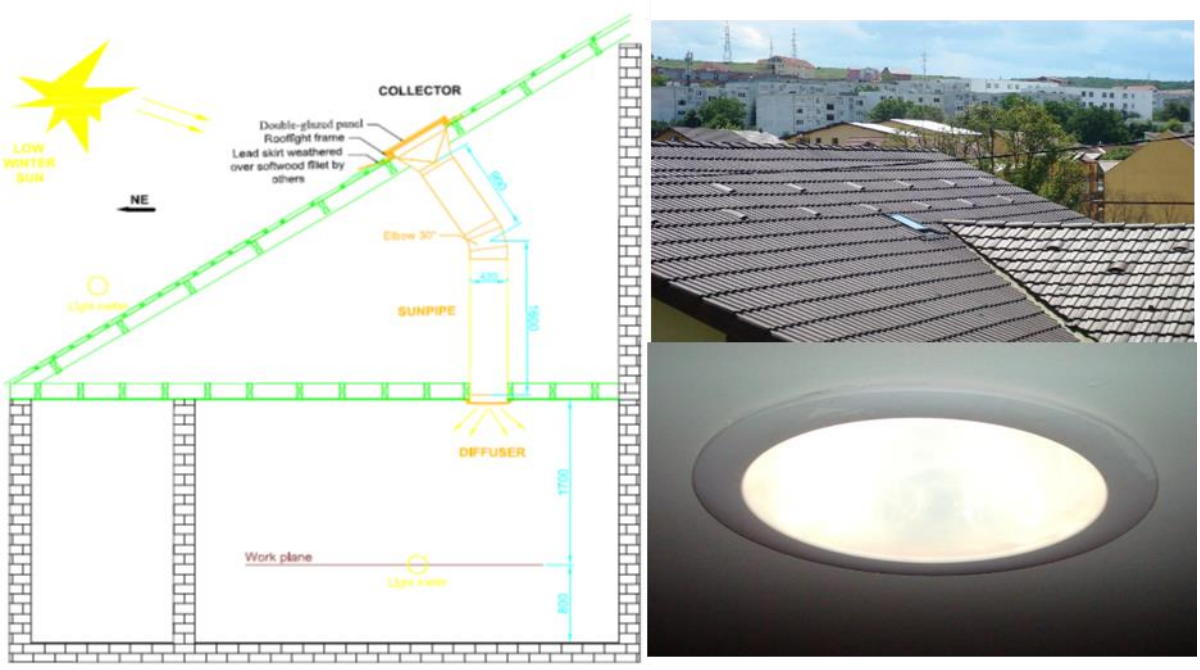


Fig. 3. The experimental set up - Velux TWR14 installed in Cluj-Napoca, Romania

The house is part of a duplex situated in Cluj-Napoca. The cylindrical light pipe has a length of 2.5 m and a diameter of 350 mm. A highly reflective film is laminated, using adhesives, to the interior surface which has a minimum reflectivity of 95%. The top of the pipe was sealed with a clear anti-yellowing acrylic plate. A pearl white diffuser was fitted to the lower opening of the light pipe for even light distribution within the room.

Illuminance measurement was carried out using a standard light meter which had a range of 0.05- 100,000 lx. The meter was based on a photovoltaic cell which has a spectral response similar to that of a standard human eye thus avoids the need for correction for various types of light sources.

Illuminance of the sun on the open field, and that within the working plane inside the room, were obtained using two separate photocells. The readings were recorded manually and care was paied to ensure that there were no passing clouds or other significant changes of lighting condition between reading the two cells. The photocell within the room was normally placed right under the diffuser, at a 0.8 m distance above the floor where the working plane is assumed to be. The data was measured in 30 different days, all around the year 2009. The collector is unfortunately facing the NE direction. Moreover, there are some shading problems when the sun is low. That is why most of the presented results are around noon, in order to eliminate these errors.

Analysing the measured data there can be calculated the maximum, minimum and average values of the indoor and outdoor illuminance. The results are presented in Table 1. For some winter days the results were not conclusive because the collector was covered with a layer of ice and snow. This should ask for second thoughts regarding the shape, geometry and orientation of the flat-type collectors, at least for northern areas with heavy winters.

Table 1. Measurements average results

Value	**Internal illuminance (work plane)**	**External illuminance**	**Average internal illuminance /day**
	lx	lx	lx
Max	238	88000	206
Min	34	3200	65
Average	151	41926	145

The maximum illumination achieved for the work plan was 238 lx, for the day 31.07.2009, at 13.45, corresponding to a value of external illumination of 80000 lx. This value does not coincide with the maximum recorded external illumination, about 88000 lx (21.07.2009, time 13.55), probably due to measurement errors. The lowest illumination value on the work plan was 34 lx registered on 04.02.2009, 14.15, overcast conditions and coincides with the minimum outdoor illumination of 3200 lx. In general, the system has provided an average illumination of about 145-150 lx.

3. HYBRID TUBULAR DAYLIGHT GUIDANCE SYSTEMS

The Technical University of Cluj-Napoca - Lighting Engineering Laboratory – LEL developed a new hybrid TDGS system that is presently under survey. The new system was developed based on the previous survey studies for a TDGS installed in Cluj-Napoca, [5].

Presently a new Hybrid TDGS is under survey. The new system is using a passive TDGS and a small photovoltaic 40W system powering LED light sources, placed next to the diffuser. The tubular daylight guidance system installed is a Velux TWF, 350 mm diameter, flexible light pipe. The photovoltaic system is geared with a 40 W photovoltaic panel 12V Poly 670×475×25mm, a Blue Solar charge controller PWM 12/24V-5A and a 12V/22Ah AGM Deep Cycle Battery providing a 10-hour autonomy for the 28 W LED. A dimming control system is used to maintain a certain lighting level on the work area – Fig. 4.

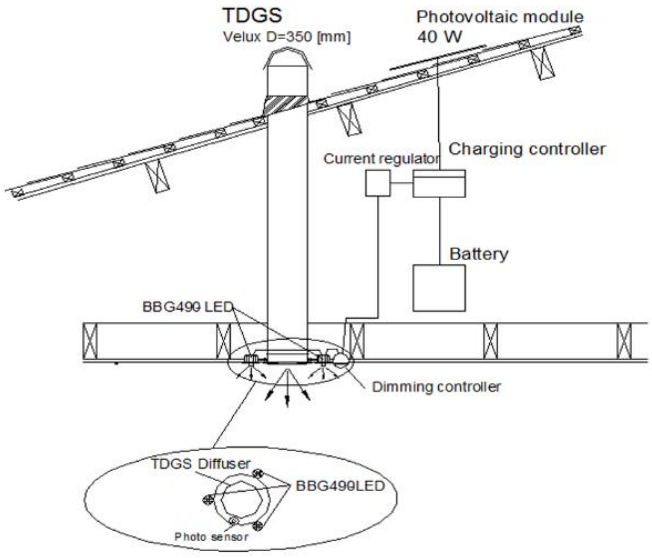


Fig. 4. Hybrid Passive Tubular Daylight Guidance System

The Hybrid Passive TDGS was installed in an outside experimental booth (3 m length, 3 m width, 2.5 m height) outside the building. The booth can provide different cardinal orientations and different roof pitches to provide various setups for the installed Hybrid Passive TDGS.

The designed hybrid system does not need the support of the electric network system, being suitable / adaptable for isolated areas where there is no electricity or for refurbishment solutions where new electrical wiring is not desired.

4. TDGS ENERGY SAVING POTENTIAL FOR THE RESIDENTIAL SECTOR

One major disadvantage of the TDGS is that it can provide natural light only during the day. Relevant for the energy saving potential of the TDGS in the residential sector there is the non-working population, the end users that need light during the day – *fig. 5*.

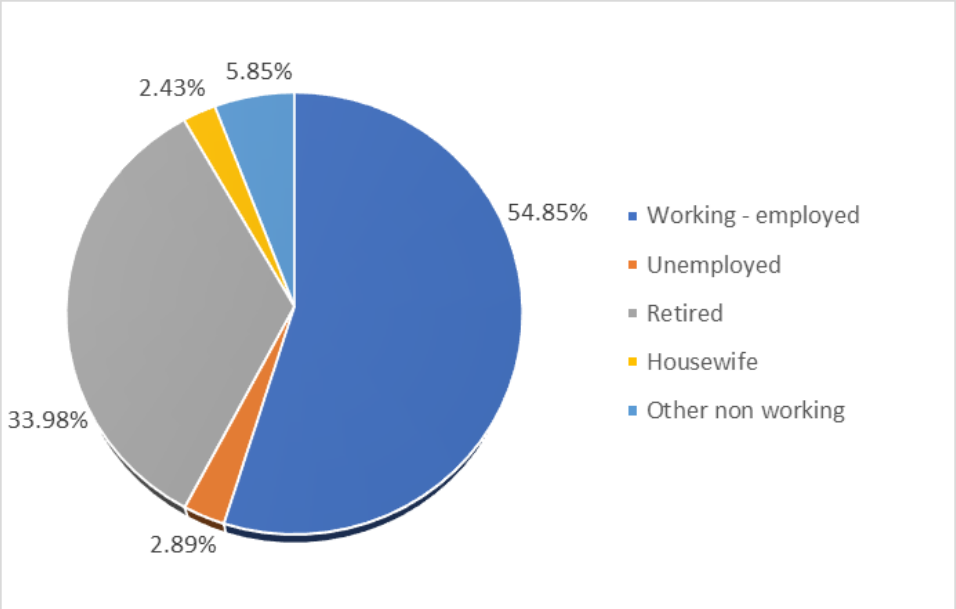


Fig. 5. Dwellings distribution by occupation of family head, Romania [10]

The last official numbers provided by the Romanian National Institute of Statistics for the year 2011, shows a total number of over 7.4 million dwellings for the Romanian residential sector. The values presented in Table 2 denote the large number of households owned by non-working family heads (approximately 3.3 million). Dividing this number with the national average of dwellings per building we can assume a total of 2.40 million buildings with dwellings having non-working family head.

Table 2. Number of dwellings distributed after the family head occupation, Romania [10].

DWELINGS BY OCCUPATION OF FAMILY HEAD	
Total Residential Buildings	**5326972**
Total Dwelings	**7470429**
Average number of dwelings per building	1.40
Working - employed	*4097641*
Non working	*3372788*
Unemployed	215972
Retired	2538226

DWELINGS BY OCCUPATION OF FAMILY HEAD	
Housewife	181860
Other non working	436730
Buildings with dwelings having working family head	**2921923**
Buildings with dwelings having non-working family head	**2405049**

Scientists estimates electric lighting savings for the residential sector taking into consideration a non-working residential couple who spend a considerable amount of time at home with a 300 mm diameter passive TDGS installed (usually in the kitchen/hallway/bathroom). The system typically replaces the burning of 200 to 500 Watts of electric lights for 3 to 7 hours per day. We can assume a 300-Watt savings for 5 hrs. per day, only 5 working days per week. This leads to electric consumption savings for a TDGS 300 mm diameter of about 390 kWh per year.

If we consider that in each 2.40 million buildings with dwellings having non-working family head, at least one TDGS 300 mm diameter is suitable to be installed and considering the previous electrical savings example, we can assume total energy savings for residential lighting in Romania of about 936000 MWh per year. Additionally, savings can be assumed for the total number of residential buildings during the weekends (total number of residential buildings – 5.32 million * 300-Watt savings for 5 hrs. per day, only 2 days in the weekend leads to additional total electricity savings of 829000 MWh per year). The previous predictions examples show electricity savings for the residential sector in Romania by installing in each building a TDGS 300 mm diameter of about 1.76 million MWh per year. Even a greater saving potential should be available for the commercial sector where usually the main activity take place during the day.

For the non-working family head, the payback of installing one TDGS can be estimated. If we consider a total electricity price of 0.15 euro/kWh and electric consumption savings for a TDGS 300 mm diameter of about 547 kWh per year (300W x 5h x 365days), a total annually running cost reduction of 82 euro can be achieved. If a 300 mm passive TDGS costs around 400 euro, the system payback time for a nonworking family head should be around 4.9 years.

Calculating the payback time for working family head if we consider a total electricity price of 0.15 euro/kWh and electric consumption savings for a TDGS 300 mm diameter of about 165 kWh per year (300W*5h*110 holydays and weekends), a total annually running cost reduction of 25 euro can be achieved. The system payback time for a working family head should be around 16 years.

5. CONCLUSIONS

A typical passive TDGS costs 300 to 500 euro installed and will prevent over 3 tons of CO_2 from entering our air over the next 10 years. All this, while providing healthy, natural interior illumination, far superior to any electric light in both colour and intensity. It just makes good common sense to implement such technology [9].

Daylighting systems require a specific conception, very close related to the geographic context where they are built, to environment (natural and artificial obstructions), to imposed levels of visual comfort and to climate.

If we think only about the annually cost reductions and make a strict economic evaluation – the passive TDGS is economic viable only for non-working family heads or places where there is limited daylight and are used during the day.

Combining a passive TDGS with an artificial LED light source powered by a photovoltaic module and a battery can extend much more the system autonomy and running hours [8].

The development of new materials with better performance in light reflection and transmission has led to various solutions of energy efficient lighting systems able to grow potential for future applications.

Any technical and economic analysis of these systems must take into account both energy efficiency, and visual comfort conditions for the lighted spaces. For example, these solutions present outstanding possibilities to improve visual comfort in underground spaces, which are energy efficient due to low thermal losses.

Perspectives offered by these solutions of integrated lighting systems lead to a higher visual comfort and to new possibilities of space utilization.

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The paper must be written in English. It shall contain at least the following chapters: introduction, research course (mathematical algorithm); method used; results and conclusions, references.

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Use DIN A4 Format (297 x 210 mm) MSWord format. Margins: top, bottom, left and right 2.5 mm each. The text should be written on one side of the page only. Use Times New Roman fonts, line spacing 1.3. The font formats are: paper title: 14 pt, bold, italic, capital letters, author's name(s): 12 pt, regular for name and 12 pt., bold, for surname; Affiliation: 11 pt., italic; key words: 10 pt., bold; Abstract: 10 pt., italic, word Abstract in 10 pt., bold; chapter titles (do not use automatic numbering): 12 pt., bold, capital letters; subtitles: 12 pt., bold, lower case letters; subsubtitles: 12 pt., italic, lower case letters; body text: 12 pt., regular; tables and figures caption: 11 pt.; italic; references: author 11 pt.; regular, title 11 pt. italic, year, pages, ... in regular.

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The number of pages is not restricted.

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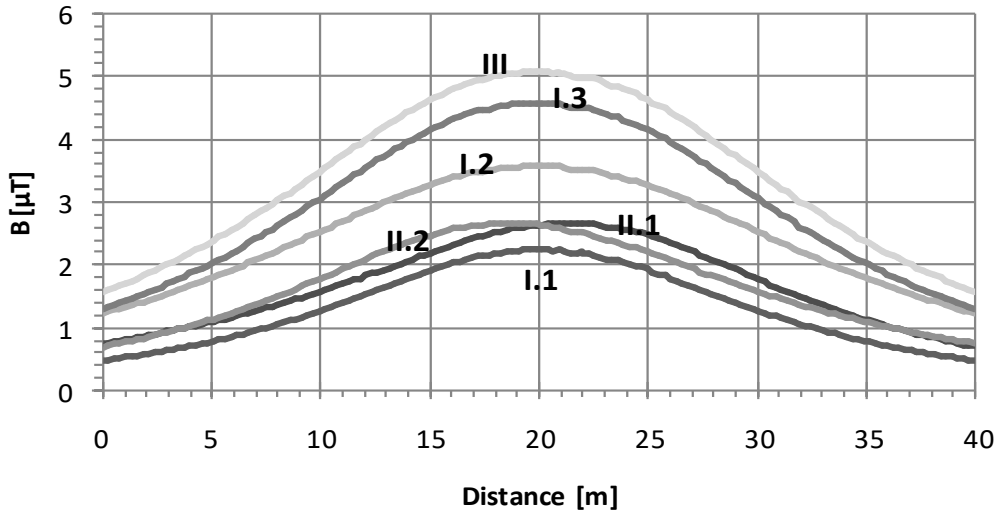

Fig. 1. Magnetic flux density at 1 m above the ground

Table 1. Transposing principle

	Circuit											
	1	*2*	*1*	*2*	*1*	*2*	*1*	*2*	*1*	*2*	***1***	***2***
1/3	*R*	*T*	***R***	***R***	*R*	*S*	*R*	*T*	*R*	*S*	***R***	***R***
line	***S***	***S***	*S*	*T*	*S*	*R*	*S*	*R*	*S*	*T*	***S***	***S***
length	*T*	*R*	*T*	*S*	***T***	***T***	*T*	*S*	*T*	*R*	***T***	***T***
1/3	*T*	*S*	***T***	***T***	*T*	*R*	*T*	*S*	*T*	*R*	***T***	***T***
line	***R***	***R***	*R*	*S*	*R*	*T*	*R*	*T*	*R*	*S*	***R***	***R***
length	*S*	*T*	*S*	*R*	***S***	***S***	*S*	*R*	*S*	*T*	***S***	***S***
1/3	*S*	*R*	***S***	***S***	*S*	*T*	*S*	*R*	*S*	*T*	***S***	***S***
line	***T***	***T***	*T*	*S*	*T*	*S*	*T*	*S*	*T*	*R*	***T***	***T***
length	*R*	*S*	*R*	*T*	***R***	***R***	*R*	*T*	*R*	*S*	***R***	***R***
Name	***I.1***		***I.2***		***I.3***		***II.1***		***II.2***		***III***	

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Equations are centred on page and are numbered in round parentheses, flush to right margin.

$$a = b + c \tag{1}$$

Between equations, not interfered by text, there is only one empty line:

$$a = b + c \tag{2}$$

$$a = b + c \tag{3}$$

In text respect the following rules: all variables are italic, constants are regular; the references are cited in the text between right parentheses [1], the list of references has to be arranged in order of citation.

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ENERGY EFFICIENCY CONTROLLED BY ARDUINO MODULES

Cristian **BARZ**[1], Zoltan **ERDEI**[1], Oleh **ONYSKO**[2], Paul **TAMAS**[1], Andreea **POP**[1], Teodora **UNGUREANU**[3]

[1] *Technical University of Cluj-Napoca, Department of Electrical, Electronic and Computer Engineering Romania,* [2] *Ivano-Frankivsk National Technical University of Oil and Gas, Department of the Computerized Machine Building, Ukraine,* [3] *The National Institute for Research and Development in Constructions, Urbanism and Sustainable Spatial Development URBAN-INCERC, Bucharest, Romania*

cristian.barz@ieec.utcluj.ro

Keywords: energy management, monitoring, Arduino modules, sensor, energy efficiency

Abstract*: To control and reduce energy consumption, it demands to install a network of sensors and using a dashboard to monitoring data acquisition from its. Energy monitoring is necessary to keep track of energy consumption according to the season, weather conditions and the flow of use of electrical appliances in the institution. The paper presents an approach for monitoring energy efficiency base on Arduino modules (smart-MAC) through a dashboard application. Dashboard WEB application has the advantage of leting the user a flexible indicator and chart widgets configuration for create an unlimited number of boards and devices connected to the same account. To realize an efficiency use of energy in public institution the date is analyze and on results can be take measurements for it.*

1. INTRODUCTION

The European Commission suggested to Romania to define more ambitious objectives and targets regarding integration in the internal energy market, recommending the adoption of certain measures to develop liquid and competitive wholesale and retail markets. Romania has recently taken significant steps in this respect, also undertaking to follow a liberalisation calendar that will ensure free pricing as of 2020/2021 depending on the demand and offer. On the other hand, the operationalisation of the support measures for vulnerable consumers and

the alleviation of energy poverty will be considered in strict correlation with the deadlines of the abovementioned calendar.

In the updated version of the Plan, Romania also clarifies the undertaken target regarding the level of interconnectedness of energy transmission grids, which will reach at least 15.4 % in 2030 based on a progress calendar for current and projected projects, which is administered by the energy transmission system operator.

Moreover, Romania is involved in the European process of integration of energy markets in the context of achieving the Single Day-Ahead Coupling (SDAC) and the Single Intra-Day Coupling (SIDC), involving the corresponding contractual framework. As regards research, innovation and competitiveness, the Romanian Government plans to prepare the National Smart Specialisation Strategy for the period 2021-2027, which is foreseen to be published in the second quarter of 2020. The strategy intends to define the national objectives and targets of funding in the fields of research, innovation and competitiveness, thus addressing the Commission's recommendation.

In conclusion, Romania has initiated various actions with the purpose of increasing the level of ambition as regards the RES share and the energy efficiency targets and is considering several measures to define and to implement strategies and policies that concern reaching the targets committed to, some from these are: decarbonisation - GHG emissions and removals and renewable energy; energy efficiency and security; development internal energy market and research, innovation and competitiveness of technologies contributing to decarbonisation. [1]

2. POTENTIAL FOR USE OF ENERGY-EFFICIENCY AND RENEWABLES

Due to availability of natural resources, the use of renewable energy sources to satisfy different human needs has long tradition in Romania. For centuries Romanians have been used wind and water to put in force mills, wood and solar energy to heat water and houses. The concerns for promoting renewable energy are dated since 1970s, Romania being a pioneer in this field [2]. One effect of the former communist state collapse was the decrease of public investments in the field, leading to the stagnation of the renewable energy sector development.

Being endowed with so many natural resources, Romania is a country with a high renewable energy potential. The type of resources and the energy potential of each are summarized in Table 1. An important problem is determined by the gap between the theoretical potential and the technical and economical feasible potential. Thus, the RES primary production in 2011 was 5028 ktoe, divided in 3618 ktoe biomass energy, 1266 ktoe hydro energy, 120 ktoe wind energy and 24 ktoe geothermal energy [3].

Table 1 Energy potential of renewable energy sources. Source: ANRE [4].

Renewable energy source	Annual energy potential	Economic energy equivalent (ktoe)	Application
Solar energy			
- thermal	$60*10^6$ GJ	1,433.0	Thermal energy
- photavoltaic	1,200 GWh	103.2	Electrical energy
Wind energy	23,000 GWh	1,978	Electrical energy
Hydro energy (total)	40,000 GWh	3,440.0	Electrical energy
- under 10 MW	6,000 GWh	516.0	Electrical energy
Biomass	$318*10^6$ GJ	7,594.0	Thermal energy
Geothermal energy	$7*10^6$ GJ	167.0	Thermal energy

Romania is pursuing renewable energy sources in three different directions:

• Electricity (RES-E). The renewable energies used to produce electricity are wind, hydropower, solar photovoltaic and bio- mass. In 2011 the electricity produced from renewable sources achieved 20673 GWh [4] leading to a share of RES-E in total gross electricity consumption of 27.05% [3]. The number of RES-E licensed producers in 2011 was 82 (of which 42 use wind energy, 32 hydro energy, 4 biomass energy and 4 photovoltaic energy) [4]. Hydro plants produce a very high share of RES-E (Table 2).

Table 2 RES-E production (2011). Source: ANRE [4].

RES-E technology	GWh
Photovoltaics	2
Solar Thermal	0
Wind on-shore	290
Winf off-shore	0
Hydro large scale	18,992
Hydro small scale	1,273
Biomass	118
Biogas	0
Geothermal energy	0
Total	**20,675**

• Heating/cooling (RES-H). As not all renewable sources have the same potential to provide in heat, the Romanian renewable energies most suited for heating and cooling are: biomass, geothermal and solar resources. Table 3 shows the share of each technology in RES-H production in 2010. Biomass contributes considerably to Romania's heat production and

consumption. These levels are the result of the high use of forestry products for heating. About 95% of the biomass resources are used in private households for heating, cooking and hot water preparation, the remaining being used by industry [5].

Table 3 RES-H production (2010). Source: ANRE [4].

RES-H technology	ktoe
Biomass	415
Solar thermal	5
Geothermal energy	18
Renewable energy from heat pumps	8
Total	**446**

• Transportation (RES-T). The country's intention to comply with the Kyoto Protocol require, among other measures, an increased use of biofuels for transport. In Romania, biofuels are obtained by processing the rape, corn, sunflower and soybean crops. Although Romania has a huge potential in terms of energy crop production, biofuels production registered very low levels (163 ktoe) [6].

Although these levels are significantly higher than the average of EU-27, the energy is obtained mainly from conventional renewable sources (large hydro and biomass) rather than through green renewable sources. [7].

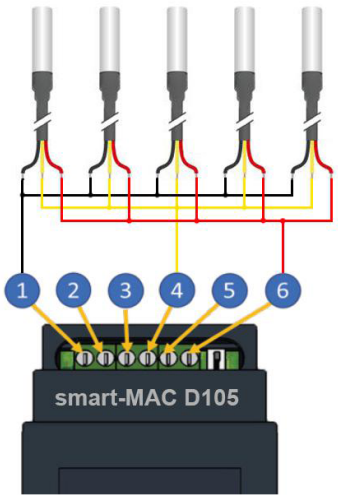
3. SENSORS IN BUILDING MONITORING

3.1. Temperature sensor

You can connect up to 5 pcs DS18b20 temperature sensors or one DHT22 temperature and humidity sensor to the universal smart-MAC D105 meter. [8] DS18b20 are digital 1-Wire temperature sensors, all of them are connected to one contact, terminal 4. Black (or White) wire all sensors combine and connect to terminal 1: GND (Ground or -5B). Red wire all sensors combine and connect to the terminal 6: 5B. Yellow (or Blue) wire all sensors combine and connect to terminal 4: Data 1-Wire.

Temperature sensors such as DS18x20 can be connected by 3 wired circuit (described in *fig. 1*) or 2 wire. Pay attention, there are many low-quality sensors on the market that work unsustainably not only on the 2-wire circuit but also on 3 wired when connecting more than one sensor. The sensors from our store are of proven quality and work sustainably on any connection scheme.

When connecting multiple Sensors such as the DS18x20, they all need to be connected the same way, using a 2 or 3 wired connection.

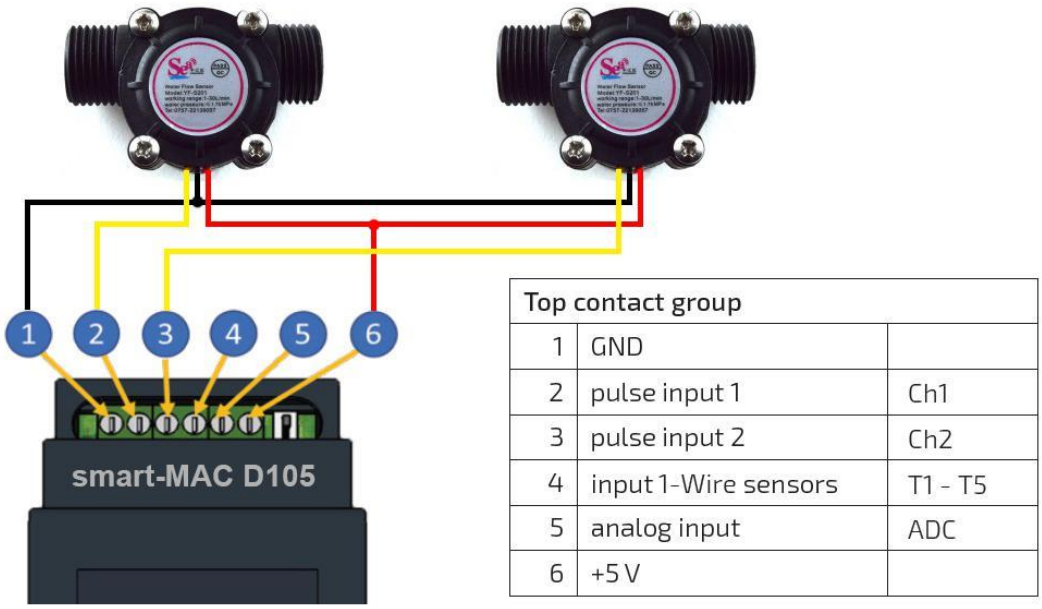


Top contact group		
1	GND	
2	pulse input 1	Ch1
3	pulse input 2	Ch2
4	input 1-Wire sensors	T1 - T5
5	analog input	ADC
6	+5 V	

Figure 1 3-wire connection to smart-MAC D105 [9]

3.2. Counters (flow meters) with impulse output

It can be meters for water, gas, heat, fuel, milk, beer and many others. Two types of impulse outputs must be distinguished: The meter with a impulse output of the type "Dry contact" (mechanical meters). The meter with a impulse output of the type “n-p” (electronic meters).



Top contact group		
1	GND	
2	pulse input 1	Ch1
3	pulse input 2	Ch2
4	input 1-Wire sensors	T1 - T5
5	analog input	ADC
6	+5 V	

Figure 2 Three-wire circuit for connecting a flow meter to smart-MAC D105 [10]

3.3. Wind Speed and Wind Direction sensors

The Wind Speed and Wind Direction sensors (figure 3) can be connected to the universal D105 meter. Wind speed and wind direction sensors transmit information via the RS485 bus. This interface is notable for its stable working at large distances, up to 100 meters. Through the

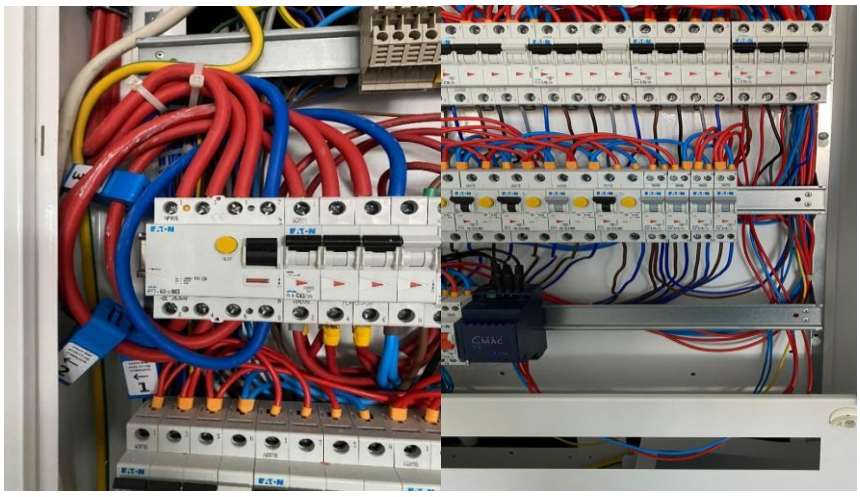
RS485-1Wire interface, which comes in a box from smart-MAC only, the sensors are connected to the digital input (4) of the smart meter smart-MAC D105. Specify the colors of the wires in the description for the sensor. [11]

Figure 3 Speed and Wind direction sensors

3.4. Monitoring interface for Arduino modules

The monitoring system is created on the basis of "smart" devices of energy monitors of the Ukrainian company smart-MAC (https://smart-mac.com/) and data obtained in the course of the monitoring process are available for viewing in real time on any device (PC, tablet, smartphone) and stored for further analysis in the cloud storage.

The obtained data on actual energy consumption, after the installation of the pilot monitoring system, during the calendar year will allow to estimate the specific thermal characteristics of the building, determine the actual energy consumption to ensure regulatory microclimate in the building, assess the rationality and trends of energy consumption. Also, such data will help to assess the real effect after the implementation of energy efficiency measures to reduce energy consumption in university buildings.



a) *b)*

Figure 4 - Reconstruction of the electrical distribution cabinet

The pilot energy monitoring system for the university building is being deployed on the basis of the Department of Electric, Electronic and Computer Engineering of TUCN-NUCBM. The Department of Electric, Electronic and Computer Engineering occupies a third part of the academic building C of the university and is located on one floor of the building.

Installation of Building Management System (BMS) will allow to maintain a balanced energy consumption through detection of electricity consumption, temperature losses, monitoring of utilities and data storage on each area where are installing the sensors, and also, calculating the specific consumption much more accurately.

For each room and node of energy consumption measurement its own page in the web application with digital and graphic representation of character of the current data of energy consumption and change of energy consumption during observation time (figure 5) is developed.

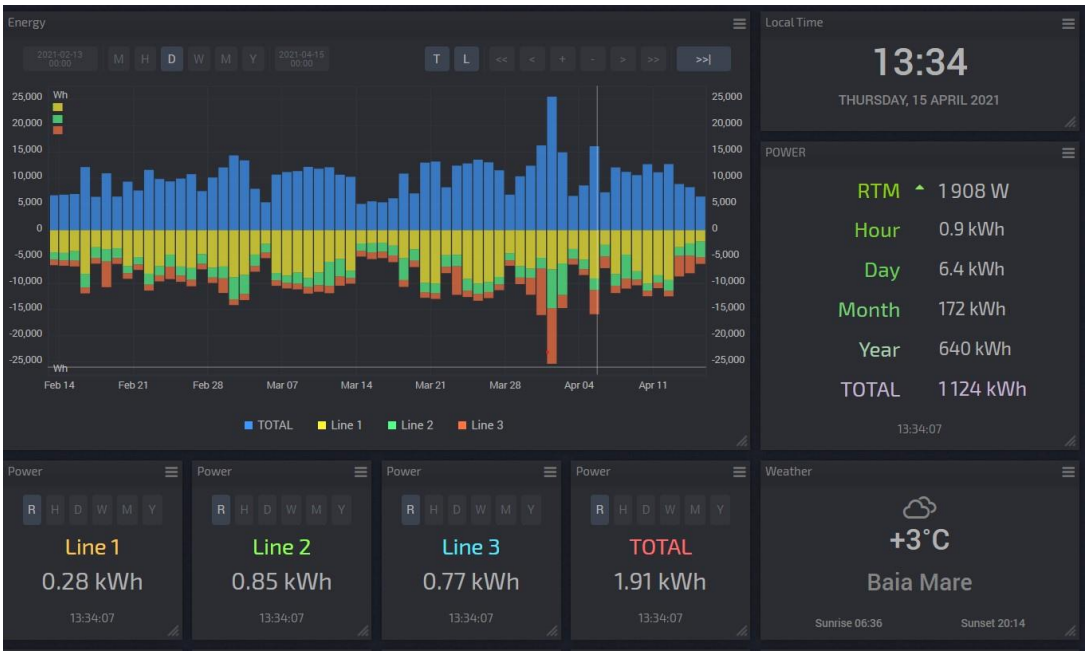


Figure 5 - Display of energy consumption and microclimate parameters

4. CONCLUSIONS

Energy monitoring is necessary to keep track of energy consumption according to the season, weather conditions and the flow of use of electrical appliances in the institution. The universal WEB application smart-MAC Dashboard base on Arduino modules, to monitor the sensors give the main advantage for flexibly configure indicator and chart widgets and create an unlimited number of boards and devices connected to the same account.

The user is able to be flexible to configure indicator and graph widgets; create an unlimited number of cards and devices connected to the same account; provides easy

monitoring of the sensors used; monitoring of sensors for reduce consumption and quite significant energy consumption costs.

Energy management in public institution depends by the control and monitoring of energy consumption and demands network sensors and dashboard to monitoring data acquisition from network create. After an analyze of date can be take measurements for efficiency use of energy in public institution.

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TECHNOLOGICAL AND MANAGEMENT SOLUTIONS TO PREVENT EMERGENCIES AT OIL AND GAS FACILITIES

Teodoziïa **YATSYSHYN**[1], Lesya **SHKITSA**[2], Mikhaylo **LYAKH**[3], Vasyl-Danylo **LIAKH**[4]

[1] *Ivano-Frankivsk National Technical University of Oil and Gas, Department of Environmental Protection Technology, Ivano-Frankivsk, Ukraine,* [2]*Ivano-Frankivsk National Technical University of Oil and Gas, Engineering and Computer Graphics Department, Ivano-Frankivsk, Ukraine,* [3] *Ivano-Frankivsk National Technical University of Oil and Gas, Oil and Gas Equipment Department, Ivano-Frankivsk, Ukraine,* [4] *Technical University of Kosice, Faculty of Manufacturing Technologies, Presov, Slovac Republic*

teodoziia.yatsyshyn@nung.edu.ua

Keywords: emergency, oil and gas, environment, defectoscopy

Abstract*: Oil and gas production is accompanied by technological processes that can pose a significant threat to the environment. The analysis of conditions of occurrence of ecologically dangerous emergency situations in oil and gas production branch is presented. This became the basis for the formation of a technical solution to increase the environmental safety of hydrocarbon production processes. The system of diagnostics of the equipment for rejection of rods is improved. The main purpose of improving the rod magnetic flaw detector was to reduce emergencies with the rods of deep pumping units by rejecting the rods with defects. The improvement of the rod magnetic flaw detector was to reduce the scattering of the magnetic field in order to improve the quality of flaw detection. The use of this device will prevent accidents, which are accompanied by energy and resource costs, as well as causing environmental pollution by fluids. Based on the above research results the management model of environmental safety of oil and gas well is suggested.*

1. INTRODUCTION

The increase in the volume of global oil and gas production is accompanied by both the introduction of modern methods of intensification of depleted fields and the search for the latest high-beta deposits. At the same time the number of drilled wells carrying potential

ecological risk to the environment is growing. These facilities pose a threat to the environment both during regulated technological processes and during emergencies.

Emergency mode during construction, operation and overhaul of a well may arise due to various factors, the following complex technogenic accidents - open oil and gas fountains. They are extremely dangerous for the surrounding areas and settlements, whith corresponding effects the economic costs.

Most often the following scheme works at enterprises: an emergency situation → economic damage calculation → determination of social damage (if a claim is made) → determination of environmental damage (if a claim is made). Unreasonable data regarding the probabilities of emergencies and consequences (economic, social and environmental) or a one-sided assessment of the occurrence of an undesirable event without systematic identification of all possible consequences is the main problem in determining risks.

Trends of modern environmental policy of oil and gas complex of Ukraine demonstrate the desire of oil and gas companies to improve the environmental management system to meet the requirements of the EU and strengthen the sustainable position in the European market. Such transformations of environmental safety management are reflected in the environmental modernization of modern production, as well as improvement of the relationship of the institutional system of society with the environment.

2. ANALYSIS OF THE CURRENT STATE OF THE EMERGENCY PREVENTION SYSTEM AND TECHNOLOGICAL SOLUTIONS OF EQUIPMENT AT OIL AND GAS FACILITIES

In the conditions of modern development of production there is a need to overcome or at least partially minimize the identified contradictions between the level of technological process and the means that support the environmental safety of human life and protect his health from the negative effects of industry [1]. In the work [2] it is observed that environmental management becomes preventive in nature, that is, to prevent the emerging of environmentally hazardaos substances of production processes, rather than the elimination of already produced pollution by using high-cost cleaning systems.

Despite the constant improvement of equipment, means and systems of emergency diagnostics and protection during the life cycle of oil and gas wells, there is a possibility of uncontrollable or poorly controlled phenomena and processes, classified as an accident and posing a particular danger to the biosphere and, above all, to the population [3]. The practice of foreign oil and gas companies shows the need to develop predictive systems to be able to respond quickly and clearly in case of emergency situations and special attention to preventive measures. The complex technogenic impact on the components of the natural environment can often have irreversible negative consequences. The experience of the last 10 years shows that

economic, environmental and social problems cannot be solved in isolation from each other. The anticipation and prevention of problems by planning and forecasting is more economically advantageous compared to the costs of eliminating their consequences [4].

Lifecycle management system as one of the significant elements of environmental management systems is aimed at minimizing environmental and socio-economic problems associated with a product or product range during its life cycle and value chain. The lifecycle management system allows you to quickly track the life cycle and balance of the product and carry out continuous improvement of the productive system [5]. In the scientific work of Stremberg L.M. it is noted that life cycle assessment (LCA) is a systematic approach to determine the environmental safety of the object and a tool for the initial stage of environmental impact assessment [6]. DSTU ISO 14040:2013 [7] states that LCA usually does not cover economic or social aspects of products, but the approach and life cycle methodology described in DSTU ISO 14040:2013 can be applied to these aspects as well. The use of eco-efficiency methodology in LCA is noted in the work of A. C. Kokossis, F. Thompson, and T. K. Das [8].

Given the above facts, attention is paid to the diagnostic systems of deep pump rods and existing defectoscopy system designs. The rods work in difficult conditions due to high temperature, aggressive environment, high dynamic and cyclic loads. The failure of rods in the well is a difficult economically costly emergency situation. The rod magnetic flaw detector is known [9], containing a frame with a magnetic flaw detector system. The magnetic system of this flaw detector is quite complicated and low-tech in manufacturing and the possibility of its operation in industrial conditions directly on the oil producing well.

The known magnetic flaw detector [10], containing a frame, a magnetizing articulated system attached to it in the form of a Π-shaped magnetic wire with permanent magnets. There is also a magnetic field sensor, connected with electronic recording equipment. The main disadvantages of this magnetic flaw detector are that: the flaw detector of this design cannot be used on the well in the process of running the rods (in the vertical position); the limitation of diameters, controlled from 30 mm to 130 mm, and the diameter of the rods from 13 mm to 28 mm, which cannot be controlled by this flaw detector; this flaw detector controls only the inner surface of pipes, and rods are solid round shapes.

The known flaw detector [11] contains a frame with a magnetizing system installed on it, made in the form of a Π-shaped magnetic wire with permanent magnets connected to the ends of the magnetic wire hinged. There is a magnetic field sensor connected to the electronic recording equipment. The disadvantage of the known magnetic flaw detector is that it cannot operate in the vertical position when lowering the rods into the well. Also the connection of the ends of the magnetic wire and the permanent magnet hinged contributes to the dissipation of the magnetic field, which reduces the quality indicators of the whole magnetic flaw detector.

Analysis of the current state of the system of prevention of dangerous situations at the objects of the oil and gas complex shows the need to improve the current system, which would avoid the identified shortcomings.

3. ENVIRONMENTAL MANAGEMENT OF THE LIFE CYCLE OF OIL AND GAS WELLS

Given the current situation in the oil and gas industry, there is a need to develop environmental management of a preventive nature, where the priority aspect is the focus on the prevention of dangerous processes for the environment during production processes. Management approaches based on the elimination of harmful effects, which have already happened; need to be reformed in prevention. Such transformations of management of ecological safety should be realized by modernization of modern production with the use of eco-efficient technologies and approaches, as well as improvement of interrelations of institutional system of society with the environment [12, 13]. The environmental management system is a tool for the development and implementation of environmental policy and environmental management aspects in order to ensure the environmental safety of the population and the environment.

The condition of the environment within the location of oil and gas production facilities is subjected to intensive technogenic impacts. "Oil and gas production object (oil and gas well) - the natural environment" is a complex multifactor system with diverse internal and external relations. The study of the system "oil and gas well - the environment" should be carried out taking into account the method of structural division into separate time intervals - stages of the life cycle. Each stage should be studied from the position of environmental safety and identify objects and processes that require improvement to improve the environmental performance of production. It is important to assess and predict environmental hazards in production to prevent their occurrence, which is more economically beneficial. In the environmental risk management system, it is necessary to identify the cause-and-effect relations of the occurrence of environmentally hazardous situations. For this purpose, the method of Ishikawa diagram construction was applied, which allows visualizing the actions of possible factors and identifying the most influential causes leading to an undesirable outcome. The diagram identifies the factors that can be managed. Thus, a diagram of the factors influencing the occurrence of environmentally hazardous situations at oil and gas production facilities was built (*fig. 1*).

On the basis of the constructed scheme, it is possible to trace the factors and their influence in the formation of ecologically dangerous situations in oil and gas production. These factors are determined on the basis of the analysis of the causes of formation of hydrocarbon production wells in different conditions and at different stages of the life cycle according to the materials of Kuzmenko V.A. [14]. 100 wells were chosen for the research. Often a combination of several factors at one well was observed, among which the organizational factor should be noted. Human error can occur both in the design and manufacturing phases of drilling

equipment, that is, before work begins on the rig site and in decision-making at the time of an emergency.

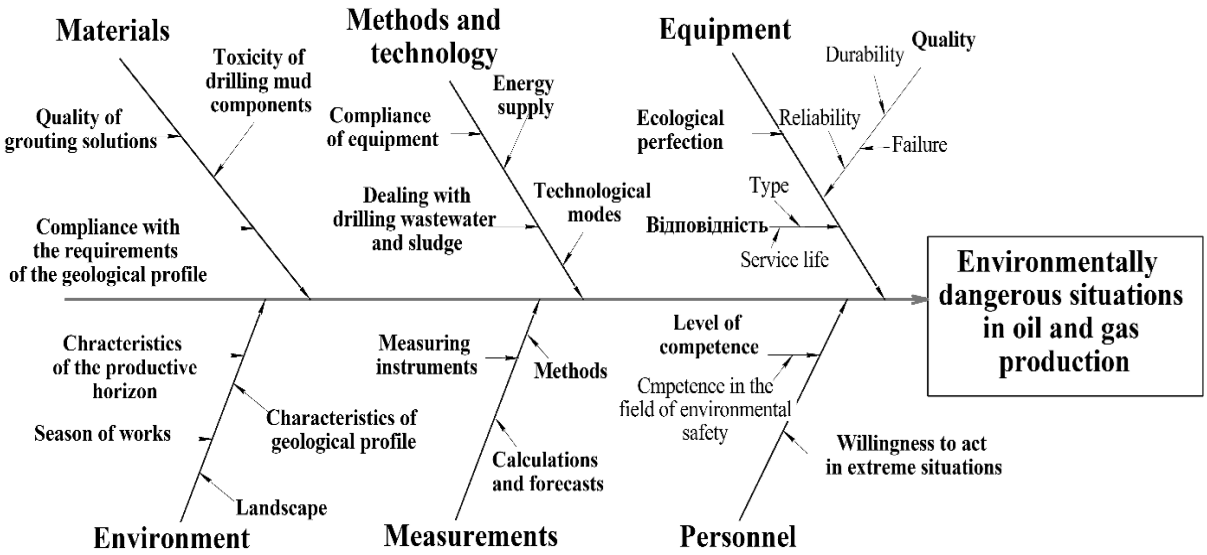


Fig 1. Scheme of factors influencing the occurrence of environmentally hazardous situations at oil and gas production facilities

The main number of open fountains is observed at gas fields. This is explained by peculiarities of construction of gas wells and probable underestimation of dangers that may accompany this process. There is also an adaptation of oil field fracturing technology and techniques to gas fields. Fountains can be caused by opening of lower productive horizons without overlapping the upper ones, especially with abnormally high formation pressure. Also, a high frequency of occurrence of accidental fountains occurs during exploratory drilling.

When examining the accident sites, sources of information did not indicate such factors as obsolete equipment, untimely replacement of equipment that has expired, lack of preventive repair work [15]. However, for the specifics of the oil and gas production industry of Ukraine, the wear and tear of equipment is an extremely acute problem. It is important to note the fact that the equipment, used its working life, is present not only at the stages of well construction, but also on the wells, taken out of operation (abandoned wells), which often remain without control of the responsible organizations [16]. This state of affairs forms a high risk of emergencies, including gas oil and water manifestations and open fountains. Thus, the environmental safety of oil and gas facilities can be assessed in terms of the impact of these facilities on the environment and in terms of the equipment of production with modern environmentally safe technologies and equipment.

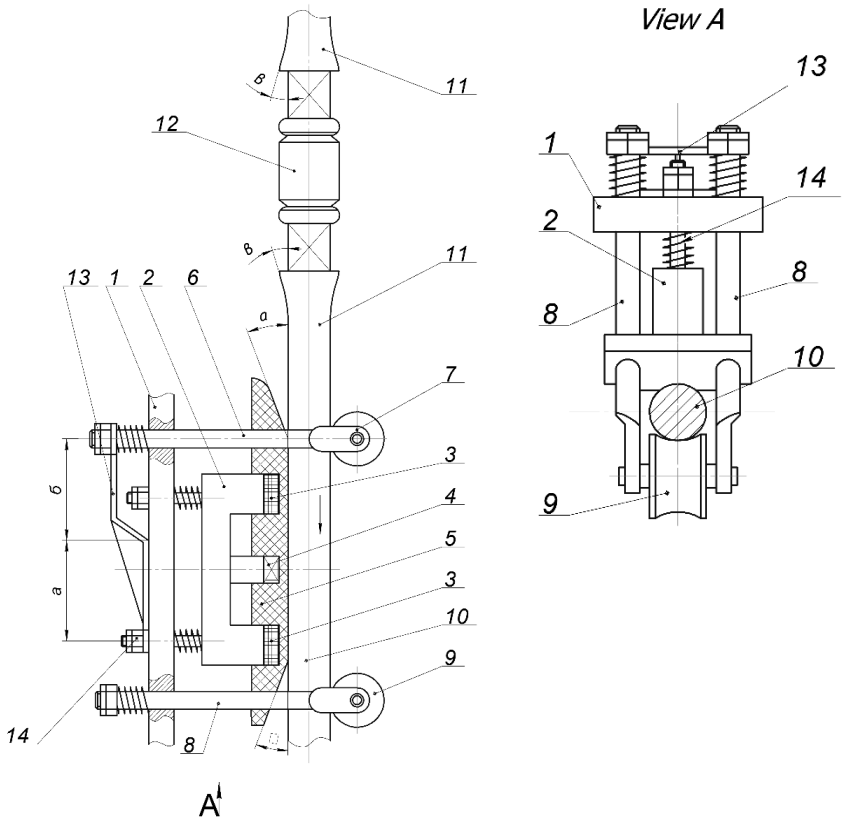
4 SYSTEM OF DIAGNOSTICS OF DEPTH PUMP RODS DEFECTS

The rods are the main element through which the drive - the forward movement of the downhole plunger pump in the process of oil production is carried out. As noted, rods work in difficult conditions, also wells may not be strictly vertical, but curved, which creates additional unfavorable conditions for sucker rod operation. All this will accelerate rod failure if there are even minor defects in them. It takes a lot of time and high-cost equipment to eliminate boom-related accidents. Defects on rods may appear during transportation, storage and handling. Therefore, it is advisable to inspect the rods directly during lowering into the well and remove the rods with defects, which will quantitatively reduce the occurrence of extreme (emergency) situations related to the rods.

The main purpose of development of this device was to reduce the emergency situations with the rods of deep-well pumping units by preventing the launch into the well of the rods with defects. Improvement of the rod magnetic flaw detector was made by reducing the dispersion of the magnetic field in order to improve the quality indicators of flaw detection. Permanent magnets are rigidly connected to the ends of the Π-shaped magnet wire without additional magnetic cores. For protection against mechanical damage a protective element made of non-magnetic material is installed on the ends of the magnetic wire with permanent magnets and on the sensor. The Π-shaped magnetic core is connected to the frame of the spring-loaded guide rods. To keep the flaw detector in a vertical position when lowering the rods into the borehole, spring-loaded rods with rollers are installed in the holes on the frame and the protective element. The profile of the protective element surface ends made of non-magnetic material, contacting with the rod, is made at an angle corresponding to the dropout at the ends of the rods to ensure the possibility of the magnetic flaw detector transition through the dropout at the ends of the rods and the coupling. To ensure parallel lifting to the boom axis of the Π-shaped magnetic core with the protective element when passing the blasted ends of the rod, there is a lever balancing mechanism on the frame, contacting with two roller guide rods at one end. It, in turn, contacts the surface profile of the rods. The other end of the lever balancing mechanism contacts the lower guide of the spring-loaded Π-shaped magnet wire.

Fig.2.a shows a general view of the rod magnetic flaw detector in operating condition on the smooth part of the boom. A bottom view of the flaw detector on the boom in the working condition is shown in *fig. 2.b*. The rod magnetic detector consists of a frame 1 with a magnetizing system mounted on it. The magnetic system is made in the form of Π-shaped magnetic wire 2 with permanent magnets 3 and magnetic field sensor 4, located between the permanent magnets 3 and connected to the electronic recording equipment. The protective element 5 of a non-magnetic material (e.g. polyurethane) is to protect the permanent magnets 3 and the magnetic field sensor 4. The holes in the frame 1 and the protective element 5 are

equipped with upper spring-loaded pull rods 6 with a roller 7 and lower spring-loaded guide rods 8 with a roller 9. The element 5 with the blown ends 11 at an angle α contacts the controlled surface of the rod 10. Between the blown ends of the rod 11 there is a coupling 12, and on the frame 1 there is a lever balancing mechanism 13, contacting with the upper spring-loaded rods 6 at one end, and with the lower spring-loaded rod guide 14 Π-shaped at the other end.



a. *b.*

Fig 2. Rod magnetic flaw detector: a. - working position on the smooth part of the rod; b. - view A, bottom view.

The rod magnetic flaw detector operates as follows. The rod magnetic flaw detector is mounted on the first, boom 11, which is in vertical position as shown in *fig. 2*. It is descended into the borehole. The rods 10 are connected to each other by couplings 12 and create a rod string. The frame 1 with all the flaw detector elements in addition to the electronic recording equipment is held on the vertical rod 10 by spring-loaded tie rods 6 and 8 in accordance with the rollers 7 and 9. The magnetizing system in the form of a Π-shaped magnet wire. The rod magnetic detector is installed on the first rod 11 being in vertical position, as shown in *fig. 2* and is lowered into the borehole. The rods 10 are connected with each other by couplings 12 and create a rod string.

The frame 1 with all the flaw detector elements except for the electronic recording equipment is held on the vertical rod 10 by the spring-loaded tie rods 6 and 8 in accordance

with the rollers 7 and 9. The magnetizing system in the form of Π-shaped magnet wire 2 with permanent magnets 3 and the magnetic field sensor 4 by protective element 5 is pressed to the surface of the rod 10 by means of guiding spring-loaded rods 14. On the smooth surface of the rods 10 the contact of the magnets 3 and the magnetic field sensor 4 is made through the protective element 5. The ends of the contacting surface of the protective element 5 are made at an angle corresponding to the angle β of the dislocated ends 11 of the rods 10. The angles α and β are close in value. *Fig. 2.b* (view A, bottom view) shows the location of the frame 1, the magnetizing system in the form of a Π-shaped magnetic core 2, the lower spring-loaded rod 8, the roller 9, the rod 10, the lever balancing mechanism 13 and the lower guide spring-loaded rod 14.

At the approach of the drop-out end 11 of the rod 10 to the defectoscope the roller 7 goes to the drop-out 11, moving the spring-loaded tie rods 6, and the tie rods 6 press the upper end of the lever balancing mechanism 13. Simultaneously with the roller 7 on the landing 1 to the axis of the rod 10 Π-shaped magnet wire 2 with permanent magnets 3, magnetic field sensors 4 and protective element 5, the lower end of the lever balancing mechanism 13 moves the lower spring-loaded link 14 Π-shaped magnet wire 2.

In addition, to ensure synchronous movement parallel to the axis of the rod 10 of the Π-shaped magnet wire 2 with all the elements connected to it. The distance between the pivot axis of the lever balancing mechanism 13 to the axis of the lower underrun rod 14 "a" and to the axis of the upper spring-loaded rods 6 "b" should be equal. Passing the blasted ends 11 of the rods 10 with couplings 12, the rod magnetic flaw detector without stopping continues to perform the necessary functions.

Application of this device will prevent emergencies, which is accompanied by energy and resource costs, as well as leads to environmental pollution by fluids. The proposed design of the rod magnetic flaw detector has been granted a patent for a useful model.

5. CONCLUSIONS

According to the methodology of life cycle assessment, the oil and gas production industry requires significant modernization in the direction of greening both the consciousness of the personnel of different levels, and all the processes and equipment. Using the methodology of life cycle assessment, it is proposed to determine the stages in the life cycle of oil and gas industry facilities, which require priority attention in terms of technological and technical improvement

Based on the analysis of the factors of emergencies, a technical solution is proposed to prevent the creation of conditions favorable to the emergencies. The system of equipment diagnostics was improved, including defectoscopy of downhole pump rods. The system allows identifying the defects of the rods and extracting them before they get into the well,

thus preventing emergencies that are potential sources of environmental pollution. The flaw detector design provides for the reduction of the magnetic field scattering, which improves the flaw detector quality characteristics and allows the flaw detector to pass smoothly through the dropout at the ends of the rods and couplings.

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RISKS ON AQUATIC ENVIRONMENT RELATED TO WASTE OF PRINTED CIRCUIT BOARDS (PCB_s)

Irina **SMICAL**

North University Centre of Baia Mare, Technical University of Cluj-Napoca, Engineering of Mineral Resources, Materials and Environment Department, 62A, Victor Babes str, 430083, Baia Mare, Romania,

irina.smical@irmmm.utcluj.ro

Keywords: printed circuit board (PCB), WEEE, risk, heavy metals, aquatic

Abstract: *Integrated circuit boards are component of most Waste Electrical and Electronic Equipment (WEEE). These are generated worldwide at an alert rhythm and their recycling is done to a small extent (about 20%). The paper presents an experimental simulation of the presence of printed circuit board waste (PCBs), from end-of-life computers, in three aquatic environments with different pH (pH 4.00, pH 5.63 and pH 8.00). After stagnation for 17 weeks, values of the concentrations of heavy metals released by the PCBs in the solutions were obtained. These indicated that the presence of these boards in aquatic media may impair water quality by inducing moderate risks for surface water and lower risks for groundwater bodies. Heavy metals such as copper and lead, especially in acidic and neutral environments, fell into the worst quality class for surface water and exceeding of the maximum allowable value for the reference groundwater body (ROSO12) were recorded for copper in the acid and neutral initial solutions.*

1. INTRODUCTION

The printed circuit board (PCB) is a flat, rigid and insulating material with two complementary functions: one for fixing electronic components and the other for providing reliable electrical connections. Thin geometrically conductive structures (rectangles, squares, circles) function as interconnections or connecting points of components [1].

Printed circuit boards (PCBs) are considered hazardous waste and they are part of most of the Waste Electrical and Electronic Equipment (WEEE) being about 3-6% by weight of the total amount of WEEE. PCB contains about 28% metals and almost 70% non- metallic materials [2, 3, 4].

WEEEs are regulated in Europe by Directive 2012/19/EU and implicitly, by transposition, in Romania by GEO no. 5/2015 on waste electrical and electronic equipment [5, 6]. In over 66% countries worldwide WEEE are managed under specific regulations [7].

Although in most countries there are systems for the selective collection of waste electrical and electronic equipment from households, some of them end up being dumped together with other municipal waste on landfills, thus leading to contamination risk of environmental factors, especially surface water and groundwater. The solution is to apply the principles of the circular economy to prolong the life of the product, to recover and recycle this waste as much as possible to save natural resources and minimize the disposal of waste [8].

Globally, statistics indicate a WEEE generation of 6.1 kg/inh in 2016, compared to 5.8 kg/inh generated in 2014 [7]. The report by Balde et al., (2017) indicates a sharp increase in WEEE given that the recycling rate is quite low [7]. Of the 44.7 million tons (Mt) of electrical and electronic equipment waste generated worldwide, only 20% was recycled by appropriate methods [7]. In Europe, in 2018, an average of 8.9 kg/inh was collected, and 45% of Member States reached or exceeded the collection target and 4 other countries were very close to this performance. The largest quantities collected were recorded in countries such as: Sweden (14.2 kg/inh.), Austria (13.2 kg/inh.) and the smallest quantities were collected in countries such as: Romania (2.4 kg/inh), Lithuania (5.1 kg/inh) [9]. Romania has failed to reach the target of 45% of the average amount of EEE placed on the market in the previous 3 years [10].

Compared to the global average recycling of WEEE, the European WEEE recycling rate is higher. Therefore, in the period 2011-2018, the total WEEE collected improved from 3.0 to 4.0 million tons (+30.9%), the total WEEE treated increased from 3.3 to 3.9 million tons (+19.5%), total WEEE recovered increased from 2.7 to 3.6 million tons (+30.3%) and total WEEE recycled and ready for reuse increased from 2.6 to 3.2 million tons (+26.2%) [9].

In order to assess the risks of heavy metal contamination posed by printed circuit board wastes on environmental factors and especially on aquatic ones, several printed circuit boards from end-of-life computers were used to make a simulation of the reactivity conditions of the respective components in three aquatic environments with various pH: an acidic environment, one that simulates the rainwater and an alkaline one. The releasing of heavy metals was mainly pursued and the results were compared with the maximum allowed values provided by the Romanian legislation for surface water and groundwater.

2. MATERIALS AND METHOD

2.1 Preparation of printed circuit board samples

In order to test the releasing conditions of some heavy metals such as zinc, copper, lead, cadmium and arsenic, contained in the printed circuit boards, such components taken from various end-of-life computers were used (*fig.1*). After their separation, they were previously crushed and brought to a size of 1-4 cm.

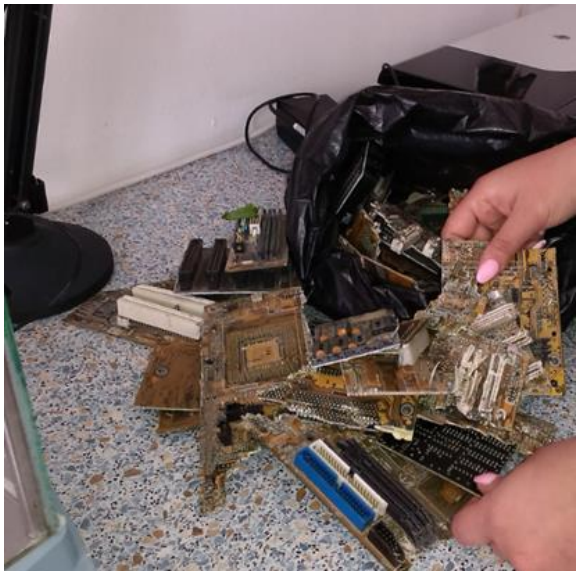

Fig. 1 Fractions of printed circuit board (PCBs)

In order to carry out the experimental part, the fragments of plates with integrated circuit were weighed so that 9 equal quantities could be obtained for their immersion in containers with solutions (3 replicates each) having three different pHs, thus simulating different liquid contact media. :

- alkaline medium, pH 8.00 (potassium hydroxide solution);
- natural environment, consisting of rainwater, pH 5.63
- acidic medium, pH 4.00 (glacial acetic acid).

The symbolization of the samples was as follows:

- For the sample with pH 4.00 the containers were marked with PI and replicates with a, b, c.
- For the sample with pH 5.63 the containers were marked with PII and replicates with a, b, c.

- For the sample with pH 8.00 the containers were marked with PIII and replicates with a, b, c.

The test of contacting the solutions with the PCBs was carried out in a ratio of 1:10 (mass of the boards to the volume of the solution) for 17 weeks, under controlled environmental conditions. The ambient temperature was kept constant at 20±4 °C.

Thus, 9 individual samples were obtained, monitored at intervals of 7 days.

After 17 weeks, the solutions in each sample were subjected to the determination of pH and heavy metals released from the immersed material.

3. RESULTS AND DISCUSSION

3.1 pH reaction of contact solutions

The pH of the solutions was measured at the beginning and the end of the experiment. This was determined using a WTW laboratory pH meter type 740.

It was observed that at the end of the experiment the pH of the solutions was higher than the initial one. Surprisingly, the PI sample (with initial pH 4.00) had an average pH above 9.0. Stagnation of PCBs in solutions with pH similar to rainwater (pH = 5.63) generated pH values above 7.00, in the case of the solution with initial pH 8.00, pH with an average value slightly above 10 (*fig. 2*).

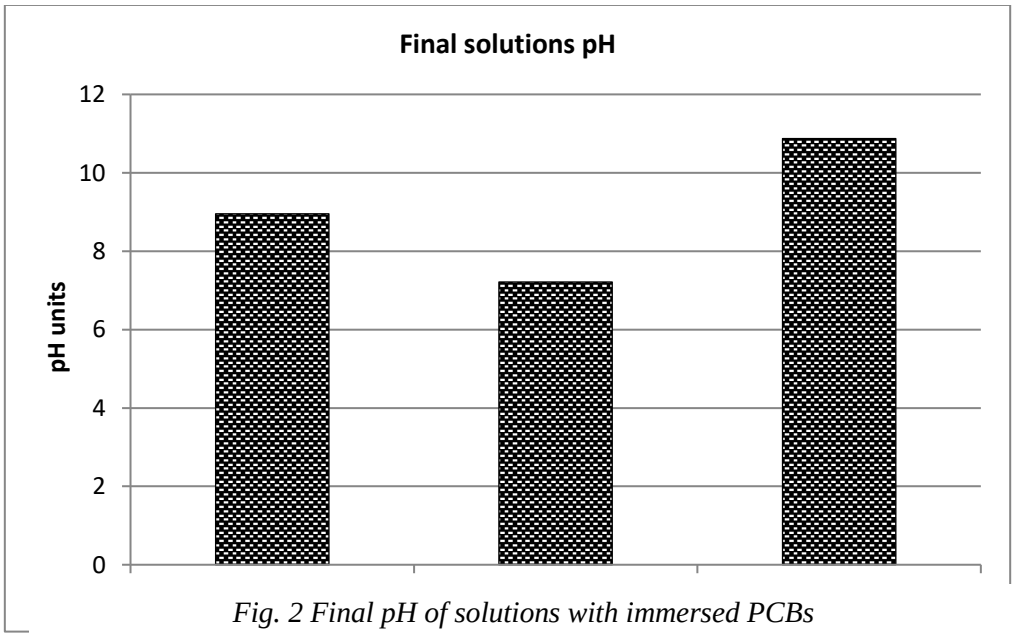

Fig. 2 Final pH of solutions with immersed PCBs

3.2 Determination of heavy metal content in solutions

At the end of the test period, after homogenization of the solutions, a volume of solution was collected from each of the three replicates (a, b, c) corresponding to each type of solution, so that the content of heavy metals in the mixed solution sample was determined.

Figure 3 shows an enhanced change in the color of the solution containing the printed circuit boards after 17 weeks of contact.

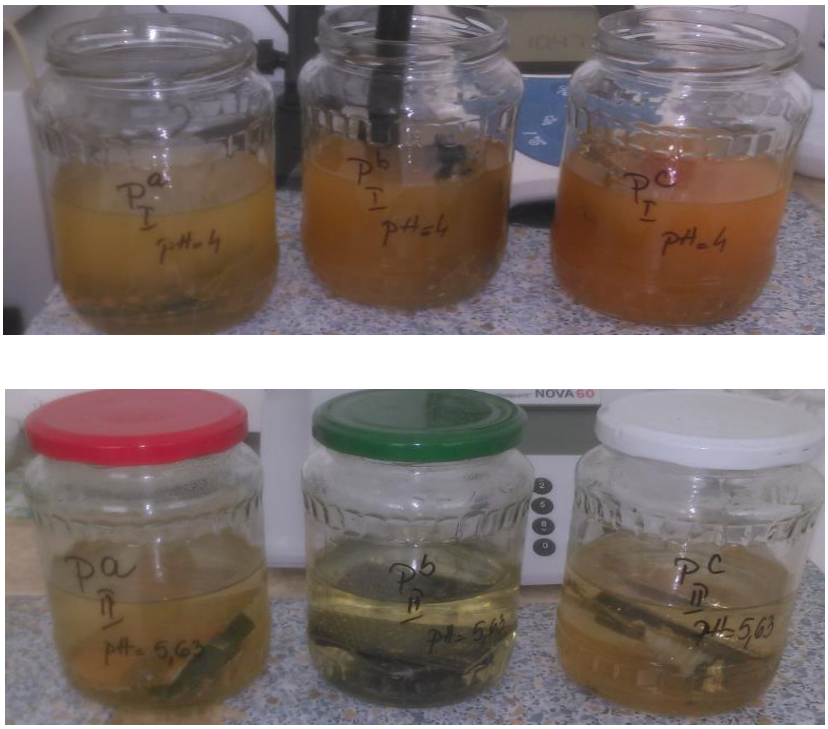

Fig. 3 The containers with solutions after 17 weeks

The sampled solutions were mineralized with regal water (HNO3: HCl = 1: 3), according to the standard SR EN ISO 15587-1: 2003- „Water quality. Mineralization for the determination of water elements. Part 1: Mineralization with regal water. ” [11], thus being prepared for the determination of metals of interest: zinc, copper, lead, cadmium and arsenic.

The metals were determined by flame atomic absorption spectrophotometry and graphite furnace, using an AAnalyst 700 atomic absorption spectrometer, manufactured by Perkin Elmer. The atomic absorption spectrometry analytical technique was performed on calibration curves, with the correlation factor $R2 \geq 0.950$, made from reference solutions with traceability to NIST (manufacturer Merck).

The values of the metal concentrations in the experimental solutions were compared with the limit values allowed for the surface waters provided by Order no. 161/2006 [12] (Table 1). It should be mentioned that quality class I refers to the best water and class V, to the most depreciated.

Table 1 Maximum allowable concentrations of metals of interest in surface waters [12]

Metal	*M.U.*	*Surface water quality class*				
		I	*II*	*III*	*IV*	*V*
Copper	*µg/l*	*100*	*200*	*500*	*1000*	*>1000*
Lead	*µg/l*	*5*	*10*	*25*	*50*	*>100*
Cadmium	*µg/l*	*0.5*	*1*	*2*	*5*	*>5*
Arsenic	*µg/l*	*10*	*20*	*50*	*100*	*>100*

Assuming the existence of extremely permeable geological layers, which would allow the penetration of solutions with the determined concentrations, entirely in the groundwater, these concentrations were reported to the maximum allowed concentrations for the ROSO 12 groundwater body, belonging to the Someș-Tisa river basin. 621 of 2014 [13] (Table 2).

Table 2 Maximum allowed concentrations of metals of interest in the body of water ROSO 12 [13]

Water body	*Zinc*	*Copper*	*Lead*	*Cadmium*	*Arsenic*
	mg/l				
ROSO12	*5*	*0.1*	*0.2*	*0.005*	*0.01*

Arsenic was the only metal of interest for which the method of determination was not sufficiently sensitive. The resulting values were less than 0.5 µg/l, which corresponds to the detection limit of the method.

Zinc was identified in all samples (PI, PII, PIII). In the case of surface water (table 1) it was classified in quality class III for all three samples (*fig. 4*). Also, its concentration was much below the maximum allowable limit of 5 mg Zn/l in the case of the reference groundwater body (Table 2).

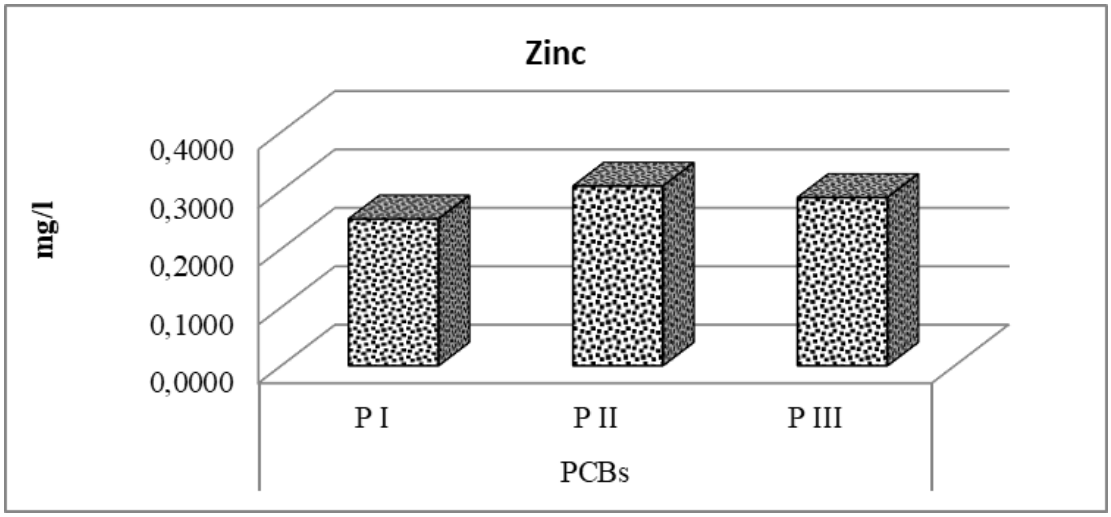

Fig. 4 Zinc concentration in solutions with PCBs

In the case of copper, regarding the quality of surface water, the concentration determined from the PIII solution fell into quality class I and the concentration of copper from samples PI and PII were much higher, falling into class V quality (table 1, *fig. 5*).

For the copper from sample PIII, it is noted that it falls within the maximum limit allowed for the reference groundwater body, but in the case of samples P I and P II the values obtained exceeded the maximum limit allowed by Order 621/2014 [13] (table 2, *fig. 5*).

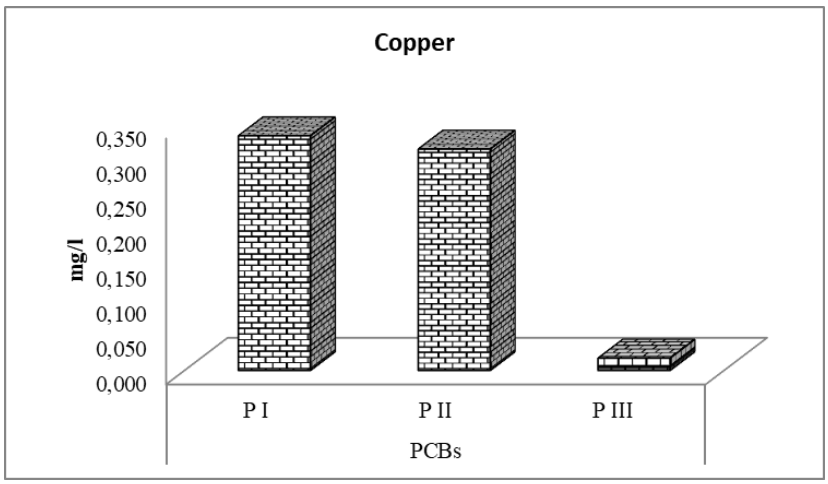

Fig. 5 Copper concentration in solutions with PCBs

The lead concentration in all three samples fell into V quality class of surface water (Table 1, *fig. 6*). Compared to the maximum allowed values for the reference groundwater body, the lead was below the maximum allowed limit (Table 2, *fig.6*).

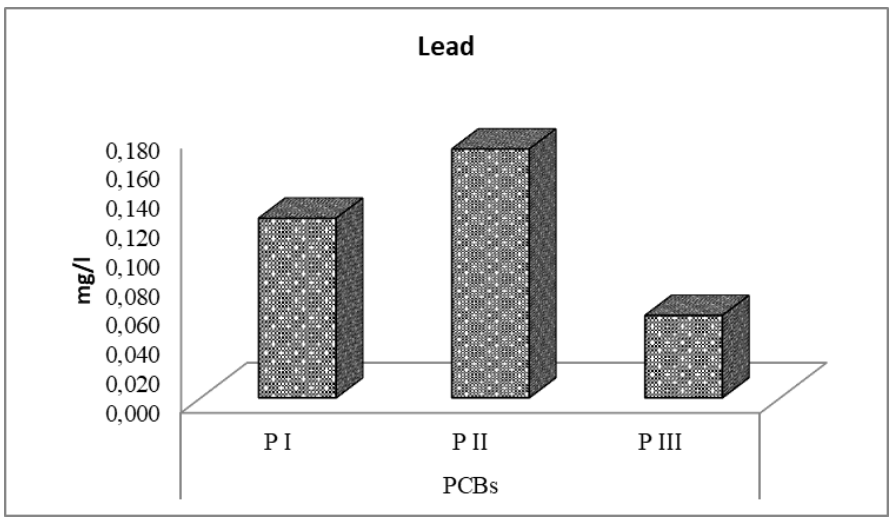

Fig. 6 Lead concentration in solutions with PCBs

The cadmium in the PIII sample was below the detection limit of the determination equipment. The cadmium concentration in the PI sample was in the II quality class of the surface water and the one in the PIII sample was in the III quality class for surface water (Table

1, *fig. 7*). Compared to the maximum allowed value for the reference groundwater body, it was noticed that all the values obtained were below this value (Table 2, *fig. 7*).

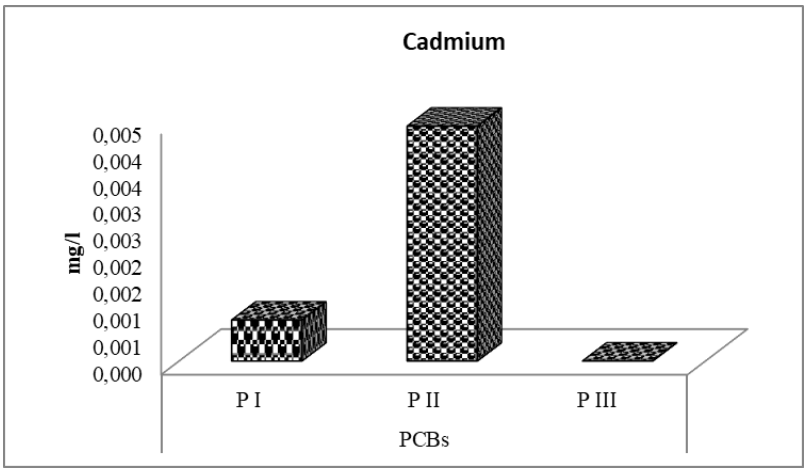

Fig. 7 Cadmium concentration in solutions with PCBs

4. CONCLUSIONS

As integrated circuit boards are components of most categories of WEEE, an experiment was performed to observe their chemistry in the aquatic environment. In this sense, integrated circuit boards were taken from several obsolete computers, which after a previous crushing and weighing were grouped into 9 equal parts. Separately, 9 containers with three pH solutions (pH 4.00, pH 5.63 and pH 8.00) were prepared to simulate different aquatic environments: acid, rainwater and alkaline. Fragmented plates and 1:10 solution were introduced into each container. After 17 weeks, the pH of the solutions and the concentration of heavy metals were determined: zinc, copper, lead, cadmium and arsenic. The values obtained were compared with the reference values for both surface water and groundwater. Thus, the zinc in the final solution was classified for all samples (PI, PII and PIII) in the class III of quality for surface water and below the maximum allowed for groundwater. In the case of copper, its value in the PIII test was in the class I of quality for the surface water and that one in the PI and PII samples was in the V quality class. The copper in samples PI and PII exceeded the maximum allowable value for the reference groundwater body while the copper concentration in sample PIII was below this limit. Lead, in all three PI, PII and PIII samples, was in the V class of quality for surface water and below the permissible limit for the reference groundwater body (ROSO12).

The cadmium in the PI sample was classified in the II quality class for surface water and the one in the PII, in the III quality class for surface waters. The cadmium in both PI and PII samples was below the maximum permissible groundwater limit. In the case of the PIII test, the value read by the device was below the detection limit. The same was the case for arsenic, the concentration of which was below the limit of reading equipment detection.

The experimental results indicate a moderate risk of the presence of PCBs in the aquatic environment for a period of 17 weeks. The metals with the highest incidence are: copper and lead and in a less share zinc and cadmium. Regarding the risk for groundwater, it can be stated that it is lower and can be conditioned by the geological and morphological structure of the area.

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ROMANIAN-UKRAINIAN TRANS-BORDER ACADEMIC DEVELOPMENT FOR RESEARCH AND INNOVATIONS

Lesya **SHKITSA**[1], Anamaria **DASCALESCU**[2], Cristian **BARZ**[3], Volodymyr **KORNUTA**[1]

[1] *Ivano-Frankivsk National Technical University of Oil and Gas, Engineering and Computer Graphics Department, Ivano-Frankivsk, Ukraine*

[2] *Technical University of Cluj-Napoca, North University Center of Baia Mare, Romania*

[3] *Association Academic Organization for Research, Innovation and Professional Development, Baia Mare, Romania*

shkitsa@gmail.com

Keywords: technical education, innovation development, student project groups, DIY ideology.

Abstract*: Establish a communication environment between Ukrainian and Romanian Partners - universities and NGO - with regional companies to use joint academicals research and innovation potential for real needs of companies, to improve exchange of good practice, the opportunities for cooperation over innovations. The ways of implementation of the project-oriented training principles in the technical university are presented, which will allow to actively involve students in scientific and innovative activities within the educational process and the performance of qualification work. The ways of increasing the innovative activity of engineering specialties students, which are proposed, include: Center of Innovation Development, equipped with modern technologies machine and tools, the researchers and students, who are able to create mockups and prototypes of their projects; database, which contains registration of companies needs of development and innovation, connects universities with economical actors; the information system, which provides documentary support to researchers and students' activities. This model of work allows the creation of associations, including cross-border, between different universities depending on the scope of tasks and the level of opportunities for implementation of decisions. The main results of the implementation of the international grant project RoUaTADRI "Ro-Ua Trans-border Academic Development for Reseach and Innovation" in the framework of the cross-border cooperation program Romania-Ukraine 2014-2020 are presented.*

1. INTRODUCTION

The general objective of the Romania-Ukraine Joint Operational Programme is to enhance the economic development and to improve the quality of life of the people in the programme area through joint investments in education, economic development, culture, infrastructure and health while ensuring the safety and security of the citizens in the two countries [1]. One of the underdeveloped fields in the programme area is research and development (R&D). The level of investment in this field is very low, although there is potential for its growth.

Cross-border educational collaboration can be a part of the much broader framework of cross-border collaboration for regional development. Collaboration between higher education institutions can support this endeavour by stimulating mutual research activities, boosting academic mobility and professional mobility of the graduates and fostering mutual understanding. Academic collaboration can provide a creative space for people from both sides of the borders.

The difficult task of education is to teach and encourage students to ask new questions, solve new problems and create new knowledge. Consequently, the triunity of knowledge, skills and motivation should be the basis of education in the modern century. Internal motivation, new skills, learning new material throughout life is the basis of success in innovation [2].

An important task of the system of higher technical education is the training of specialists for innovation and project activities. The analysis of pedagogical practice and theoretical research allows determining the project activity as means of developing competence, in the course of which the evolvement of professionally important qualities of a specialist, formation of his key competencies take place (The CDIO™ Initiative is an innovative educational framework for producing the next generation of engineers) [3]. The concurrence of the subject-oriented (skill-oriented) and project-oriented management of the educational process in the institution of higher education is a separate problem.

Therefore, in order to ensure the goals of sustainable development in the conditions of accelerated evolution of the industrial and economic system, higher education should be sufficiently dynamic, and the experience and achievements of the best educational systems of the world should be used as a roadmap of change [4].

In the future, the university campus will become a precinct that interfaces university and society, with start-ups, community organizations and social enterprise intermingling with the students: there will be full integration with society and industry. Universities will remain vital places for the development of global citizens; a university thinks internationally, is based in the local economy, but works for the purpose of national and regional development [5].

Europe has a solid research and industrial base and is the home of bold, creative entrepreneurs. Yet it often needs to strengthen the use of its scientific excellence and industrial prowess to accelerate innovation and turn innovative SMEs into global technology giants. By reinforcing close cross-border collaboration between multiple actors, including academia, the public sector, industry and individual entrepreneurs, Horizon Europe aims to develop radical solutions to pressing societal challenges and fostering sustainable economic growth and employment. Through its Pillar III 'Innovative Europe', the Programme will focus on supporting the development of disruptive and market-creating innovations and on enhancing European innovation ecosystems [6].

National Sustainable Development Strategy Romania 2013-2020-2030 [7] underline the necessity of building and maintaining a broad partnership for innovation. As a result of Ro Government's specific commitments, it is expected that active base of human resource involved in research-development-innovation TDI (related to population) to converge towards the European Union's average. The priorities of intelligent specialization involve defining and consolidating areas of high competence in which are real or potential comparative advantages that can contribute significantly to GDP. By concentrating resources and mobilizing a critical mass of researchers, these domains can ensure, including in their regional dimension, competitiveness on regional or global added value chains.

Ukrainian State Strategy for Regional Development for 2021-2027 [8] provides for ensuring the development of cross-border, inter-municipal and macro-regional cooperation in the development and implementation of joint sustainable development projects and creating conditions to encourage regions and local communities to cooperate and implement joint interregional projects.

Ivano-Frankivsk National Technical University of Oil and Gas (Ukraine) together with the Technical University of Cluj Napoca - North University Center of Baia Mare and Association Academic Organization for Research, Innovation and Professional Development (Romania) implement the project "Ro-Ua Trans-border Academic Development for Research and Innovations" (RoUaTADRI) aimed at creating pre-conditions for sustained cooperation in the fields of research and innovation [9].

General objective is to increase the potential of development, research and innovation in mechanic, electronic, environment protection domains in order to reduce technological differences and to contribute to economic development of trans-border region. The achievement of this goal involves accomplishment of at least the following objectives: to establish a communication environment between universities and regional companies to joint academical research and innovation potential with companies' real needs; to support researchers and students in developing new competencies in modern technologies; to create for the students new competences for innovation and involve them in research and innovation projects, increasing the quality of students projects by creating competition premises.

2. SEARCH

An important step for straightening the collaboration of regionals' researchers from universities and NGO research domain is the development of “International Society of Innovators and Researchers” (ISIR). The activities of the partnership aim at promotion of regional problems identifying suitable for common solutions, innovative way of development, facilitating the joint research development, raising the level of economic security of innovators through the history of partnership cooperation, creating conditions for proposals regulatory change (local, regional, cross-border), training youth in innovation and modern technologies.

One of the tools of ISIR's is the "open innovation model". The European strategy for innovation development involves the development of open innovation, which is realized through interaction between business, research institutions and civil society. The idea of a European open-source cloud (EOSC) was formed by the European Commission in 2015, which will become a virtual environment for all researchers in Europe to store, manipulate, analyse and reuse them for research, innovation and education. It must provide both general functions and local services for the individual community. EOSC unite existing resources through national datacenters, European e-infrastructures and research infrastructures [10]. The creation of the EOSC aims at removing the technical, political and human barriers that hinder the creation of knowledge and economic prosperity in Europe.

The information system with the WEB-interface is accepted as the technological basis of interaction. The need to develop a separate information system is predetermined by the European Strategy for Innovation Development. The strategy envisages the creation of national and regional units of the modern research infrastructure of the EU and the provision of access to open data and knowledge in the single digital European market. The proposed information system improves the interaction of existing information systems of universities. The development of the information system will help to accumulate the experience of creating a joint of modern research infrastructure. The effective operation of ISIR at Trans-border Academic Development for Research and Innovations (further in the text - RoUaTADRI) in the direction of systematization, promotion and dissemination of innovation is complicated without the development of the information system. The accumulated experience of introducing open innovation model during the operation of the ISIR informational system within the framework of the project will be used to assemble recommendations to introduction of open innovation model at universities at regional and state levels. ISIR will also contribute to the achievement of strategic common goals for the development of Europe and cooperation with Ukraine.

Effective activity of the RoUaTADRI implies the involvement of innovative activists (researchers, engineers, entrepreneurs). Support at the information and legal level, attracting researchers to cooperation is a necessary, but insufficient condition to stimulate innovation

development. To ensure the availability of modern hardware and elemental base, the development of contacts with suppliers of equipment, materials and components is a necessary element. The Centre of Innovation Development (CID) will serve as a tool to achieve this. First of all, CID is the premises on which the local ISIR center will be based. The room will be divided into two zones - the informational co-working area and the technology zone. The informational co-working zone is the space, equipped with workplaces with a network connection. The technology zone is a space equipped with modern digital equipment, automated tooling for prototypes production [11].

Fig.1. Center of Innovation Development, Ivano-Frankivsk, Ukraine

Fig.2. Open Center of Innovation Development, Ivano-Frankivsk, Ukraine

The technological experience of the Romanian partners and the greater experience of Romania's integration into the EU is a valuable advantage of this partnership for Ukraine, while the high level of penetration of higher education on the Ukrainian side is its advantage in finding partners for the mutual implementation of projects with Romania. But the introduction of the proposed instruments will enable not only bilateral cooperation. After all, similar problems are also present in any cooperation with European countries.

The implementation of the CID on both sides of the border (*figures 1-3*) will enable the work on joint projects, realizing them on the same technological basis. The need to create technology zones within the framework of the project is due to the lack of investment in JOP areas of R&D, and, accordingly, the lack of a modern technological innovation base. One of the main areas of the Canter's activities will be training about the use of modern technologies, providing and improving the skills of working with CNC machines. Researchers will be able to create prototypes for the development of know-how and the establishment of a reasonable price in a non-specialized unit production. The available technological base and innovative expertise of participants in the ISIR will provide a stimulus for innovation, a fundamental opportunity to implement the internal innovation potential of JOP areas of action.

Fig. 3. Center of Innovation Development, Baia Mare, Romania

Scientists from the two countries have prepared joint textbooks based on the use of equipment from two established centers of innovation development, in particular:

- Handbook on CNC machines programming.
- Handbook on Design &3D prototyping.
- Guide on innovation in mechanical domain.
- Guide on innovation in electrical domain.
- Training material for Course: Basics of innovative activity for high school students.

The proposed project makes possible further academic development for research and innovation of actual project implementation for the relevant regional production plants. The

created Innovation Development Canters (CIDs) will increase the competence of researchers and students in modern equipment usage; will make possible producing the real prototypes of innovative products. The project achievement and distinguished feature will be the preparation of human potential able to solve the actual challenges of society, production to strengthen innovation development.

DIY ideology is taken as the basis for promoting innovative development. There has been proposed special laboratory with equipment, which would be a center of innovation development for students. As a result of the implemented project the student will acquire knowledge, skills and possibly equipment suitable for immediate use in the labour market or to implement their own projects. The proposal for the implementation of projects, proposed by potential employers or through own challenges/problems of potential students, the availability of infrastructure for the projects, the availability of supplies, spare parts, contacts with suppliers, the executed projects (portfolio) is the basis for the increase of the interest in technical education. The modern university has to be a sort of business incubator and the "first job" for its graduates.

Realization of innovative projects also can act as a catalyst for investment in innovation by local population, the results of projects will be a clear reflection of the benefits of innovation development, their impact on improving the living standards of users and improving their economic ability.

In general, the implementation of the above mentioned tools will provide the achievement of the following results: improved collaboration between researchers of the two regions involved in common research ideas and in development of companies' projects; increased amount of information about companies' development, research & innovation needs in Ivano-Frankivsk and Maramures Counties; improved researchers and students' competencies in modern technologies, such as 3D printing - scanning, virtual reality for modelling, robots manipulation, CNC machines, renewable energies; developed infrastructure enabling researchers to create the experimental model in minimum time after registration and selection of ideas; increased number of joint research activities, researchers and students from the two countries involved in development of innovative projects; increased number of students' projects involving new technologies determining improved students' projects quality.

CID's equipment (f*igures 4-5*) may also be based on existing technological equipment. Even outdated or unassembled machine equipment (if its massive and precise parts are available) in modern conditions can easily be modified by adding modern electronic and mechanical components. It is clear that each case is individual, but the development of such projects is possible for modern technical HEI even within the educational process (for example, in the form of complex qualification works).

Fig.4. Equipments of Center of Innovation Development, Baia Mare

Fig.5. Equipment of Center of Innovation Development, Ivano-Frankivsk, Ukraine

The possibility of the realization of such projects appeared as a result of progress in the production of engines, systems of numerical data processing and CNC in particular. The globalization of markets, the possibility of direct cooperation between manufacturers and potential buyers, the development of common education and the broad usage of numerical devices in everyday life played an important role in providing such a possibility.

The CID will provide the functioning of the information and reference system. The system includes the following modules: registration of tasks; formation of project groups; organization of the distribution of time and material resources during the implementation of a specific project and between projects; an electronic directory of implemented projects and a database of documents for the verification of project results.

The module of the formation of project groups provides the implementation of several role functions: a student who joins the task performance; a teacher who assesses the task for compliance with a particular discipline and offers the number of points a student can gain upon completion of the assignment; a representative of the stakeholders, who proposes tasks and evaluates their solutions.

The Database will contain registration of companies' needs of development and innovation and connect universities with economic actors, growing the involvement of researchers and students in regional companies' future development and the responsibilities of highly qualified human resources in regional development. Joint projects that insure the learning through projects are developed. The tutor for company-end coordinator for university is conducting the project development ensuring the quality of the results. Along with theoretical development of the project, the main component is the practical result obtained using CID's equipment.

3.CONCLUSIONS

The ways of increasing the innovative activity of engineering specialties students, researchers, local entrepreneurs which are proposed, include: Center of Innovation Development, equipped with modern technologies machine and tools, the researchers and students, who are able to create mockups and prototypes of their projects; database, which contains registration of companies needs of development and innovation, connects universities with economical actors; the information system, which provides documentary support to researchers and students' activities. This will help achieve the following results: increased amount of information about companies' development, research & innovation needs; improved researchers and students' competencies in modern technologies; developed infrastructure enabling researchers to create the experimental model in minimum time after registration and selection of ideas; increased number of joint research activities, researchers and students involved in development of innovative projects; increased number of students' projects involving new technologies determining improved students' projects quality.

The main function of CID in the context of cross-border cooperation is similar to one of the functions of the FabLab network - ensuring equal access to modern technologies on both sides of the border. Although in FabLab this feature contributes to a simple transfer of technical

developments, in the context of CID it is a function of promoting joint development of innovation through the equalization of technological capabilities.

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DISCUSSING EMPLOYABILITY SKILLS IN ENGINEERING HIGHER EDUCATION

Luminița **TODEA**, Anamaria **FĂLĂUȘ**, Ramona **DEMARCSEK**
Technical University of Cluj- Napoca; Faculty of Humanities, Baia Mare,
luminitatodea@yahoo.com

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Abstract: *The employability of graduates has become an issue that countries around the world have imposed on their national higher education systems to varying extents. Acquiring effective employability skills becomes increasingly important for both employers and employees in the field of engineering. Employers generally see a graduate's achievements related to the subject discipline as necessary but not sufficient for them to be recruited. Achievements outside the boundaries of the discipline, the so-called soft skills, are generally considered to be relevant in the recruitment of graduates. A certain level of awareness among engineering undergraduates should be addressed regarding lacking or mismatching specific soft skills required in their potential workplace context. Therefore, the purpose of the article is to identify and discuss engineering students' perception on the importance of employability skills such as: communication skills, problem solving and interpersonal skills so that they should overcome problems in getting suitable jobs in the future.*

1. INTRODUCTION

The higher education curriculum must be designed so that graduates should be prepared to face the challenges they would encounter in their future careers and to overcome problems in getting suitable jobs by understanding employability skills and their dimensions. Training work-ready engineering graduates can be achieved by integrating technical knowledge and skills learned at university with employability skills required by industry. In order to perform their knowledge and technical skills effectively, engineering graduates should acquire a set of employability skills such as communication skills, problem solving and interpersonal skills properly.

The purpose of the article is to examine the evidence related to what employers seek when recruiting work force in terms of characteristics, skills, and qualifications, and to discuss a selection of engineering employability skills that have been identified by undergraduate students in the field of Electronics and Information Technology as important and relevant to their future professions.

2. EMPLOYABILITY SKILLS – DISCUSSING THE CONCEPT

Nowadays employers emphasize the need for trained work force with certain fundamental skills that contribute to an effective working environment, which are professionally named employability skills. Engineering employability skills, also known as generic skills, are highly related to non-technical skills. Nevertheless, it has been argued that young people enter the professional world without sufficient employability skills and understanding which are necessary to succeed in the working context.

According to [1] the term skill is defined as:

a. the ability to use one's knowledge effectively and readily in execution or performance.

b. dexterity or coordination especially in the execution of learned physical tasks.

c. a learned power of doing something competently, a developed aptitude or ability.

Technical skills also identified as hard skills are defined according to www. the-definition.com as "job-specific knowledge and techniques needed to proficiently perform tasks that require particular expertise; occupation/job-specific skills" or "job specific tasks directly necessary for successful completion of the job." [2] Furthermore, soft skills / core skills/ key skills refer to people's abilities to communicate with each other and work well together, such as communication, leadership ability, teamworking, motivation, willingness to learn and problem-solving. They vary less from one industry to another, and complement technical or hard skills, which are specific to different branches of engineering. During the recruitment process, the importance employers place on soft skills depends on the nature and requirements of the job. Assessing how soft skills are measured precisely is challenging as it is usually based on employers' perceptions of their interaction with candidates at interview. [3]

Yorke and Knight (2006) explain employability as a set of skills, understandings and personal attributes that make graduates more likely to gain employment and be successful in their chosen occupations with advantages towards themselves, the workforce, and the community. The concept implies something about the capacity of the graduate to function in a job, but, nevertheless, this is not to be confused with the acquisition of a job. "Employability is a multi-faceted characteristic of a person, a set of skills, knowledge and personal attributes that make an individual more likely to secure and be successful in their chosen occupation(s) to the benefit of themselves, the workforce, the community and the economy." [4] Along with

employers' opinions, employability may be defined as 'work readiness' which refer to the possession of the skills, knowledge, attitudes, and commercial understanding that will enable graduates to make productive contributions to organizational objectives soon after commencing employment. [5]

Employability skills are described as a range of competencies or abilities that are necessary for graduates to gain success in the labor market at all employment levels; attributes or transferable skills that support individuals to adapt and progress in their work in order to become employable. They focus more on acquiring skills essential for a job while soft skills focus on personality development and require interpersonal adaptability among different kinds of people, problems, and situations. Employability skills or career management skills imply a display of core characteristics that candidates should possess, such as self-confidence, self-control, inter and intrapersonal skills, honesty, integrity, decision making skills, problem solving skills, reliability, adaptability, flexibility, willingness to learn, time organization, motivation, communication, positive attitude, adaptability, and working with others. [6]

These skills cut horizontally across all industries and vertically across all jobs and depend on the need of the industries of the respective countries bearing different names. For example, in the United Kingdom they are named core skills, key skills or common skills; in Germany- key qualifications; in France- transferable skills; in Australia- key competencies, employability skills, generic skills; in Canada- essential skills, employability skills; in the United States- foundation skills. The Employability Skills for the Future [7] report has identified and described eight employability skills: communication, teamwork, problem solving, initiative and enterprise, planning and organizing, self-management, learning and technology.

However, the nature of employability skills varies from discipline to discipline, and there is "a lack of consensus as to what constitutes employability skills and how they are levelled." [8] Thus, employers' skills requirements may differ by region, sector, and occupation.

Individual employers have their own preferences about the most appropriate recruitment methods for the job in order to enable candidates to demonstrate relevant soft skills to the position in their company which could include tests, asking candidates to provide an example of previous written or project work, taking up references from a previous employer, measuring skills against a set of internally developed competencies, reviewing a student's college portfolio or examining their record of achievement. [9]

Some employers feel that educational institutions focus too strongly on academic skills and qualifications at the expense of employability skills. Employers consider work experience as very important in assessing soft skills because, "many of the employability skills that employers are seeking can only be learned in 'real life' employment situations, even on a temporary basis, such as work placements of two or three weeks." [10] In their study, it is stated that work experience for young people is extremely valuable because young people with

experience of work are better equipped for the world of work than young people without it. Employers may overlook a lack of qualifications if young adults demonstrate positive attributes considering the fact that although young people are perceived as lacking maturity, they are more receptive to learning, they can be trained to perform the job requirements and to fit the organisation's culture and they have the potential to develop their soft skills. [11] [12] Younger people with little or no work experience may be assessed according to their extra curricula activities, such as sporting or volunteering achievements, which employers consider in order to measure employability skills. The definition of 'young people' that most authors agree with refers to people aged up to 25.

[9] report that when employers use formal recruitment methods such as a written CV or an application form, they evaluate the applicant's level of soft skills or employability skills and whether or not to interview them. CVs are used by the employer to infer and assess soft skills. Thus, this formal document in terms of written content, spelling, grammar, presentation unquestionably displays the applicant's motivation in terms of interest in the position or company [13]. From a series of qualitative interviews with employers, [9] highlight the fact that interviews are the most important selection methods in which employers may assess their candidates' suitability and employability for a particular job. Employees are often required to work in teams, so team-working skills are frequently assessed in the recruitment process by asking applicants to provide examples of their experience of working in teams that have been successful or problematic or to explain how they would resolve hypothetical team working situations. Furthermore, employers may use a wide range of recruitment strategies to assess applicants' soft skills from interviews to trial periods considering the field and occupation, the job's duration, its associated benefits, or its nature [13]. While developing technical and hard skills, there is also a need to give importance to soft skills as engineers will have to work in a team, write formal documents, give presentations, negotiate, report to someone else, deal with work pressure etc. Recent employer research has found the growing importance of IT skills to seek job opportunities and also to apply for them.

Communication plays a central part in workplace settings and "many of the tasks people typically perform in their everyday workplace lives are in one way or another related to communication" [14]. Engineers in all positions must communicate the purpose and relevance of their work, both orally and in writing concisely and accurately. When people communicate in their workplace, they always have a clear purpose in terms of what they want to achieve, they need to deal with an audience, peers and supervisors in the company or people outside the company who are going to read the document, attend the oral presentation, visit the website etc. Thus, technical communication creates and maintains the public image of the organisation and also reflects the values, goals, and culture of the organization. According to Koester, workplace discourse "involves interactions occurring across a whole range of occupational settings, from factories to offices, hospitals to government offices, private businesses to non-profit organizations." [15] Workplace discourse is embedded in professional and organizational

contexts; therefore, it implies communication between people displaying different roles and relationships. Some of the main characteristics of workplace discourse are the following: "goal orientation": "an orientation by at least one of the participants to some core goal, task or identity …conventionally associated with the institution"; turn -taking rules or restrictions; "constraints on allowable contributions" implying what it is regarded appropriate to write or say in the workplace setting; professional lexis which may be illustrated by the lexical choice; structure: workplace and professional interactions may be structured in specific ways; the existence of special "inferential frameworks" which includes different ways of interpreting discourse that are particular to the institutional or workplace setting [16]. Workplace interactions are also considered, most of the situations, asymmetrical, as a result of the different amounts of institutional power or expert knowledge distributed among the participants.

Context-specific role-plays should focus the engineering undergraduate's attention on the differing types of communication required with various groups in potential work situations. Oral communication helps them to deliver presentations, explain a process, improve meeting coordination, or develop a project team; whereas, written communication helps them write technical reports, specifications, informational material etc. This type of communication is generally evaluated through the interview process and employers perceive how the candidates express themselves, their vocabulary, and how sociable they are when faced with an interview panel. Listening, the ability to be inquisitive, and the absorption of information are also assessed via this method [13].

Teamwork is another important skill required of graduate engineers because it is "a social strategy built upon knowledge, attitudes, skills, and the ability to combine cognitive appreciation from all team members." [17] Team working skills define the ability to function effectively as an individual and in a group with the capacity to be a leader or manager as well as an effective team member. Team members often get involved in multiple projects in multifunctional, multidisciplinary environments; therefore, they need to cooperate efficiently working as an individual and as a member of a team, to collaborate in order to reach a common goal, to identify the strengths of team members, to show mutual respect.

Considering [7], problem solving skills imply the ability to view problems and challenges pragmatically and to have an analytical approach towards solving problems, to develop creative, innovative solutions and practical solutions, to solve problems in teams, to apply problem solving strategies across a range of areas, to test assumptions taking the context and circumstances into account etc. Self-management refers to having a personal vision and goals, evaluating, and monitoring own performance, having knowledge and confidence in own ideas and vision, articulating own ideas and vision, and taking responsibility. Learning that contributes to ongoing improvement and expansion in employee and company operations and outcomes is describes considering the following features: managing own learning, contributing to the learning community at the workplace, using a range of mediums to learn, for example mentoring, peer support, networking, information technology (IT), courses, applying learning

to dealing with issues about technology and people, having enthusiasm for ongoing learning in order to invest time and effort in the acquisition of new knowledge, skills and technologies, being open to new ideas and techniques. Planning and organising implies managing time and priorities being resourceful, taking initiative and making decisions, establishing clear project goals and deliverables, allocating people and resources to tasks, developing a vision and a proactive plan to accompany it, collecting, analysing, and organising information etc. Technology that contributes to effective execution of tasks means having a range of basic IT skills, applying IT as a management tool and being willing to learn new IT skills. Initiative and enterprise that contribute to innovative outcomes suggests adapting to new situations, developing a strategic, creative, long-term vision, identifying opportunities, and initiating innovative solutions to problem solving.

3. EMPLOYABILITY SKILLS FRAMEWORK CASE STUDY

The activity was conducted to determine the engineering students' perceptions on the level of the employability skills needed in a professional setting. The target group consisted of a number of forty second year engineering students in Applied Electronics and Information Technology from the Faculty of Engineering, North University Centre of Baia Mare, Technical University of Cluj-Napoca. Their task was to rank the eight employability skills included in the activity from the most important one (1) to the least important one (8) according to their own opinions on how important and relevant these skills might be in their future working context.

Tabel 1. Employability Skills Framework -adapted from [7]

Nr. crt.	**Employability skills**	**Ranking**
1.	Communication that contributes to productive and harmonious relations across employees and customers	3.275 (2)
2.	Teamwork that contributes to productive working relationships and outcomes	3.325 (1)
3.	Problem-solving skills that contribute to productive outcomes	3.75 (3)
4.	Self-management skills that contribute to employees' satisfaction and growth	5.25 (6)
5.	Planning and organising that contribute to long- and short-term strategic planning	4.02 (4)
6.	Technology skills that contribute to effective execution of tasks	5.65 (7)

7.	Learning skills that contribute to ongoing improvement and expansion in employee and company operations and outcomes	4.8 (5)
8.	Initiative and enterprise skills that contribute to innovative outcomes	6.525 (8)

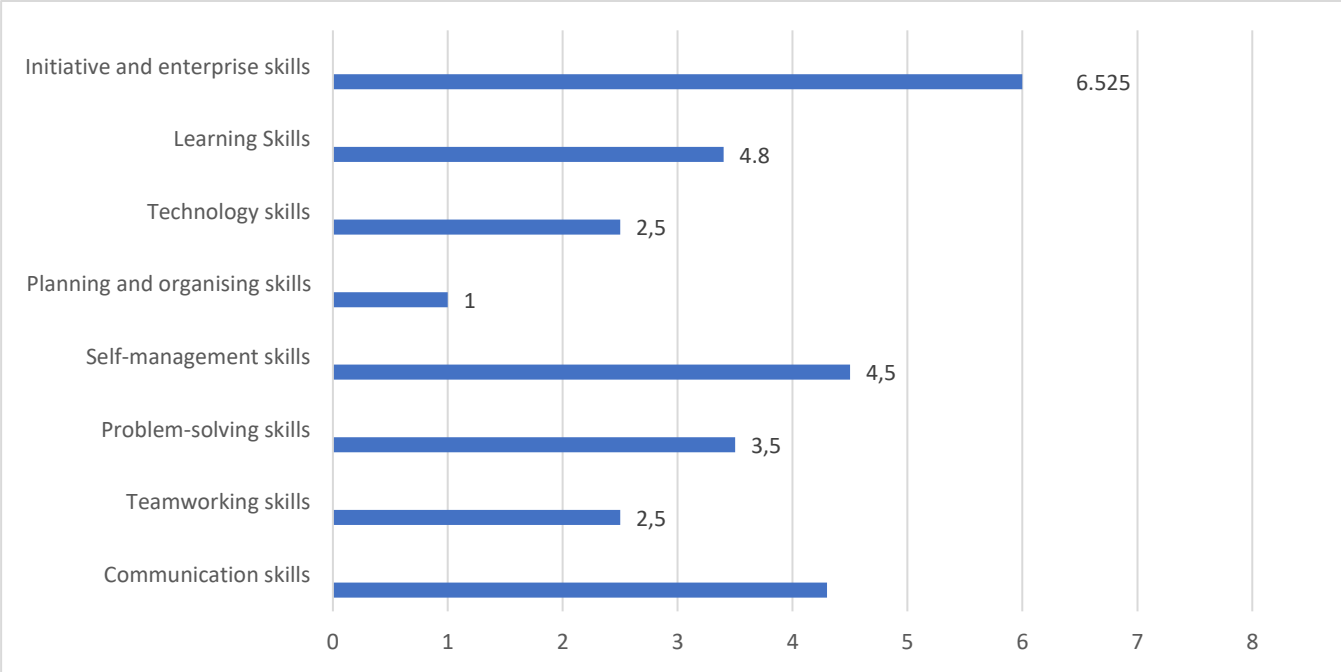

Fig 1. Employability Skills Framework

The three most frequently selected employability skills are teamwork skills, communication skills and problem-solving skills. These skills are essential in order to become competitive and reliable in a professional context, at the same time planning and organising, lifelong learning and self-management skills are considered important too.

4. CONCLUSIONS

Unemployment and the existence of skill gaps among the newly qualified engineering graduates are two challenging issues of the contemporary world that negatively impact all stake holders involved in industry. According to [18], lack of soft skills is associated to younger-generation applicants and employees. Although Millennials and Generation Z who are generally known as digital natives because they have grown up with computers, apps, and the Internet and are able to learn software and systems quickly, they tend not to possess an adequate level of soft skills, such as communication and teamwork. The Role of Career and Technical Education and 21st Century Skills in College and Career Readiness report released by [19]

recommends to education leaders to build infrastructure, programs and relationships that support 21st century readiness. Skills gaps can be closed by providing education which delivers the knowledge and necessary skills for becoming highly competitive, by designing study programs that integrate academic subjects, technical knowledge and 21st century skills. This may be achieved by developing reliable partnerships between educational institutions and businesses or industry organizations; by supporting professional development and learning communities in the field of expertise. [20]

A set of actions should be taken in order to improve employability skills in engineering education by all interested parties: encouraging students to participate in national and international technical competitions that should support them to develop leadership skills, communication skills and teamworking skills; introducing creativity and innovation courses to stimulate future engineers in problem-solving skills; designing industry-initiated courses provided by industry partners jointly with faculty members with a focus on application-based learning that develops critical thinking and promote deep learning; organising compulsory industry internships that would help undergraduates to learn more about the industry work culture etc. As a consequence, given employers' strong focus on employability skills and attributes, any kind of programme, strategy or experience that leads candidates to improve these aspects are likely to contribute to a positive employment outcome.

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CONCRETE STATION AUTOMATION APPLICATION USING EASYSOFT

Andreea Cristina **POP**[1], Paul **TAMAS**[1], Cristian **BARZ**[1], Alina **NECHITA**[2],
[1] *Technical University of Cluj-Napoca, Department of Electrical, Electronic and Computer Engineering,* [2] *Technical University of Cluj-Napoca, Psychopedagogical Specialty Department*
andreeapop05@yahoo.com

Keywords: Easy-soft, Programmable logic controller, Easy819-DC-RC, automation

Abstract*: The paper presents the automation of a concrete plant, with the help of PLCs (programmable logic controller). For the development of the development program, we used EASY -SOFT, which allows the use of different types of relays such as: EASY 500, EASY 700 and EASY 800. In the works we exemplified five automations of the most important processes underlying a concrete plant.*

1. INTRODUCTION

The development of the first PLCs began in 1968 in response to a request of the US car manufacturer, so the first PLC was installed in this industry a year later. Communication skills began to appear around 1973 and can also be used to send and receive various voltages allowing them to enter the analog world.

The 1980s brought the standardization of communications with the production automation protocol (MAP), reduce the size of the PLC and make them programmable by symbolic programming on personal computers instead of dedicated programming terminals or portable programmers [1,2,3].

Programmable logic controllers are automatic controllers used in processes technological. They were first developed in the automotive industry to provide flexible, robust and easy-to-program controls when replacing relays, timers and hardware sequences. Since then, they have been widely adopted as automation regulators high reliability, suitable for harsh

environments. A PLC is an example of a hard system in real time, because the results of production must be produced in response to the conditions of entry over time limited. PLCs can range from small modular devices with dozens of inputs and outputs in one housing integrated with the processor, with large modular devices, with thousands of inputs and outputs [4].

With the availability of general programmable devices, they have been a very short time to control sequential and combinatorial logic in industrial processes. At the same time, these early computers required the intervention of specialized programmers and a rigorous control of the environment for temperature, cleanliness and food quality. To meet these challenges, PLC has been developed with several key attributes. This would tolerate the store environment, support discreet entrances and exits in an easily extensible manner, would not it requires years of training and would allow it to be monitored.

Given that many Industrial processes have an easy response time depending on response times milliseconds, modern electronics (fast, small and reliable) greatly facilitate the construction of reliable controls and performance can be traded for reliability.

2. EASYSOFT PRO 6

EasySoft Pro 6 is an easy-to-use graphic editor program that directly displays the representation of the desired circuit chart. The selection menus and Drag & Drop functions make it easy to establish links by selecting contacts and reels and connecting with a simple click.

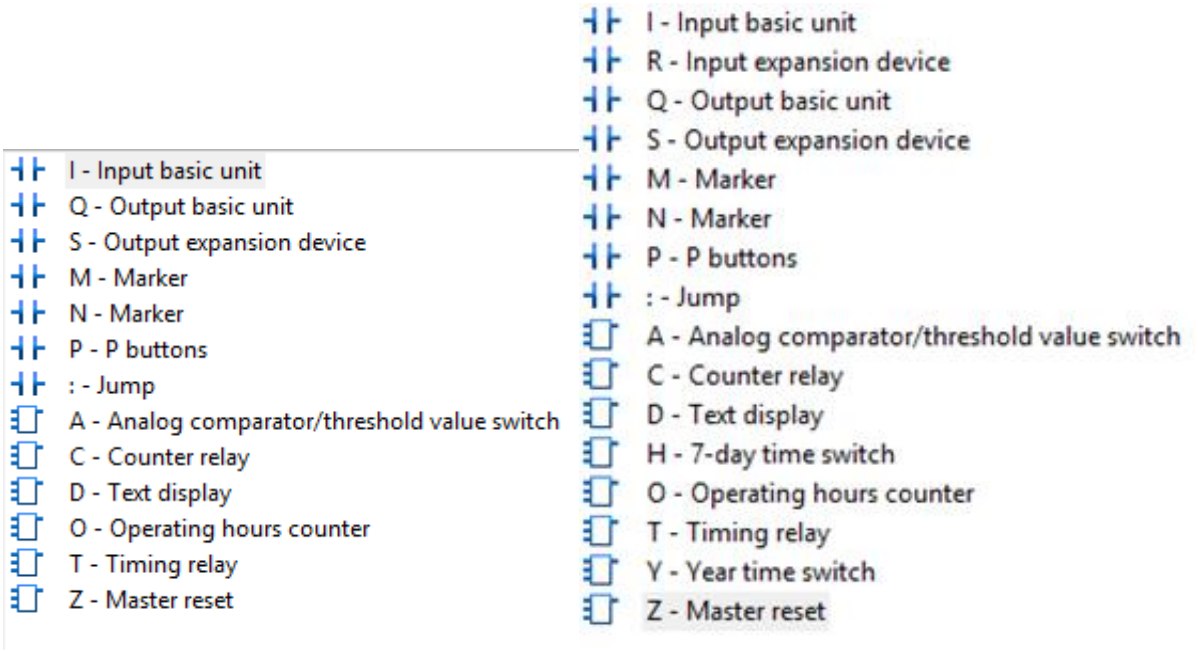
We also have the option to choose from 13 languages with easySoft menus and easy-to-use text [5,6,7].

The program has several display options available for viewing, editing, and printing the program, which are: comply with the contact symbols and the IEC symbol, international standard; have a light circuit diagram, 1: 1 as it appears in the display window; compliant with ANSI, the American standard.

The integrated off-line simulation tool allows us to check the correct operation of the circuit diagram, before commissioning and without a connected device. Comments and names for contacts, reels and function blocks allow us to create a clear structure. A cover sheet with the individual company logo, different text fields and a cross-reference list with comments gives us a perfect documentation solution for the application [3].

In this program we have the opportunity to create new automation applications with thousands of different types of electronic control relays, among which we have the devices easy500, easy700 and easy800 [8,9,10].

In the first phase we have the Easy500 device that provides us with some elements with which we can create a simple application, for example a traffic light [11,12].



Easy500 *Easy700*

Fig.1 easyRelay Ladder Logic Symbol

3. EASY-SOFT CONCRETE PRODUCTION AUTOMATION APPLICATION

The creation of the program for the control system was done taking into account all the components that they also make up the concrete plant and the process by which the concrete is produced.

An easy 819-DC-RC PLC will be used to create this program.

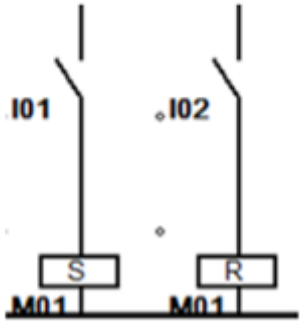


Fig.2 Start / stop section

The above figure shows the start / stop section of the operating system, where I01 is the start input and I02 the stop input. These activate the marker M01, which when actuating I01 has the role of keeping the ignition on and the process running until the actuation of I02 which stops the process.

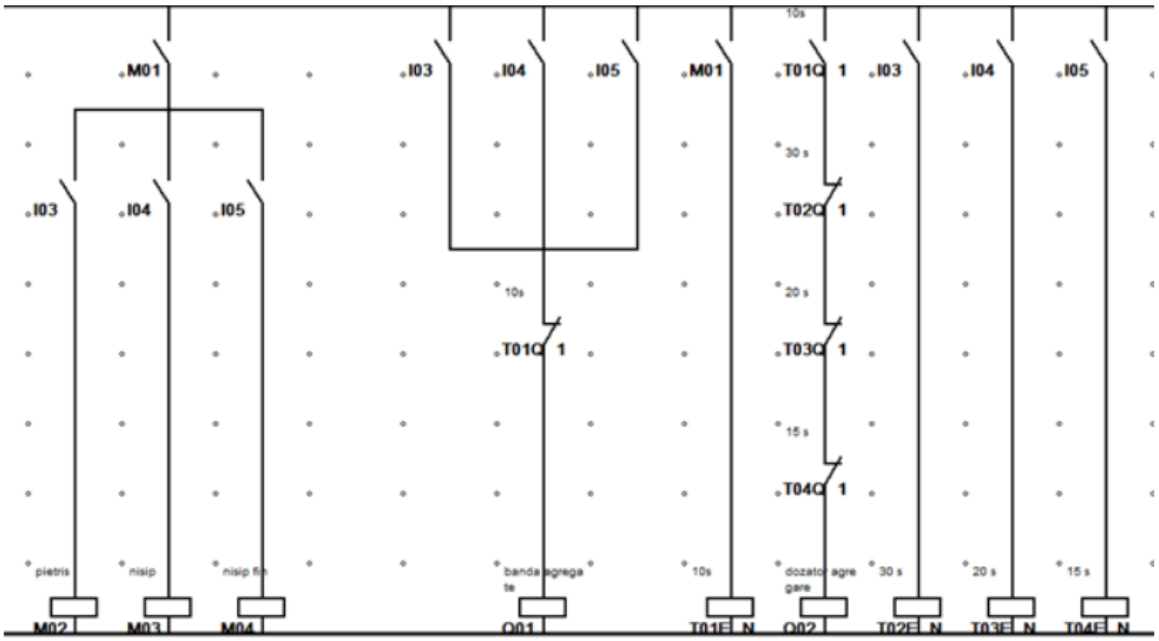


Fig.3 Aggregate supply

When M01 is activated the system starts, and further on by actuating one of the inputs I03, I04 or I05 we have the possibility to choose the type of aggregate desired. After that, one of the markers M02, M03 or M04, corresponding to the selected input, activated the valve that kept you open for a predetermined time. This process is performed using the time relays allocated for each of the above inputs, the relays being represented by T02EN, T03EN and T04EN as inputs, and T02Q, T03Q and T04Q as outputs.

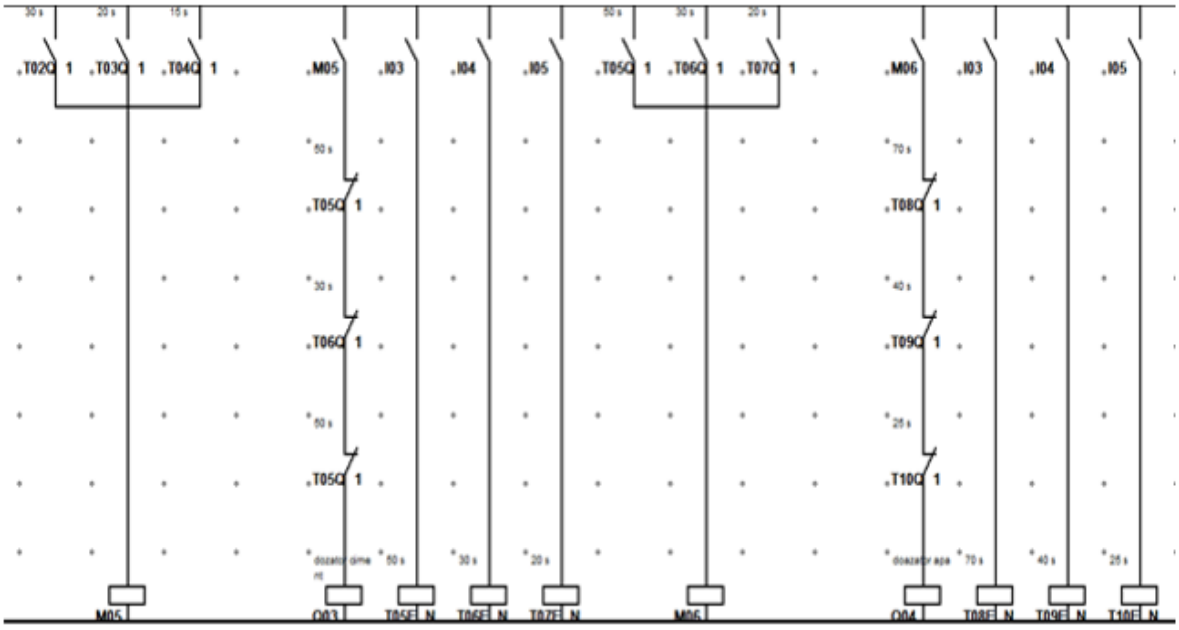


Fig.4 Cement and water supply

In *fig. 4* we have presented the supply of cement and water.

In the next step, the M05 marker will automatically operate to supply cement. This marker also operates the output Q03 which is the cement dispenser, and also depending on the desired recipe, one of the time relays T05EN, T06EN or T07EN will act as input and one of T05Q, T06Q or T07Q as output.

After the proper dosing with cement, the water supply follows, a process very similar to the cement supply. In the same way the marker M06 acts automatically, through it being the water dispenser Q04 you have activated one of the time relays T08EN, T09EN or T10EN as input, and T08Q, T09Q or T10Q as output

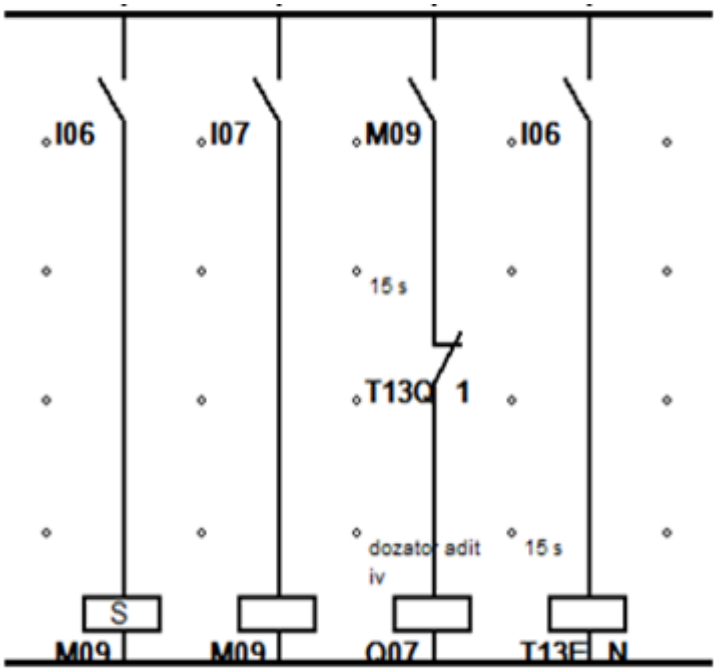


Fig.5 Feeding additives

In the following figure we have presented the optional part of the process, the supply of additives is not strictly necessary, but nowadays it is much more common because these additives or hardeners as they are called only help to accelerate the drying of concrete faster, not having an impact on its quality. .

At this stage we have as at the beginning of the software we have an I06 input for starting the additive supply system and an I07 input for stopping it.

Assuming that the system is turned on, it will automatically operate the M09 marker from the power supply, through which in turn the additive dispenser Q07 will operate, which will activate one of the time relays T13EN as input or T13Q as output that will hold the when the additive supply is closed if the system is switched off or open if the system is switched on.

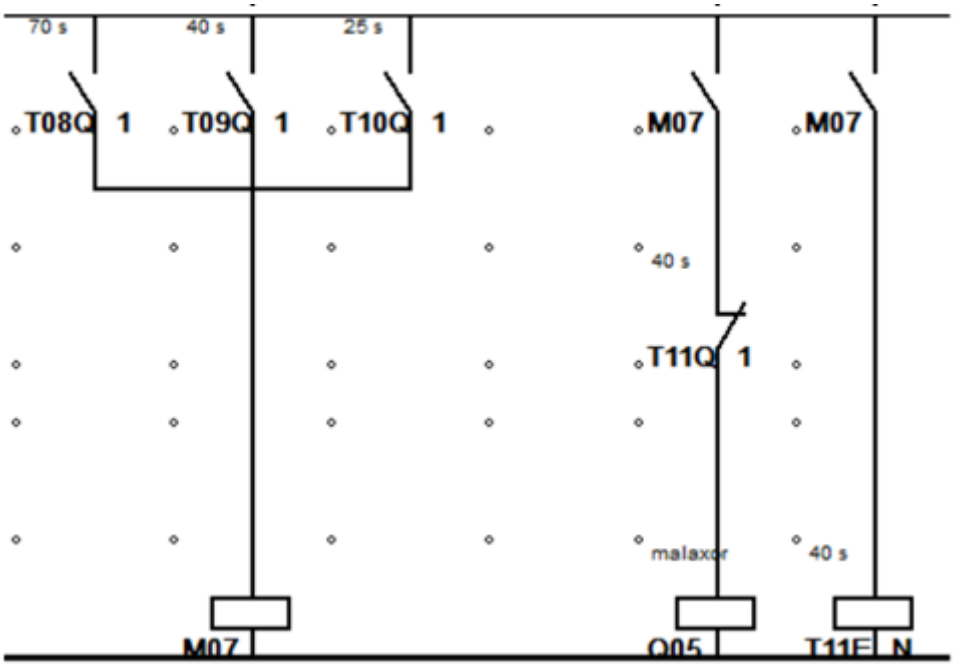


Fig.6 Concrete conveyor

After we have finished selecting the desired recipe type by executing the previous processes, by automatic actuation the M07 marker will start the Q05 mixer which will work for a time preset by the time relay, T11EN being its input and T11Q its output.

4. CONCLUSIONS

Automation of a concrete plant is very practical, because the control and monitoring they can be executed remotely, providing a greater degree of safety to the staff, while fluidizing the manufacturing process.

EasySoft Pro 6 is very easy to use because it allows the user to With the availability of general programmable devices, they have been a very short time to control sequential and combinatorial logic in industrial processes. At the same time, these early computers required the intervention of specialized programmers and a rigorous control of the environment for temperature, cleanliness and food quality.

To meet these challenges, PLC has been developed with several key attributes.

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ENVIRONMENTAL IMPACT OF MICRO-HYDROPOWER - A PURELY ROMANIAN PERSPECTIVE

Bogdan-Vasile **CIORUȚA**[1,3], Mihaela **ȘTEȚ**[2], Mirela **COMAN**[2,3]
[1]*Technical University of Cluj-Napoca - North University Center of Baia Mare, Department of Informatics – Office of Informatics, 62A Victor Babeș, 430083, Baia Mare, Romania*
[2]*Technical University of Cluj-Napoca - North University Center of Baia Mare, Faculty of Engineering, 62A Victor Babeș, 430083, Baia Mare, Romania*
[3]*University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca, Doctoral School - Agricultural Eng. Sciences, 3-5 Calea Mănăștur, 430372, Cluj-Napoca, Romania*
Bogdan.Cioruta@staff.utcluj.ro

Keywords: environmental monitoring, hydropower plants, environmental impact, energy.

Abstract*: The construction and commissioning of micro-hydropower plants is a solution for obtaining cheap electricity, but it also has a not negligible impact on the environment. Romania, like any of the member states of the European Union, has committed itself to a share of energy, in the sense of obtaining electricity in the most environmentally friendly way possible. Micro-hydropower plants also fall into this category. From our point of view, their construction started with too much exuberance because we not only have some European rules that we must obey about the green energy quota, but we also have some European rules provided by directives that refer to the protection of ecosystems. And then we must judge a balance between getting the share of green energy we are committed to, but at the same time protecting our ecosystem. We have synthesized, reported, and analyzed the impact of micro hydropower plants according to good practice guidelines aimed at the harmonious development of communities about nature.*

1. INTRODUCTION

Water as an environmental factor is a limited global resource and an essential condition of human existence. Today's society, under the auspices of globalization and the human-environment relationship [1], uses water resources to generate and support the economic growth of communities through activities such as agriculture, commercial fishing,

energy production, transportation, tourism, and more [2, 3]. In recent decades, it is becoming more and more common that the water demand is increasing, which puts a lot of pressure on both sustainable community development strategies about the diagrams reproduced in Fig. 1 [4], as well as on the resources available [5].

Being a limited resource, water can be damaged if no concrete protection measures are taken. To prevent the degradation of water resources, it is necessary to find coherent ways of managing water resources, to ensure its assessment, conservation, protection of its quality and quantity [2].

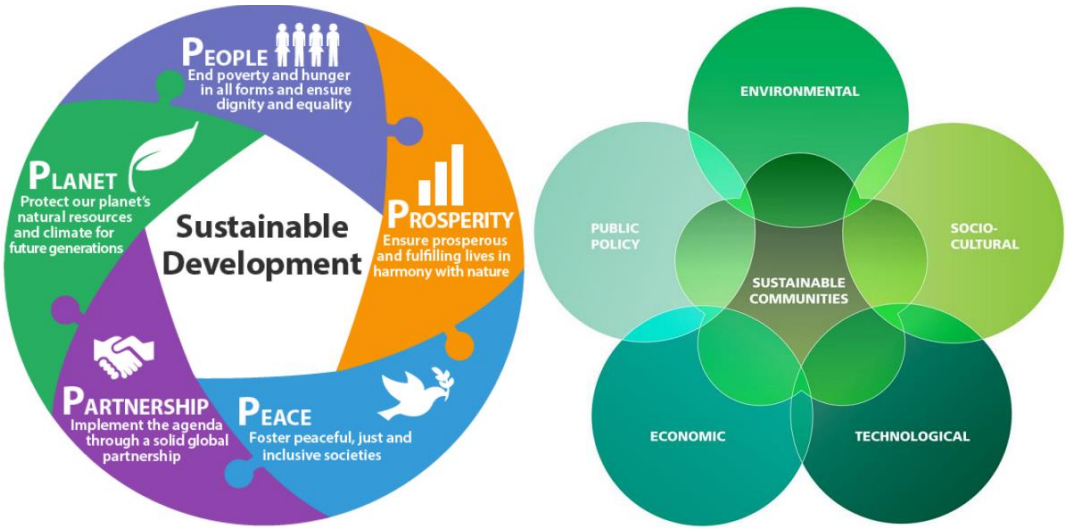

Fig. 1. Sustainable Development diagrams with 5 parameters (sustainable communities)

In fact, in the hitherto wild valleys of the Carpathian Mountains, we have a devastating war going on that exterminates the naturalness of the mountain waters, advancing on hundreds of fronts: bulldozer squadrons, excavators, dynamite experts and finally pouring concrete. Crawler's crush and tarnish life on natural watercourses. Each watercourse receives several deadly injections of reinforced concrete, which destroys the watercourse in question for a century (at least) and the biodiversity is affected [2, 3]. Even in Natura 2000 sites with fish species and other living things of Community interest, such concrete constructions appear, which cause the waters in some places to be captured, leaving entire sectors of the courses almost completely dried up.

From the beginning of the production and use of electricity, the benefits of electricity have been recognized worldwide. Gradually, however, several shortcomings were revealed, negative effects that accompany electricity from the extraction and exploitation of energy resources to its use [6].

In these steps, regarding the stage of design, construction, and use of power generation facilities through micro-hydropower plants, we set out to look at the perspective of the impact they have on the environment. It is known in the literature that there are many forms of impact that the energy sector has on the environment. Of these, an important part is due to electricity,

their presence being identified throughout the life cycle of electricity generating installations, both in the phases of energy production and in the stages of transport, distribution, and domestic or industrial use.

2. MICRO-HYDROPOWER BETWEEN ENERGY HUNGER AND ENVIRONMENTAL DAMAGE AND DESTROYING

Promoting the production and consumption of electricity from renewable sources is an imperative of the current period and an important Community priority motivated by environmental protection strategies, increasing energy independence from imports by diversifying energy sources, as well as economic and cohesion reasons. social [7]. As such, Romania was among the first European countries to transpose into its legislation the provisions of Directive 2001/77/EC on the promotion of electricity produced from renewable sources (by GD 443/2003 with subsequent amendments and completions) [8] and established that over 33% of gross domestic electricity consumption be covered by such sources [9, 10].

Obtaining energy from renewable resources is a global trend in the age of growing energy demand. Hydropower has some potential in this area, especially for low-power locations. However, the construction of such installations requires high costs, which is why some attempts have been made to reduce costs, by proposing alternative solutions to the classic ones [11, 12].

Regarding the design of underground structures associated with micro-hydropower plants, it must be thought out and configured cost-effectively and optimally. The design itself is a challenge and requires gradual investigations into the geological engineering status of the area where these structures will be located [13]. The orientation, modeling, and sizing of the micro-hydropower plant play an important role in the overall stability of each structure, both in terms of hydraulic requirements and in terms of long-term stability.

Micro-hydropower plants are hydropower plants with an installed capacity of less than 10 MW, thus mitigating the environmental problems associated with hydropower plants [14]. Micro-hydropower plants are based on a reliable and proven technology, which is suitable for rural electrification and for supplementing the supply of electricity at the industrial level. Capacity building, long-term financing, and improving the livelihoods of the local population are the key challenges and benefits of such structures. The structures and equipment associated with micro-hydropower plants can be easily built and implemented, often using local, national, and regional resources. Multi-skilled labor is needed for the operation and maintenance of the micro-hydropower plant [15], and if its zoning is on the border with other states, then special control and a multi-national team are required.

Micro-hydropower will not have the same negative effects on the environment as large hydropower systems, as microsystems require a much smaller water tank to operate

efficiently. Micro-hydroelectric systems will have a similar negative impact on the environment but will be significantly smaller than conventional hydroelectric systems that require a large water tank.

There is no doubt that the impact of hydropower on the environment can be positive if a system is properly planned and managed. The hydropower ecosystem can be very sensitive to change, but there can be a net benefit to society and nature, in the first instance even as an alternative to fossil fuels.

The most well-known negative effects of micro-hydropower plants are manifested on environmental factors (air, water, soil/subsoil, biodiversity) by modifying their characteristics through noise, electromagnetic and visual pollution, discharges of harmful substances, vibration generation, and waste (see Table 1) [6].

Table 1. Different types of activities and impacts associated with energy production and transport (adapted and updated after [6]*)*

Types of activities	**Air pollution**	**Electromagnetic pollution**	**Impact on biodiversity**	**Land use and pollution**	**Noise**	**Use of hazardous materials**	**Vibration**	**Visual pollution**	**Waste generation**	**Water use and pollution**
Electricity transport	X	X	X	X	X			X		X
Geothermal plants	X			X						X
Hydropower plants*	X		X	X	X		X	X	X	X
Nuclear power plants	X		X	X		X		X	X	X
Solar power plants	X			X		X				
Thermal power plants	X		X	X				X	X	X
Wind power plants			X	X	X			X	X	

*micro-hydropower plants are included in this category

The negative impact of micro-hydropower plants also affects the local communities, by affecting the groundwater and, implicitly, the water sources. In Romania, over 430 micro hydropower plants are in different stages of planning, authorization, and construction, and over a quarter of them are in protected areas, in the cross-border area, or at their border.

While the use of energy from renewable sources is promoted in the European Union, it is known that hydropower infrastructure has major negative effects on aquatic ecosystems and thus on the services they provide locally and regionally, while watercourses with very good ecological status and floodplains have become increasingly rare in Romania.

The remaining ones urgently need protection to maintain their good and very good ecological status, while the negative actions on the watercourses, which are in the process of altering at a fast pace, must be stopped urgently, and where possible ecological reconstruction must be carried out following the provisions of the Water Framework Directive.

The potential impact of the construction and operation of micro hydropower plants is mainly represented by:

- alteration of surface water quality and deterioration of aquatic ecosystems;
- bank degradation;
- intervention works in the minor riverbed for the installation of water catchments and supply, coupled with the reduction of the flow of the watercourse;
- modification of the hydromorphological characteristics and segmentation of the continuity of the watercourse.

Micro-hydropower plants significantly affect river ecosystems and cause irreversible damage. A dammed or captured watercourse almost completely loses many of its original features and can never be compared to a natural river that has healthy habitats and functional ecosystems. Micro-hydropower plants also fragment habitats along rivers and prevent the recovery of aquatic species populations in areas downstream of catchments or isolate individuals from species found only in mountain rivers. The devastating effect of micro-hydropower plants is permanent, dramatic during construction with dynamite, bulldozers, concreting, etc., and persistent during operation that can extend over a century with the interruption of natural ecological flows on the watercourse.

Sediment retention and clogging also change sediment flow and other geomorphological and landscape aspects. Such disasters also occur in protected areas, Natura 2000 sites designated by the implementation of European legislation for the protection of certain species and habitats of Community interest. However, there is a real conflict of interest between biodiversity conservation and renewable energy production. The problem is that to produce green energy there is the financial interest produced by green certificates and subsidies, related to investment and political interests, while for the conservation and protection of biodiversity there is disinterest, neglect, and ease.

By upgrading the existing power plants in Romania, a significantly higher increase in installed power and energy can be obtained than by investing in new micro-hydropower plants. But the construction of micro-hydropower plants is much more economically advantageous due to the support scheme, with green certificates. That's one of the economic benefits. The other economic advantage of micro hydropower plants is their potential to solve problems locally. The main reason for micro-hydropower plants would not be their minor energy contribution, but the supply of isolated hamlets or houses.

3. CONCLUSION

There is a struggle between ecological, naturalistic thinking, and the technical-aggressive, rude, detonating and concreting approach. Who will win? Do they help communities, or do they lack the benefits of nature? Does it contribute to national energy

production, or does it inflate the pockets of some businessmen? Is it green energy or does it have serious, long-term environmental costs? Do we prefer the new ones or the old ones? These are questions that we are still waiting to answer. However, we believe that micro-hydropower plants are far below their impact, even if they affect all environmental factors.

The highest value of micro-hydropower plants is the local value. It raises the area, the locals have some work to do, the investor, through the specifications, is obliged to help people, to raise their standard of living a little, to sell them electricity directly. At the same amount of electricity produced, a micro hydropower plant has a 5-8 times greater impact on biodiversity, compared to a dam hydropower plant.

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Authors' statement

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WHEN DOES THE USE OF TECHNOLOGY IN THE EDUCATIONAL PROCESS BECOME TOO MUCH?

Ramona **DEMARCSEK**, Luminița **TODEA,** Anamaria **FĂLĂUȘ**
Technical University of Cluj-Napoca, North University Centre of Baia Mare
ramona.demarcsek@fsc.utcluj.ro, luminitatodea@yahoo.com, anamaria.falaus@fsc.utcluj.ro

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Abstract*: The current global situation brought about by the recent pandemic, has wreaked havoc through educational systems worldwide. From the traditional face-to-face interaction during the educational process, we were all suddenly faced with the daunting task of teaching online, and we all had to learn on the go. So, we adapted, teachers and students alike, and in this process, we unexpectedly found ourselves bombarded with various videoconferencing platforms, eLearning platforms, applications meant to make the teaching-learning process easier and smoother, and a wide range of devices on which all these platforms and apps could run. In this article we are analysing the results of a survey taken by a sample of 202 students from our university in an attempt to provide an answer to the question of when technology in the educational process becomes too much.*

1. CONTEXT

In March 2020 the entire world was shaken by the realization that a new pandemic was threatening its very existence. Countries went into lockdown; businesses shut down; schools closed, and the entire educational process went online. Education as we had known it until that moment came to a griding halt. The concept of online education was not foreign or novel to most cultures. Yet it was an educational approach implemented by choice and not forced by external circumstances. And that was probably the daunting aspect of the matter! Not the fact that it was online, but the fact that it was an issue that we, as educators and instructors, could not decide upon, it was something forced upon the entire educational system – all educational systems throughout the world, as a matter of fact – and nobody had the opportunity to get accustomed to the situation, there was no time, we plunged directly into it

and had to learn things on the go. It was not easier for students either. They are more technology oriented indeed, they use technology more extensively and for long increments of time during a day, yet that still did not prepare them for the impact of online education.

What seemed, at the beginning, to be a blessing in that it offered people living at great distances from the university, or people with jobs, the possibility to access and participate in the course or seminar from the comfort of their homes or from their offices, ended up being a nuisance and a source of stress in that it alienated people from one another. It impacted the educational process in the most unexpected manner: it eliminated the direct interaction between teachers and students, and thus the exchange of ideas, the challenging debating and questioning – all of which generate growth and development in any field of research.

As if with the turn of a switch, teachers and students alike were displaced: the familiar environment of the classroom was no longer available to anyone, the educational facilities once swarming with life became "ghost cities", silent, empty, futile. The change was sudden and radical, yet the psychological impact was something to be acknowledged in the long run for, at that moment, the thrill of being able to attend (or deliver) a lecture from the comfort of one's living-room overshadowed the danger of social alienation, as well as the negative impact of prolonged screen time on one's health (both physical and mental). Three semesters later, both teachers and students became aware of the need for direct interaction inside a classroom, as well as of the fact that the only major advantage of online education was the feeling of safety. Being online meant staying safe, and that was the only real benefit.

Faced with a technology-infused educational process, the question this paper attempts to answer is: when indeed does technology become too much? We understand that education has been employing technology for decades. Projectors and televisions seem to be ubiquitous and are still being used in the classroom as they have been for many years, even if the former can now fit into a purse and the latter has been replaced by Smart TVs. Yet, at this point, the question of whether education has become too dependent on technology is haunting teachers throughout the world [1].

Education has constantly moved further, and so has its worship of technology. Classrooms are now invaded by laptops, hand-held devices, electronic whiteboards, sophisticated word processing apps, 3-D printing, and much more [1]. At the current state of technological evolution, people in general, and schools in particular can barely keep up with all the gadgets and electronic devices available to the large public. The question is: should they? Should schools give in to the pressure of tech companies and keep purchasing their products in the hope that the quality of education would increase, all at the expense of teachers, who are faced with decreasing respect on the part of the students, increasing pressure from the parents, poor payment, growing requirements from the management, lack of personal time, and all to the detriment of actual quality education?

Dr. Nicholas Kardars, in his article *Screens In Schools Are a $60 Billion Hoax* [2], provides quite a harrowing answer to this question and points out the reasons why schools

should “not fall for the Siren song of the tech companies—and all of their hypnotic screens” [2]. In his article he speaks about the screen revolution and the seismic shift in pedagogy brought about by technology which now “dominates the educational landscape”. Classrooms are invaded by electronic devices and one can “find some type of screen in almost every classroom” [2]. It is nevertheless true that some of these devices enhance the educational experience and engage students in ways that were unimaginable not long time ago, while it is also true that they can become a distraction, for “no matter how animated or engaging the teacher, it’s tough to compete with” [3] all the distractions available at a click on a smartphone, for instance.

This article approaches the use of electronic devices during the educational process from the perspective of the actors impacted directly, namely the students. Thus we delivered a 13-question-long questionnaire to a sample of 202 student from the Technical University of Cluj-Napoca, North University Centre of Baia Mare (TUCN-NUCBM), and analyzed their responses. The relevance of the study may be greater than anticipated considering the current global situation caused by the recent pandemic. In the light of the Covid-19 pandemic and its impact on the educational process, technology can be both a support and a hindrance. This is what we are attempting to discover and provide an answer to in this study.

2. THEORETICAL APPROACH

The issue of technology in the classroom has been approached before, from various perspectives. It is not a novel issue since technology has always been present in the classroom in one way or the other. Though with the recent shift to online teaching over the past couple of years, it has nevertheless become prevalent. It is a fact that “students are enthusiastic about using smart devices and the latest technology” [4], and the transition to online learning, as sudden as it might have been, was welcomed quite enthusiastically by most players involved. Yet after a while, the entire process became tiresome, and just like anything else, technology was starting to lose its appeal due to overexposure and overuse. And these days it has become even more obvious that “moderation should be the norm” [4], especially when it comes to the employment of technology in the educational process.

In previous research we approached the issue of the use of technology in class with the aim of improving the quality of the teaching-learning experience [5], as well as about taking advantage of the students’ technical abilities with the exact same purpose [6]. The outcomes of our research proved that technology does indeed have a positive impact on the educational experience and that students are eager to use it in all wakes of live. Yet in this article we are challenging this statement to a certain extent because we consider that the current situation of the global pandemic has brought a shift in the educational paradigm and consequently technology has been abused.

Numerous articles [8-13] approach this issue of excessive use of technology in the classroom. While some present the advantages and disadvantages of the use of technology for educational purposes [8], with the number one disadvantage being the fact that it can be distracting, others focus on the negative impact technology has on humans, from addiction, to bullying, to changes in our communication style, socializing, travelling behaviour, and even the way we research (approaching books less frequently and using the internet extensively) [9]. There seems to be a lot of focus on the addictive aspect of technology, generating novel types of mental disorders with odd names, issues which maybe a couple of decades ago were inexistent, for instance gaming addiction, FOMO (Fear of Missing Out) which is an addiction to social media, all following the same pattern and with alteration in the chemicals in the brain similar to drug addiction [10]. We are not qualified to approach the issue of addiction, yet in our study we do touch on the issue to some extent, since overuse of technology in the classroom can contribute to the general harmful effect of excessive reliance on technology. We do focus though on the perception of students, as well as their preferences in terms of technology and education, and how interwoven these are, so much so that they have become inseparable.

In earlier research [7], where the studied group was also students from the TUCN-NUCBM, we approached the issue of smart devices being used by the students during the educational activities for issues unrelated to the lesson, and thus these devices were considered at that point a disturbance, and the use of these devices by the students was considered a challenge that had to be overcome. The suggested solution at the time was the employment of these devices for actual educational purposes [7]. Since then, smart technologies have become so common-place and so ingrained in virtually all educational environments and processes that we cannot conceive of the teaching-learning process without them. And thus in [4] we described the first steps we had taken towards online education at a time when humanity was oblivious to the possibility of the outbreak of a pandemic. These referred to the use of a Moodle platform implemented within NUCBM, and about which we will speak more extensively hereafter (i.e. Knowledge Base). The main purpose for piloting this platform within the NUCBM was to reduce the consumption and waste of paper, while at the same time provide ease of access to educational materials to all our students, inside and outside the classroom, as well as a more challenging environment than the traditional (in-class) one. Little did we know that the eLearning platform would become indispensable during the pandemic, yet the fact that the platform had already been piloted for a couple of years before the pandemic made the transition to online education less traumatic.

This paper analyzes the use of various educational platforms within the NUCBM and the student's perception on online education, as well as the use of technology during the educational process at two years after the onset of the pandemic which brought about the current shist in how education is approached and the extent to which smart technology impacts it.

3. CASE STUDY. THE SURVEY

In order to assess the students' perception with regard to the use of technology during the educational process, we designed a thirteen-question survey and delivered it to 202 students from the three faculties of the NUCBM, a smaller campus within the TUCN. The three faculties in question are the Faculty of Sciences, the Faculty of Humanities, and the Faculty of Engineering. The students who took the survey were students at bachelor level in the fields of Mechanical Engineering, Environmental Engineering, Business Administration, and Romanian Language and Literature. Thus, we made sure we covered quite a wide range of domains, ensuring a substantial diversity of opinions and perceptions on the issue of the use of technology in class.

The questionnaire was designed to assess the use of technology during the educational process in general, not focusing on a certain class or a certain type of activity (e.g.: course or seminar), yet it was applied during the English classes, and the focus of this analysis is on the use of technology during the English classes in particular.

The questionnaire included both general questions, with multiple response options, and questions to which students had to input their viewpoint. Thus, the first question, referring to the type of electronic devices owned by the respondents, provided a list of seven very common devices from which students could choose one, several or all (desktop computer, laptop, smartphone, tablet/notepad, eBook reader, smart watch, smart TV), while also providing the option to mention other devices (if any). The purpose of this question was to find out what the most common devices were amongst students.

In *figure 1* you can find a visual representation of the answers provided by the respondents to the first question.

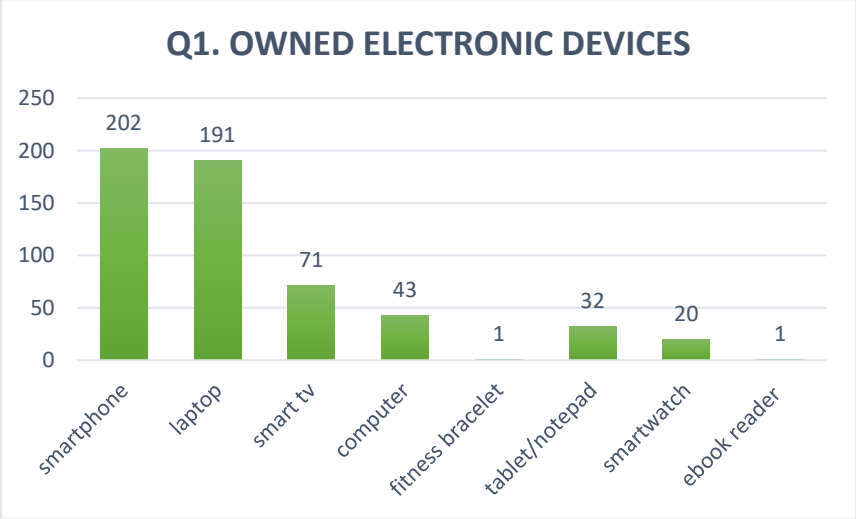

Fig. 1. Question 1 - What internet connected electronic devices do you own?

Not surprisingly, all 202 respondents own a smartphone, the second most frequently owned device by the participants in the survey being a laptop, and the third in terms of frequency being the smart TV. What was nevertheless disappointing, yet not entirely unexpected, considering the trend in reading, was the fact that only one respondent said they owned an eBook reader, thus only confirming the decreasing interest in reading amongst the younger generation.

The second question was meant to assess the frequency with which these devices were employed by the students. The same list of devices as for the first question was provided, as well as the option to include other ones. The responses provided by the students to this question were quite predictable and in strong connection to the responses provided to the first question. Since the smartphone was the one device owned by all respondents, the device most frequently employed was unsurprisingly the same, followed by the laptop in second position and the smart TV in the third, as can be seen in *figure 2* below.

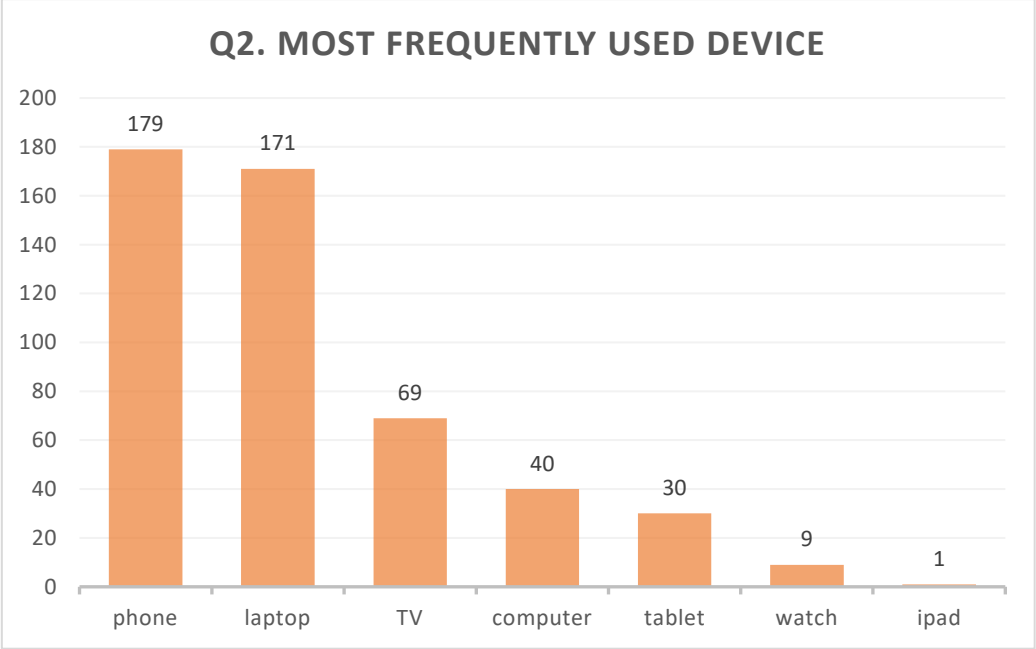

Fig. 2. Question 2 – Which 3 do you use most frequently?

The third question referred to the average amount of time students spent daily on these devices. The response options provided were: 1-2 hours, 3-4 hours, 5-6 hours, and more than 6 hours. As seen in *figure 3*, the percentages are somewhat balanced, especially regarding the timeframes 3-4 hours and 5-6 hours. Unsurprisingly, the lowest percentage of students (15%) reflects the choice in terms of the shortest period of time, i.e. 1-2 hours, while the highest percentage (36%) was scored for the timeframe "more than 6 hours a day". This only confirms the trend regarding the increasing amount of time people spend on electronic devices.

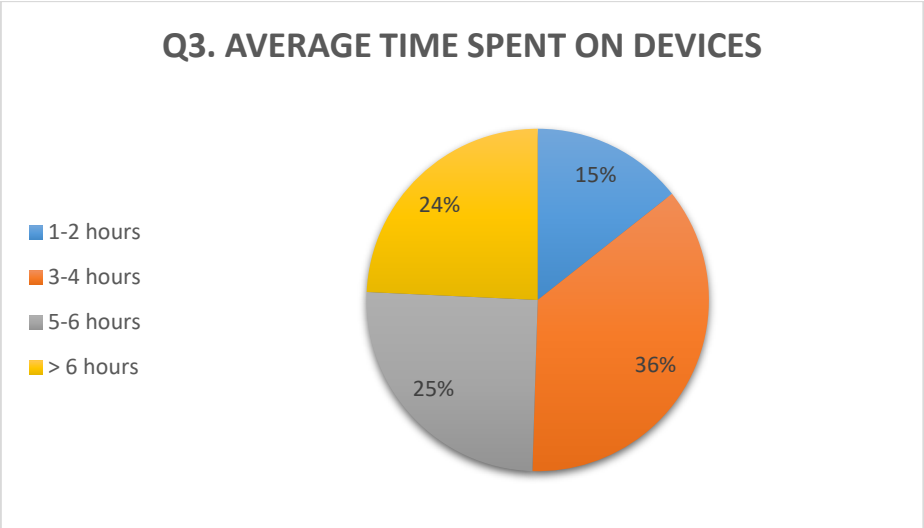

Fig. 3. Question 3 – On average, how much time do you spend daily on your preferred device?

For the fourth question the students had to decide upon the three most frequent uses of that particular device, the six response options provided being categorized into personal interests (communicating with friends and family, playing games, shopping) and educational purposes (reading, studying, solving school-related tasks), while also being provided with the option of mentioning other purposes. Unlike the previous two questions for which this option was provided, i.e. questions 1 and 2, where respondents chose to stick to the suggested devices and not mention others, for this specific question there were several employments of these devices mentioned by the respondents, which meant than for them, there were other, more important usages for the devices than those listed. Amongst these other usages, some mentioned watching films or videos on YouTube or performing job-related tasks.

As regards the answers where respondents only chose from the provided list, the classification in terms of most frequent employment of these devices provided no surprises, as can be seen in *figure 4.* Thus, the fact that *communication with friends and family* was the number one purpose for using a smart device (164 respondents mentioned it), only confirmed that (1) students were referring mainly to the smart phones, and thus the answer was in correlation with the answers provided for questions 1 and 2, where the device owned by most students and the one employed by most was the smartphone, and (2) since it is a phone that respondents were referencing, it only made sense that communication would be the main purpose for using it.

In terms of the second and third most frequently mentioned employments of the electronic devices, namely for *studying* or *solving school-related tasks*, mentioned by 132 and 121 students respectively, since the entire sample of 202 respondents were students, these numbers actually speak about the predominant activities in which the respondents are involved.

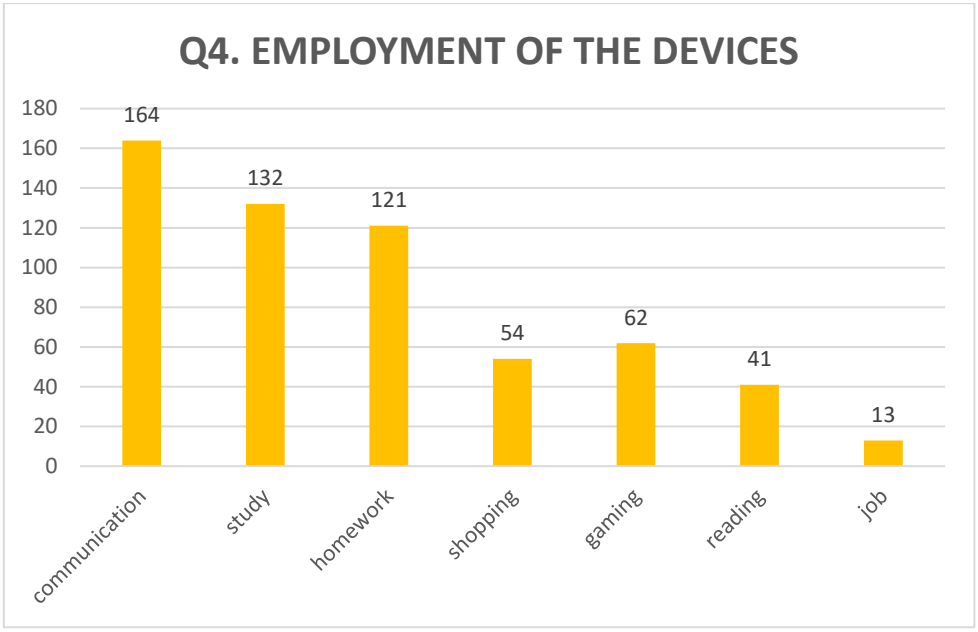

Fig. 4. Question 4 – What are the 3 main purposes for using those devices?

The second part of the questionnaire was dedicated to the actual use of electronic devices in education, and the students' perception of the issue. Thus question no. 5 inquired about their preference regarding online or face-to-face teaching, and the responses were almost at a perfect tie, with 104 students choosing online education and 98 opting for the traditional on-site or face-to-face education, i.e. a mere 6 responses difference. *Figure 5* below presents the situation in percentages.

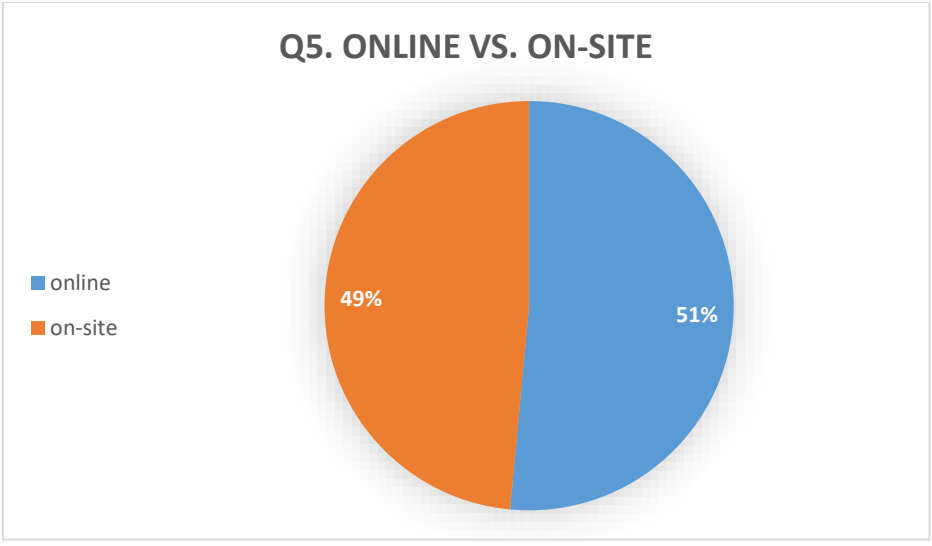

Fig. 5. Question 5 – What do you prefer: online or on-site education?

Question no. 6 was the first open-ended question of the survey, asking students to name one advantage and one disadvantage for each of the teaching variants, no matter their preferences. It was clearly easier to identify an advantage for their preferred variant since that

only justified their initial choice. Yet when it came to mentioning a disadvantage, students found it more difficult to identify one, and many ignored that part completely. The question was meant to assess their critical thinking at a basic level, as well as their ability to make a decision based on objective arguments. This may not have been entirely in correlation with the initial purpose of the survey and will therefore not be analyzed here, yet it may constitute ground for further research. Responses to this question did nevertheless bring an insight into the students' perception of the online teaching process with which teachers and students had been faced for the past two years. Thus, the argument of those who were in favour of face-to-face teaching was the fact that they could focus much better in class and understand much better the topic being taught. It was not the only argument though, lack of socialization and lack of teacher-student interaction were some other, quite frequently mentioned arguments in favour of face-to-face education. Yet online education had, as already seen, its share of support, with respondents arguing that it provided ease of access to educational resources to those living far from the university, thus eliminating expenses incurred by the commute, or to those with jobs for whom online education provided the otherwise unavailable opportunity of attending classes from various locations outside the university, from virtually anywhere.

As of question no. 7, which referred to videoconferencing platforms used during classes, the focus was on the actual educational experience. This question required students to choose from a list of six videoconferencing platforms (Zoom, Cisco Webex, Google Meet, Skype, Microsoft Teams, BigBlueButton) the one(s) they were familiar with from their courses and seminars, as well as providing the option of mentioning any other videoconferencing platform they may use.

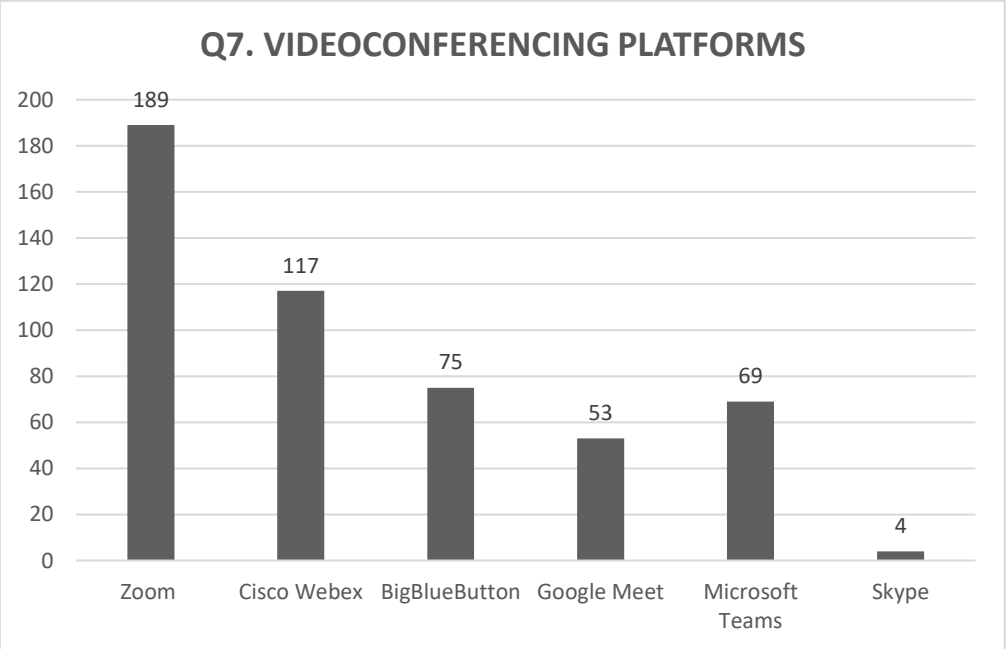

Fig. 6. Question 7 – What videoconferencing platforms do you use during the educational activities

Question no. 8 addressed the issue of educational platforms, more specifically eLearning platforms used during classes, providing four response options: Knowledge Base (a Moodle platform developed for employment at the NUCBM, and which was used quite extensively for various educational activities especially with students in Computer Science and/or Informatics or ICT's in general, yet not restricted to these, even before the pandemic), Google Classroom, Microsoft Teams, and Didatec (another eLearning platform developed within the Technical University of Cluj-Napoca as an output of a project, dedicated mainly to the students and staff of technical orientation). With the onset of the pandemic, when all educational activities moved online, Knowledge Base, having already been used for a couple of years, became the prevalent platform for educational activities in the NUCBM, fact confirmed by the results of the survey presented in figure 8. Microsoft Teams, on the other hand, is predominantly used within the engineering milieu of the university, the second position in terms of usage within the NUCBM being thus justified, considering the ratio of engineering versus non-engineering students on campus, as well as those who took the survey.

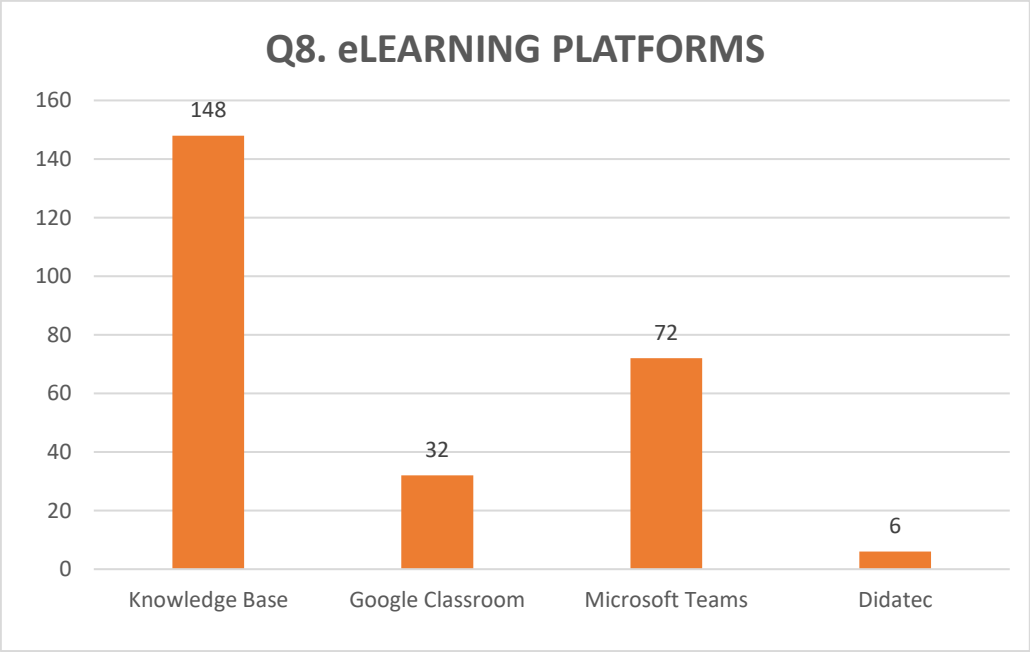

Fig. 7. Question 8 – What educational platforms do you use during the educational activities

Question no. 9 addressed the issue of educational platforms and applications used by the students for tasks and assignments they had to work on individually, outside the timeframe of the courses and/or seminars. The question provided a list of six options (Knowledge Base, Google-provided applications – such as Classroom, Docs, Sheets Forms – Microsoft Teams, Didatec, Microsoft 365, the classical Office package – Word, Excel, PowerPoint etc.), plus the extra option of mentioning any other platform or application they may use, the platforms mentioned being all used during the educational activities within all faculties of the TUCN.

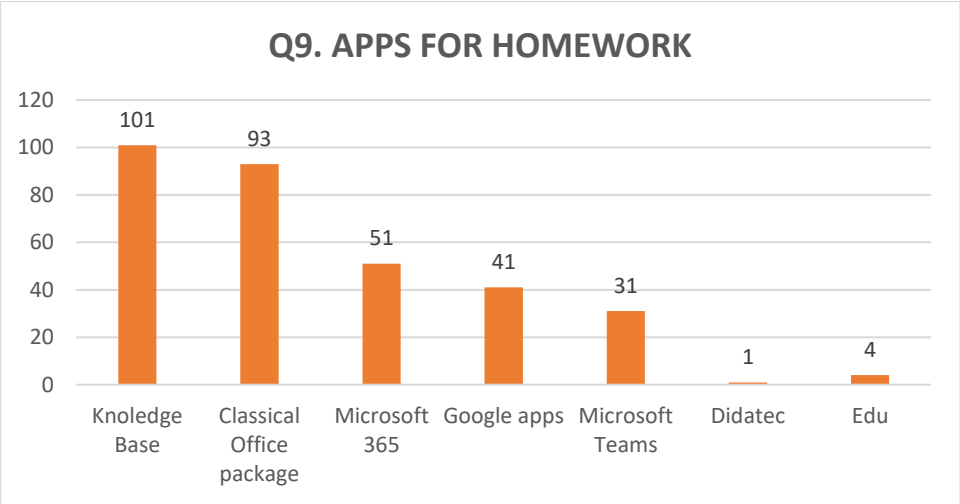

Fig. 8. Question no. 9 – What platforms and/or applications do you use for assignments and homework?

With question no. 10 the focus shifted again on the students' preferences, this time asking them to choose their preferred educational medium, i.e. electronic devices or the classical pen-and-paper option. *Figure 10* shows that the respondents' preference clearly leans towards electronic devices, with two thirds, or 66%, of them expressing preference for these (134 students), and only one third, or 34%, going for the classical pen-and-paper (68 students). In a world overcome by technology changing at a pace unseen before, with people emersed in electronic screens for the most part of the day (for work, study, or pleasure), it is unsurprising that people prefer them. Besides, the common marketing discourse refers to them as environmentally friendly, in that by saving paper we protect the trees, and thus the environment, with total disregard for the enormous amount of waste we generate due the speed at which technology evolves, and the aggressive marketing campaigns urging buyers to change their devices every six months. Yet that is an entirely different issue, meant for further research.

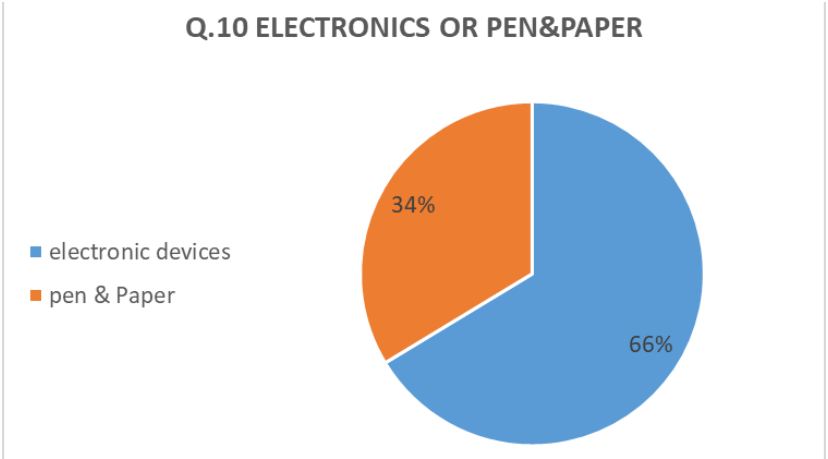

Fig. 9. Question no. 10 – In the educational process, what would you prefer: the use of electronic devices or of the traditional pen-and-paper?

A follow-up of their responses provided for question no. 10 was question no. 11 where respondents were once again faced with an open-ended question for which they had to provide an advantage and a disadvantage of each of the two options. Just as above, in question no. 6, the answers collected were mainly justifications of their choice, rather than clear arguments for and against one option or the other. The ensuing overall perspective on the issue was nevertheless based on clear reasoning. Thus the major advantages of electronic devices were ease of use and fast access to information, while the most frequently mentioned disadvantages were the negative impact on the users' eyes, the lack of speed when taking notes (especially because regular users do not have training in typing – if we are considering laptops, and if we are considering phones, their size makes them quite uncomfortable for note-taking), and limited battery life. The main advantage of the use of the traditional pen-and-paper identified by the respondents was the fact that information is retained with more ease through the process of handwriting, while the disadvantages mainly referred to the environmental impact of the cutting of trees required for the production of paper.

In the final part of the survey (the last two questions) the students were faced with an exercise of imagination: question no. 12 was a simple yes/no question which required them to express their opinion on whether education *could* become completely paper-free, while question no. 13 challenged them to think about the possibility of paper-free education, requiring them to express their viewpoint on whether education *should* become paper-free, as well as support their response with a short argument.

Responses to question no. 12 showed a quite clear inclination towards traditionalism, despite the students' preference for electronic devices which resulted from question no. 10. The percentages generated and presented in figure 12 seem to be almost a mirror-view of the percentages in figure 10. Thus only one third of the respondents (35%, i.e. 71 students) considers that education can become paper-free, while the other two thirds (65%, i.e. 131 students) take the opposite stand.

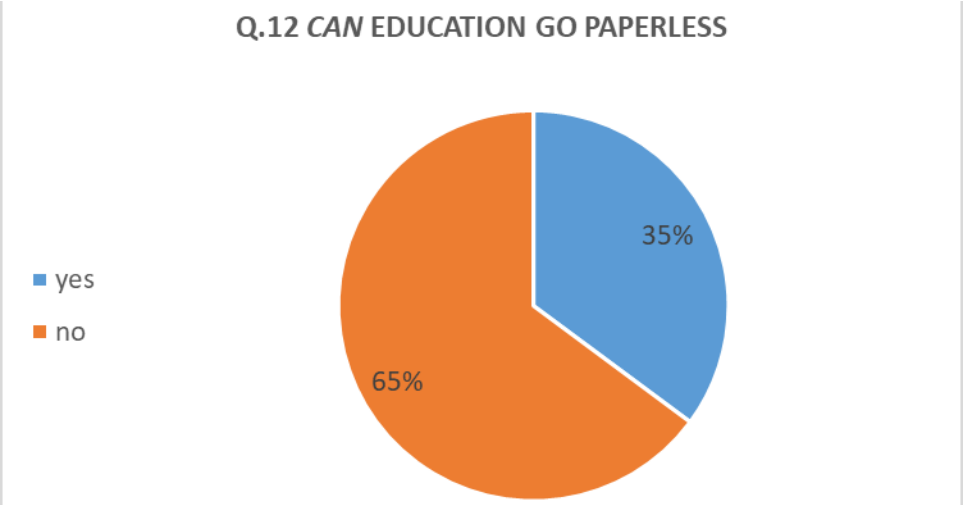

Fig. 10. Question no. 12 – Do you think education can go paperless?

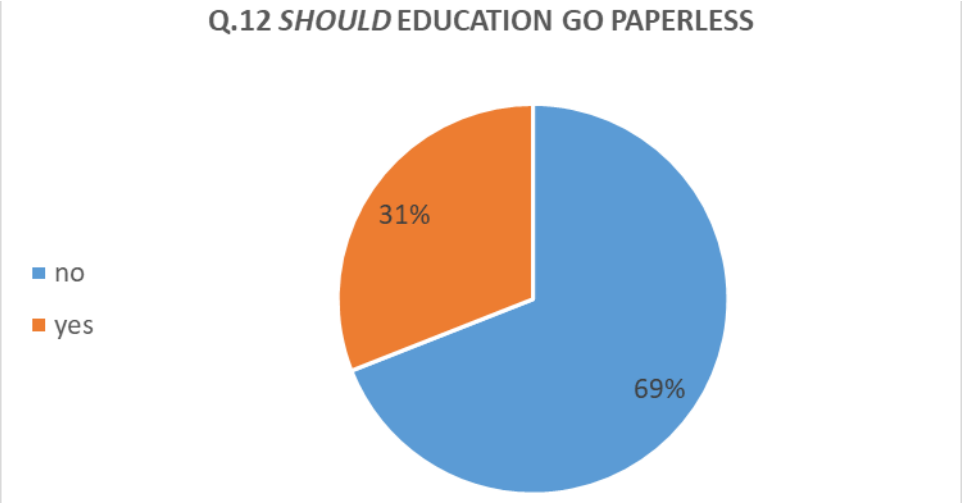

Fig. 11. Question no. 13 – Do you think education should go paperless?

Clearly the important aspect in question no. 13 is not how many students answered in the affirmative and how many in the negative – the percentage are very similar, as seen in figure 12 – but how the respondents argued in favour of their response. Thus, the arguments of those in favour of paperless education were in the same line of thinking as the answers provided to question no. 11 where respondents had to point out one advantage and one disadvantage for each of the choices in question no. 10, i.e. electronic devices or pen-and-paper. Consequently, those you said that education should go paperless considered the environmental impact of paper production, the negative impact on human eyesight, and energy consumption, while those who were against paperless education argued that writing information on paper aids in the retention of information, that children need to start in pen-and-paper and exposure to electronic devices should be delayed as much as possible, as well as the fact that writing develops creativity. Another aspect mentioned in opposition to paperless education was an economic factor, namely the fact that not all students can afford to make the switch from pen-and-paper to electronic devices, this risking to become a major issue of inequality in schools. And yet another aspect referred to the infrastructure required for the proper functioning of paperless education, viz. internet connection or even access to the power grid. Yet some respondents saw compromise as a solution, suggesting that preschoolers and primary school pupils still study traditionally, using pen and paper, and that education should only shift to electronic devices in secondary school or later.

4. CONCLUSIONS

In the light of the information collected through the survey, we can conclude that, despite the fact that the sample of students who answered the questionnaire own various electronic devices, favour them in educational activities (see question no. 10) and use them

extensively (see question no. 3) in their everyday lives (at the job, at school, for entertainment purposes, at home etc.), they would not support a complete transition to paperless education. Oddly enough, when it came to online education, the opinions were slip almost evenly (see question no. 5), with almost an equal number of respondents preferring online education and those preferring the classical, face-to-face interaction between teachers and students, in the traditional environment of the classroom. Why this is so is probably an issue for further research and strays a bit from the issue approached in the current paper. Here we attempted to provide an answer to the question of *when* education becomes overwhelmed by technology. Thus, considering all the aspects in the theoretical part of our paper, corroborated with the outcome of the survey, we draw the conclusion that there is a fine line between technology aiding the educational process and hindering it, between being useful and being a nuisance and a distraction in the classroom.

When teacher-student interaction is impaired by the abundance of electronic devices in the classroom, when communication is disrupted and attention diverted from the actual lesson to irrelevant content that is permanently available on the internet – that is when technology becomes *too much.* When the actors partaking in the act of teaching-learning lose sight of themselves, when they forget that *teaching is not the filling of a pail, but the lighting of a fire,* when the hands-on experience of a school trip is replaced with the virtual tour of a museum, when schools invest more in inanimate objects, i.e. gadgets, (being convinced that they are buying these devices to aid teachers in the educational process, while teachers themselves would trust these devices with their own lives – metaphorically speaking), rather than in humans – that is when technology becomes overbearing.

Technology in the classroom is an amazing tool, but it is exactly that: a tool. It depends on us, teachers and students alike, whether this tool is used to the advantage of the educational process and in the best interest of the players. Technology can provide great help and generate extraordinary outcomes, and it has done so for ages. We cannot imagine education without it, because it is not just about electronic devices connected to the internet; it is so much more than that, and it could not have been created without education. Education and technology are interconnected and usually work in harmony towards the brighter future of generation after generation of students. It is when *we let it* that it becomes a nuisance and a hindrance. Technology can become harmful if we allow it.

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OPTIMIZING THE CMM CONTROL PROCESS OF AIRCRAFT FRAMES

Marius **COSMA**[1], Dinu **DARABĂ**[1], Norbert **GAȘPAR**[2]
[1] *Technical University of Cluj-Napoca North University Center of Baia Mare, Romania*
[2] *Universal Alloy Corporation Europe, Dumbrăvița, Romania*
marius.cosma@imtech.utcluj.ro, dinu.daraba@imtech.utcluj.ro,
norbert.gaspar@universalalloy.com

Keywords: aircraft structure, aircraft frames, aircraft manufacture, CMM control, modular device, sliding assembly, optimize, low cost.

Abstract*: The paper presents the optimization of the control process of a family of complex aircraft parts by designing a modular device for the CMM (coordinate measuring machine), how to assemble the elements, how to align the device on the machine table and the presentation of real advantages and disadvantages regarding the designed device.*

1. INTRODUCTION

The objective of the paper is to optimize the control on the CMM (*Coordinate Measuring Machines)* of a very large number of frames used in the structure of the aircraft fuselaje (fig.1) that are similar but at different sizes and radii. Fuselaje frames perform many diverse functions such as [1]:

-support shell (fuselaje skin-stringer panels) compression/shear;

-distribute concentrated loads;

-fail-safe (crack stoppers).

They hold the fuselage cross-section to contour shape and limit the column length of longerons or stringers. Frames also act as circumferential tear strips to ensure fail-safe design against skin crack propagation.

Fig. 1. Structure of the aircraft fuselaje

The primary loads due to fuselage as bending, shear, torsion and cabin pressure are carred by stiffeners with frames spaced at regular intervals (conventional value 20 inches for transport airplanes) to prevent buckling and maintain cross-section.

2. MODULAR DEVICE DESIGN

2.1. The current control process

The current control solution uses a dedicated device required for each frame type. For each part, a mainboard is needed for the overall dimensions of the frame plus other modules depending on the size and shape (radius) of the part. For each device an overall processing is required because on each module there must be a surface conjugated with the negative surface of the respective part.

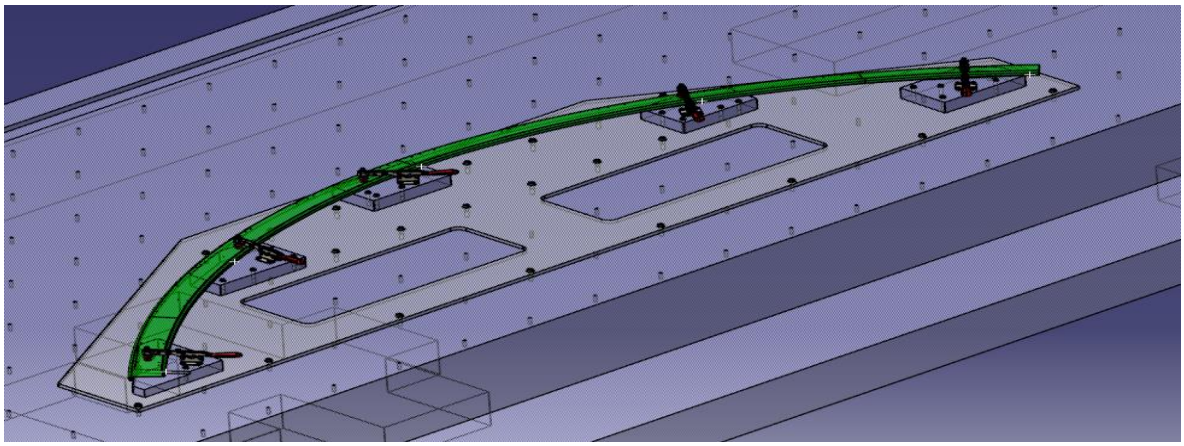

Fig. 2. One of the current control devices

2.2. The new concept of the modular device

The new own concept is the use of a modular device usable for a large number of frames that can be grouped according to various criteria. The grouping is done according to the radius and length in five sets (100, 200, ... 500, *fig. 2*.).

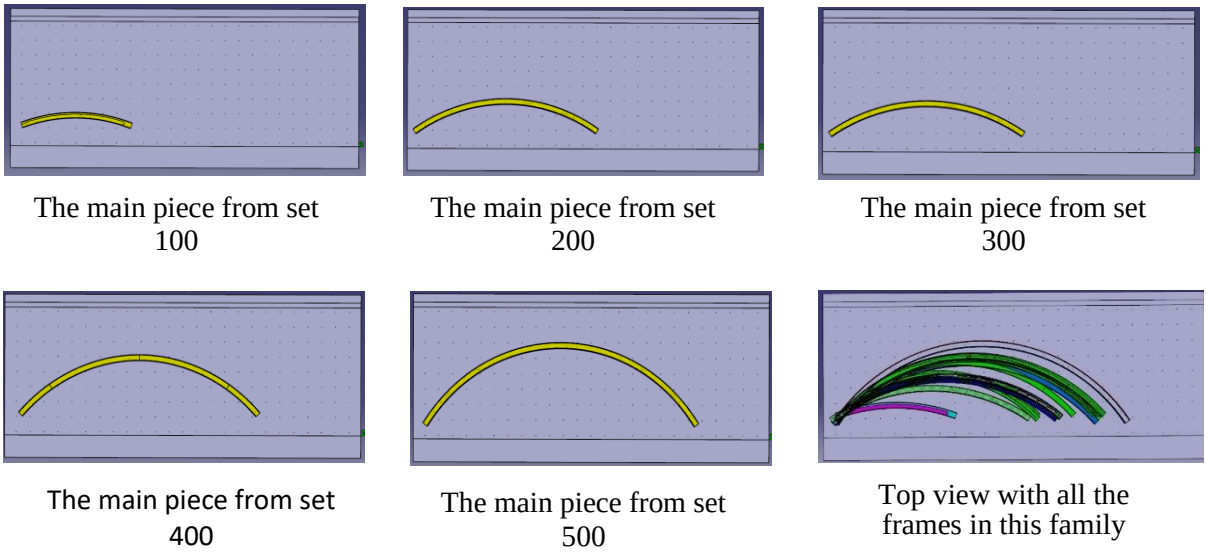

Fig. 3. Gruping the frames

The new device will contain six large modules (required for the largest frame) of which only five modules will be able to slide on the X and Y axes respectively (*fig.4*). On this assembly above, the base plate of the device is mounted and guided on the X and Y axes and has a travel limit of 510 mm on each axis. At the same time, for each axis we have mounted two locking systems in order to be able to fix the plate at the required dimensions.

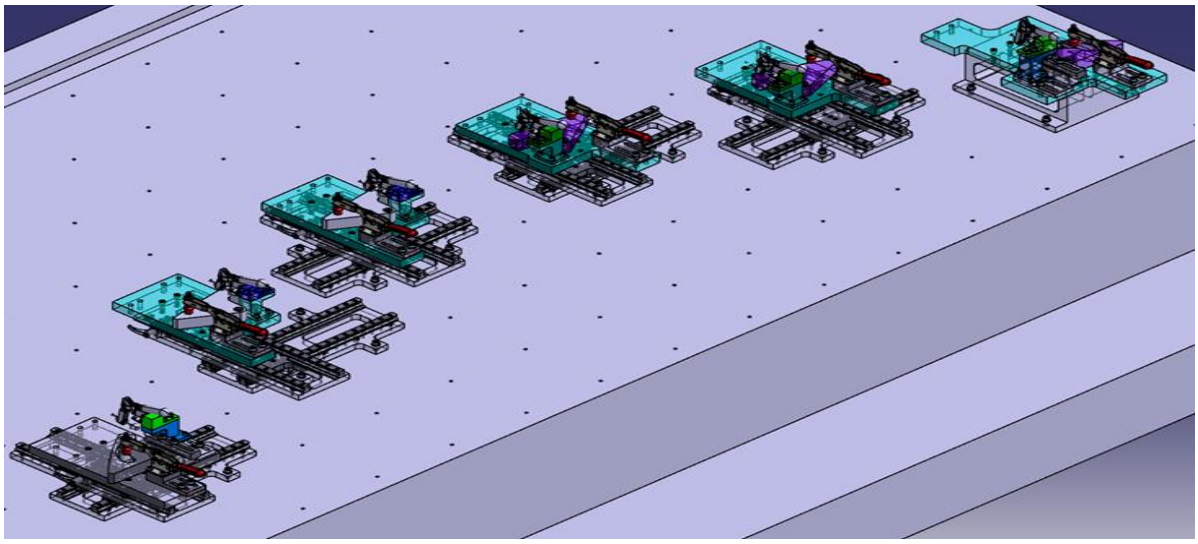

Fig. 4. The new modular control device

2.3. Design of orientation and fixing subassemblies

The new concept of the device is based on the use of modules designed to be usable, through very precise adjustments on the two axes (X and Y), using in their construction roller guides and locking systems type of Bosch Rexroth (*fig.5*).

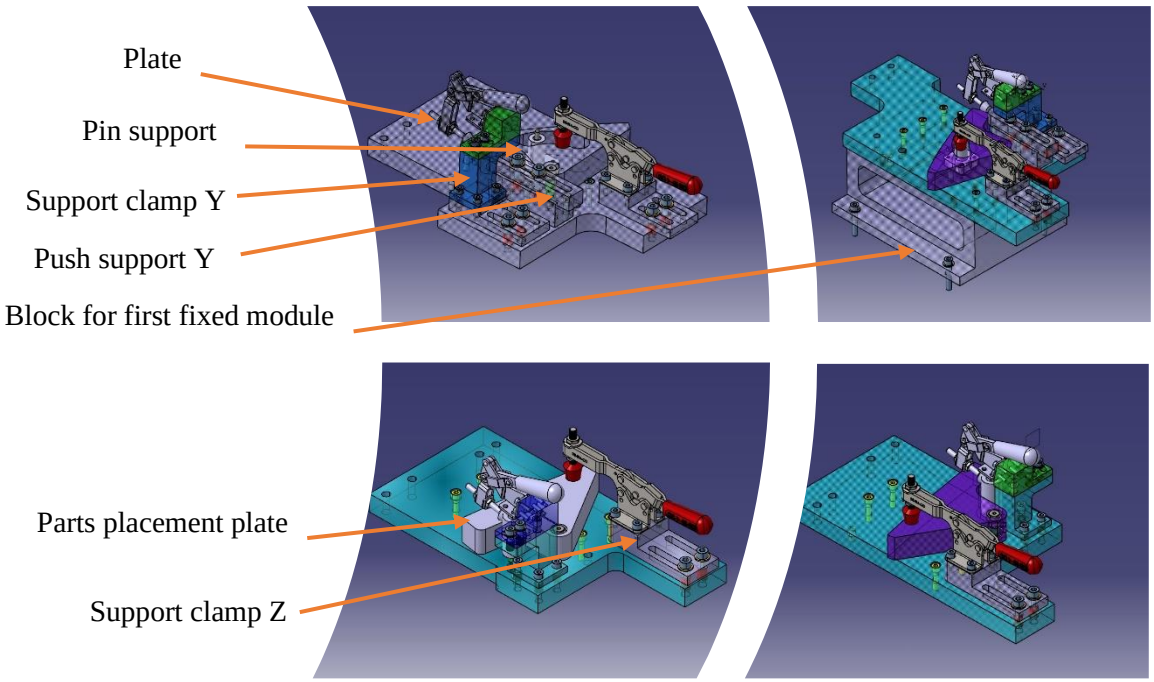

Fig. 5. The orientation and fixing subassemblies

The fixing clamp supports used to secure the frame to the device were designed to make it possible to rotate around the Z axis up to 12° (*fig. 6*).

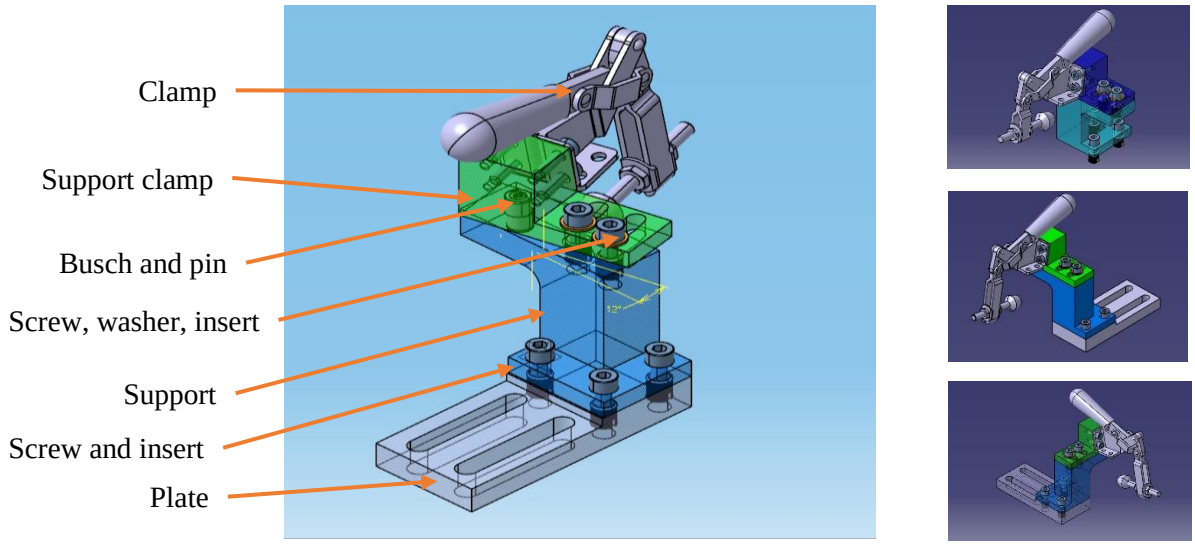

Fig. 6. The fixing clamp supports

3. THE CONTROL PROCESS WITH THE NEW DEVICE

3.1. Mounting the modular device on the CMM

To measure the parts with this device, the positioning dimensions of the modules are required for the CMM operators to position each mainboard together with its subassemblies in the required dimensions according to the shape of each part. These dimensions are set according to the shape of the part so that it is positioned centrally in the translation modules, so that they can be oriented and fixed within the limit of 510 mm of translation on the axes (exemple for one frame from 300 set, *figure 7*).

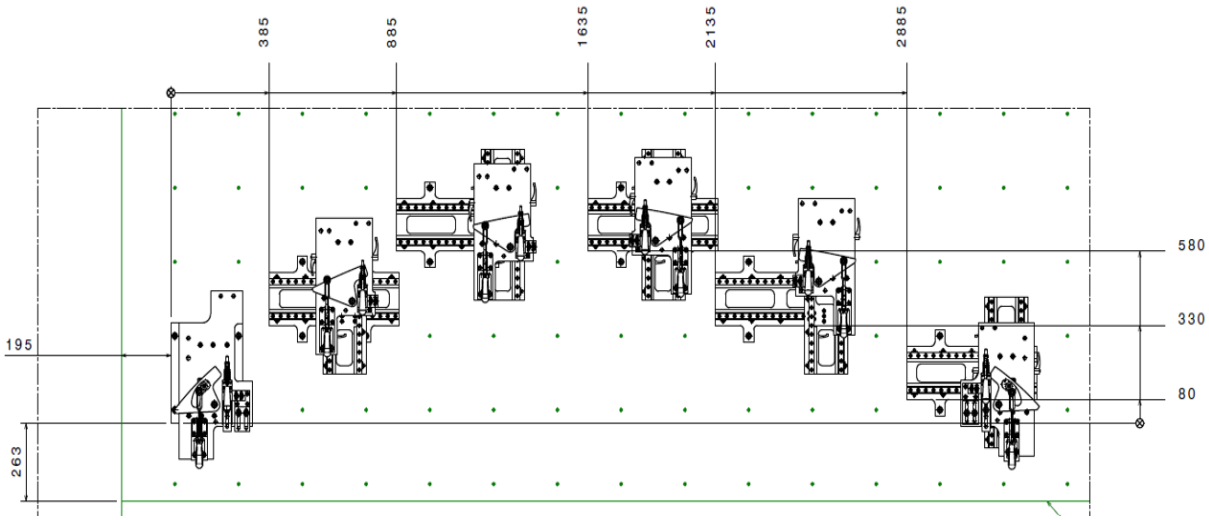

Fig. 7. Module fixing dimensions for a part

Positioning dimensions are very important because with their help the modules are structured for the shape of each part so that it can be measured and verified without the existence of certain problems. For each part, the upper modules will have to be repositioned on the X and Y axes, or if they exceed their stroke, the sliding assemblies will have to be repositioned. The holes of the coordinate measuring table are M10 threaded holes and are at a distance of 250 mm on both the X and Y axes.

The alignment of the moving bases is done with the help of the hole *Φ12H7x13* mm specially created for the positioning of the upper assemblies with precision on the machine table, all the positioning dimensions of the upper assemblies that are mounted on the sliding assemblies will be given on the X and Y axes starting from the first mainboard. fixed support.

The alignment dimensions of the part will be given from the capsule assembly with the centering pin of the first fixed support to the capsule with the pin that is found on the last sliding assembly with its afferents, so they will be exactly in the areas where the part will be positioned on the device.

3.2. Orientation and fixing of parts in the device

In the figure below you can see how the part was positioned with the pins and at the same time you can see how each subassembly works, respectively fixing the part with the fixing clips on the Y and Z axes. For each part, a control sheet is generated with the specific adjustment dimensions after which the part is oriented and fixed ready for control (*fig.8*).

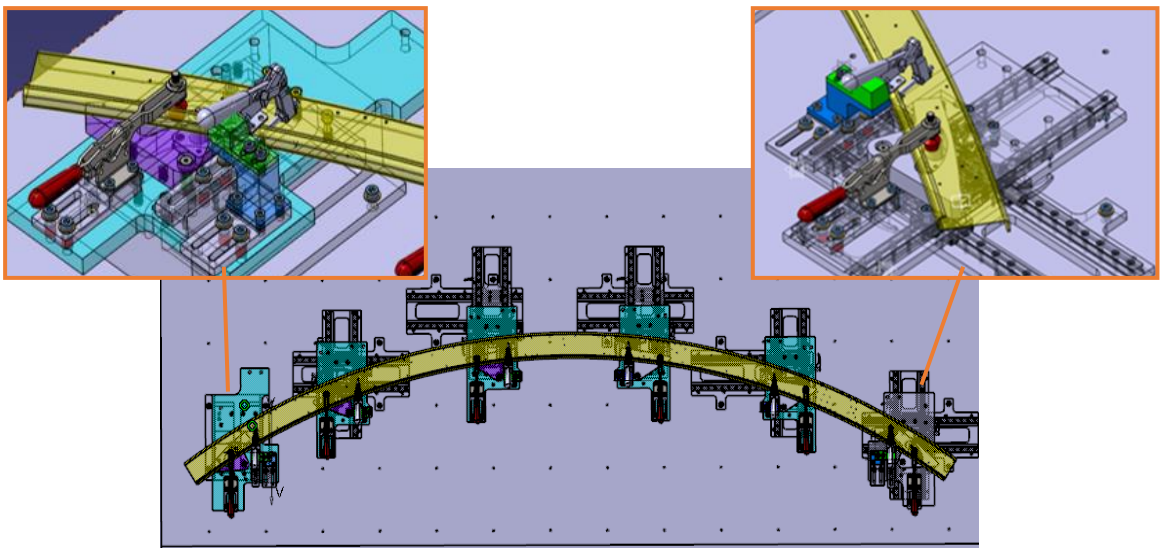

Fig. 8. Part orientated and fixed in the device

4. RESULTS AND CONCLUSIONS

The implementation of the new device in the control process on CMM brings many advantages, among which the most important would be: low cost of processing and purchasing the necessary compared to 42 devices dedicated with the negative contact surface with the part; designing only one device; storage of only one device for the whole family; reduced material consumption compared to the variant of dedicated devices; with a simple assembly of the device, several parts can be measured, being included in its stroke.

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USING THE WEINTEK HMI IN SMART HOME CONTROL

Mihaela-Anamaria **LIHET**[1], Cristian **BARZ**[1]
[1] *Technical University of Cluj-Napoca, Department of Electrical, Electronic and Computer Engineering*
mihaela.lihet@ieec.utcluj.ro, Cristian.BARZ@ieec.utcluj.ro

Keywords: smart home, HMI, automatization, Weintek, home automation.

Abstract*: The importance of smart homes is growing rapidly due to growing industrial demand. One of the main goals of a smart house is to make our daily lives easier by increasing the level of comfort. This paper presents the process of designing an interface of a smart home through which we can control certain devices and features of the house such as: lighting, alarm and surveillance system, outlets, air conditioning system and so on. The application was made using the EasyBuilder Pro software. The great thing about Weintek screens is that they are compatible with a multitude of PLCs, and due to their modern appearance, it is easy to include them in the interior design of a home. Smart homes will gain massive popularity in the future as current trends indicate that they are becoming the center of smart services consumption.*

1. INTRODUCTION

In a world where technology is advancing from one second to the next at a rapid pace, we must adapt and learn to keep up with it. We live in an almost entirely digital world where a simple voice command or a simple click acts on an electronic device which, in turn, will receive and further execute the received command. The terms smart homes and intelligent homes have been used for more than a decade to introduce the concept of smart devices and equipment in the house [1,2].

According to the Smart Homes Association the best definition of the smart home technologies is “The integration of technology and services through home networking for a better quality of living” [3]. Smart homes are not only an interesting topic, but also a growing

industry as well as entering to a broad audience home gradually. Most programmers have to design smart home systems case by case and spend a lot of time managing them [4,5].

This paper presents the process of designing an interface of a smart home through which we can control certain devices and features of the house such as: lighting, alarm and surveillance system, outlets, air conditioning system and so on.

2. WEINTEK EMT3120A TOUCHSCREEN

For this simulation, we used the Weintek eMT3120A touch screen and the EasyBuilder Pro software. The touch screen makes it easy to create a graphical interface for a large number of PLCs on the market. This is more than a simple screen; it is able to program the PLC and transfer data and programs between several similar devices from this manufacturer.

There are many things that this panel can do. It connects to over 300 different protocols/devices (PLCs, inverters, etc.), the CAN Bus port supports the CANopen protocol, it can communicate with different devices/protocols at the same time, it has a switching function (PLC program via HMI connection), remote monitoring and error diagnosis, it has Internet Of Things (IoT) connectivity and access to any HMIs via EasyAccess. Weintek eMT300 series brings together in a single HMI robustness (aluminum box), high speed process (up to 800 MHz CPU), communications and remote management of alerts [6].

EasyBuilder is a powerful software that greatly simplifies the visualized project editing and supports more types of communication protocols like Ethernet/IP, Modbus TCP. Users are ensured to communicate with peripheral devices all with ease and complete project designs swiftly in the shortest possible time [7].

Fig. 1. Weintek eMT3120A touch screen

3. SMART HOUSE CONCEPT AND APPLICATION

The concept of smart homes is widely preferred because it improves the lifestyle of its residents through easy control of lighting, temperature, security, and many other features. As smart home networks continue to grow in size and complexity, it is essential that we address many of the challenges like data loss due to interference and efficient energy management. The field of home automation is expanding rapidly as electronic technologies converge [8]. The only thing that remains constant is the permanent control of the intelligent system that the residents of an automated house have. In addition, a lot of routine tasks that are part of the owner's comfort such as (adjusting the heating, activating, or deactivating the security system, lowering and raising the blinds, etc.), become an ensemble that can be transformed into simple sets of pre-programmed and customized operations. As soon as such a plan is set up, the comfort level of the house will increase to a level that previously seemed unimaginable.

3.1. Home page of the interface

The program opens with the home window where we find the general button which gives us access to all the rooms in the house. In the figure below, you can see the buttons for the upstairs rooms. You cand choose wich room you want to enter and change the lighting, blinds, temperature and security control individually.

Fig. 2. Home page

3.2. Lightning control

Lightning is one of the most important aspects in terms of home comfort. So, we are talking about the use of lighting in certain areas of the house considering the needs and the season or time (whether it is day or night). At the same time, we need the access roads lighting at night or lighting for surveillance cameras, as well as outdoor lighting for the garden or pool lighting. We can also talk about the light architecture that automatically contributes to the comfort and ambiance of the home. In the bedroom plan presented below, we marked the two-way switches together with their corresponding light with the red color. This way, you can turn on the light as you enter the room, and you don't have to worry about turning it off, because you can do this through the other switch next to the bed.

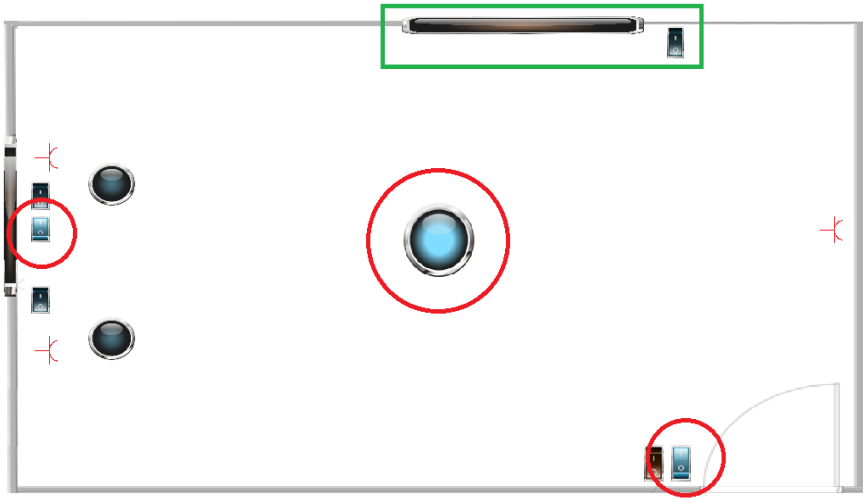
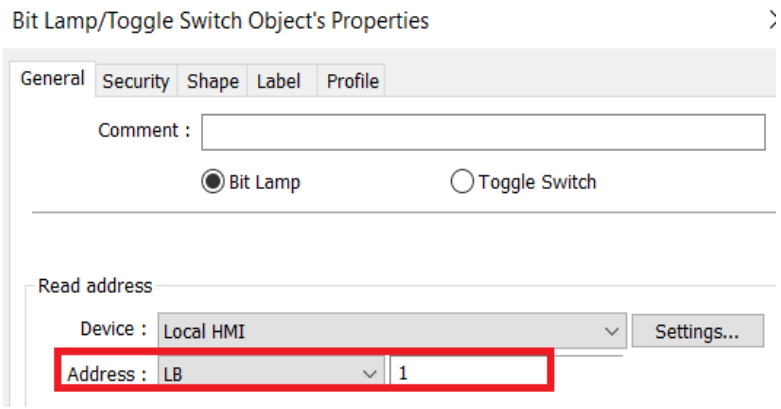


Fig. 3. Bedroom plan

The switch connects to the lamp through an address number. How this works is that the bit lamp with the address LB 1 will be turned on/off by the toggle switch with the address LB 1 as seen in *figure 4*.



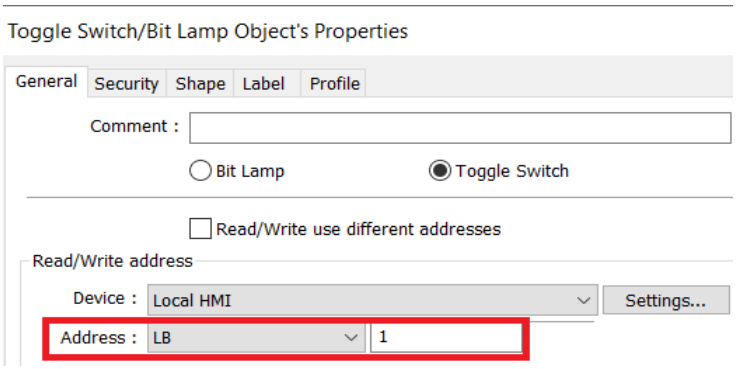


Fig. 4. Lamp/Switch selection

3.4. Temperature control

Temperature comfort increases with the automation of the heating system. An automated system will ensure a set temperature in any room, which is created to the liking of residents, regardless of its orientation or space. For example, in the figure below we presented the case for the living room. The ideal temperature was set at 23 degrees Celsius. If the temperature drops below 23, the heating system will automatically start, and it will be warming up the room until the desired temperature is achieved. On the other hand, if the temperature rises above 23, the air conditioning system will start, and it will be cooling down the room in order to achieve the ideal temperature.

Temperature control is performed on each area of the house and on hourly levels, with the possibility of changing the scenario at any time, through the application or remotely via the Internet from any phone, tablet, or PC.

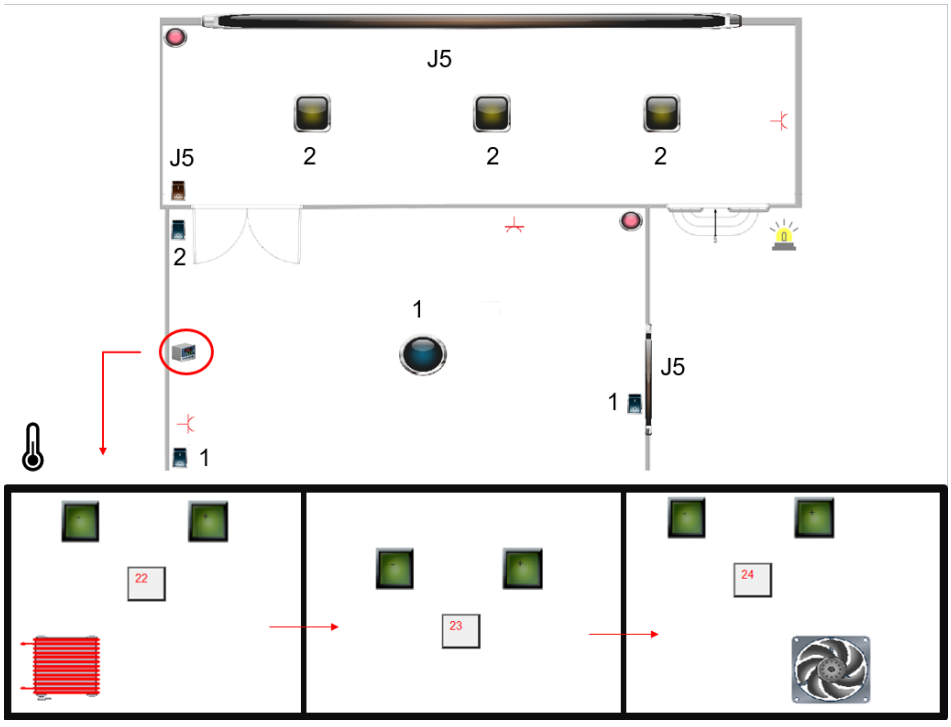


Fig. 5. Temperature control

The properties used for the heating and cooling system can be seen in the figure below.

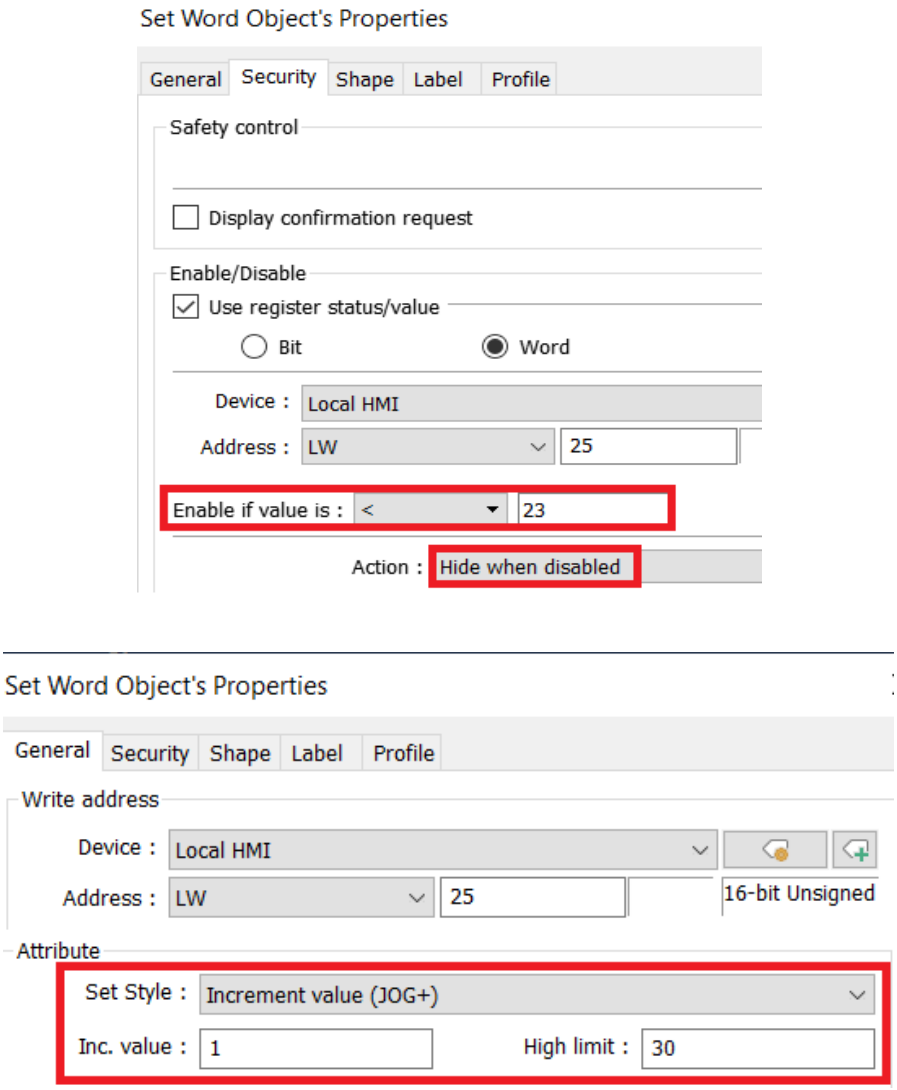


Fig. 6. Heating/Cooling system properties

3.5. Security control

You can "teach" your home to call people close to you or even you if there is an alert situation. You can save money on security monitoring services or even to monitor non-traditional security events such as the baby, water, or gas. Each resident of the house is assigned an access code with which, once entered, he is allowed access to certain devices in the house depending on the class corresponding to the device. The passwords for each resident are assigned individually from the system parameter settings tab like in *figure 7*. Also, from this menu, you can choose which class the residents have access to.

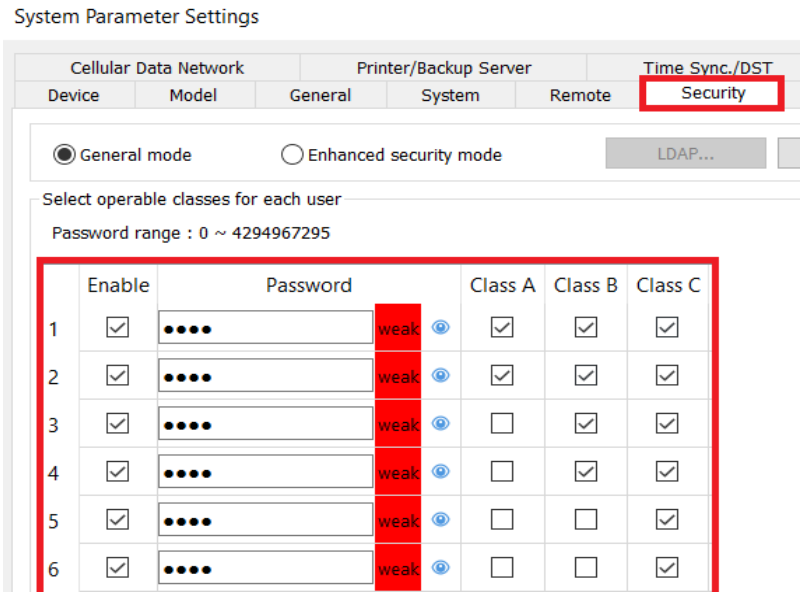


Fig. 7. Password distribution

The plan of the entrance of the house is presented in *figure 8*. In this scenario the alarm sensors are off, thus the whole security system is off.

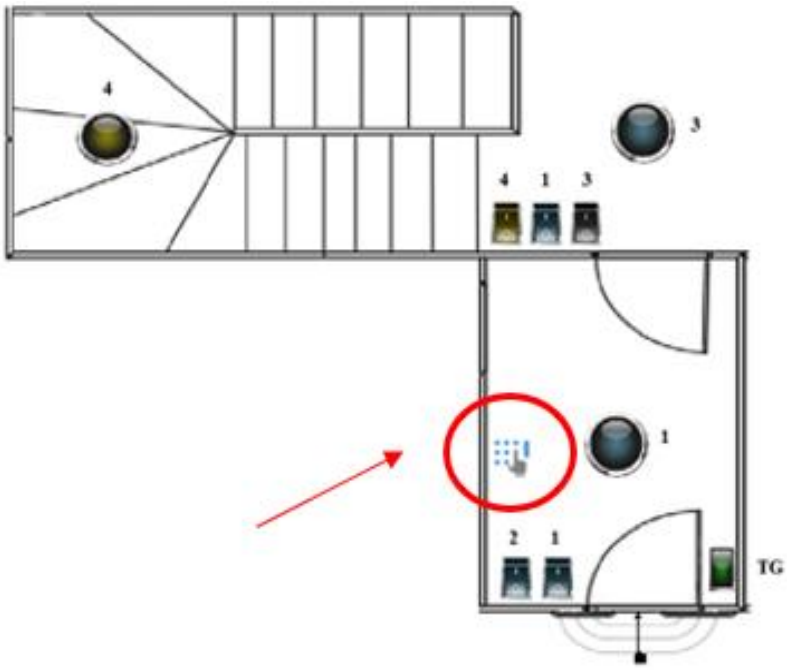


Fig.8 Entrance Hall plan (alarm off)

When you press the keyboard image that is circled with red from *figure 9*, it will pop up a new page where you have to choose the resident and insert the password. In the top left corner of *figure 10*, there is a list with the residents and the allocated password for each one that consists of a four-digit number.

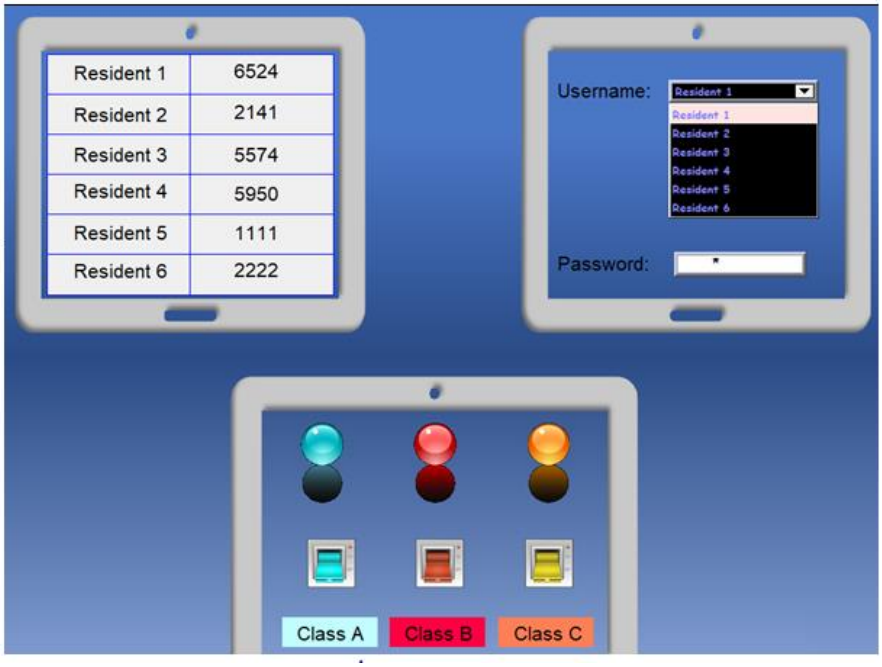


Fig. 9. Access control

By logging in with the username and password designated to resident 1, you get instant access to the security system by turning on the class A switch. After that, the moving sensors will activate instantly.

4. CONCLUSIONS

The importance of smart homes is growing rapidly due to growing industrial demand. One of the main goals of a smart house is to make our daily lives easier by increasing the level of comfort [9]. This paper presents the process of designing an interface of a smart home through which we can control certain devices and features of the house such as: lighting, alarm and surveillance system, outlets, air conditioning system and so on. The application was made using the EasyBuilder Pro software.

The great thing about Weintek screens is that they are compatible with a multitude of PLCs, and due to their modern appearance, it is easy to include them in the interior design of a home. Smart homes will gain massive popularity in the future as current trends indicate that they are becoming the center of smart services consumption.

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TRANSFORMATION OF TELLER/COUNTER SERVICES USING MODERN MOBILE DIGITAL INFORMATION TECHNOLOGIES

Mirko **SAJIĆ**[1], Dušanka **BUNDALO**[2], Željko **VIDOVIĆ**[3], Zlatko **BUNDALO**[4], Dejan **LALIĆ**[5], Luka **SAJIĆ**[6]

[1]Independent University Banja Luka, Faculty of Information Technologies, Republic of Srpska, Banja Luka, [2]University of Banja Luka, Faculty of Philosophy, Republic of Srpska, Banja Luka, [3]University of East Sarajevo, Faculty of Traffic Engineering, Republic of Srpska, East Sarajevo, [4]University of Banja Luka, Faculty of Electrical Engineering, Republic of Srpska, Banja Luka, [5]NLB Banja Luka, Republic of Srpska, Banja Luka, [6]Pan-European University Apeiron Banjaluka, Faculty of Information Technologies, Republic of Srpska, Banja Luka

Keywords: **teller/counter services, business transformation, process automation and robotization, modern and mobile information technologies, pandemic, universal multifunctional digital devices, mobile banking, digital signature.**

Abstract: *The paper considers, proposes and describes the possibilities and ways of transforming teller/counter services using modern and mobile information technologies in order to increase the efficiency of such business. The shortcomings of the traditional teller/counter services are pointed out, and the reasons that will lead to the transition to a modern automated way of providing teller/counter services, without the physical presence of a person, are presented. Then, various variants of partial or complete automation of teller/counter services using modern mobile information technologies are considered. The impact of the pandemic on accelerating the online working and services is mentioned. Then, ways of transforming teller/counter business are proposed and described, through several variants, such as the use of intelligent digital teller/counter terminals and the application of remote online services, through several practical examples. Factors that influence the limitation of the degree of automation and what needs to be done to overcome these limitations are highlighted. Groups of users are profiled who, according to their objective and subjective reasons, will use certain types of automation of teller/counter operations. Appropriate intelligent multifunctional devices are presented, which are already used in some areas as a transitional solution in the automation of the provision of teller/counter services.*

1. INTRODUCTION

The first thing to focus on is the reasons why someone who organizes the provision of teller/counter services would look for some new possibilities in relation to the classic, well-established way of providing counter services.

Modern man (user of the mentioned services) is increasingly realizing the advantages provided by modern mobile digital technologies and devices. And he rightly wonders if some things can be done “online,” e.g. to buy various goods through web shop stores. That exactly means that the user chooses the time when he will do it and the place from where he will do it (it is important that he has access to the Internet), so why not get the possibility of "online" servicing. [1] Modern man has less and less free time at his disposal. Furthermore, there is less and less time to perform certain tasks, which include the provision of teller/counter services. Because these services, if performed in the classic way, require the user to go to a specific and prescribed place to do so. This again entails wasting time, nerves, etc., as traffic jams are to be expected at that time. Because as working people have their working hours, so do the counters, realized in the classic way.

The employer is dissatisfied, because the worker has to leave his job, lose time while doing his jobs related to the performing teller/counter services, such as going to banks, municipalities, various other state institutions, to pay something, get a certain document. Since the classic counter has the prescribed working hours, then, depending on the frequency of services it provides, you can expect crowds and queues in front of such counters. We are also witnessing other problems brought to us by the modern age, in the form of pandemics, which further complicates the provision of counter services in the traditional way. Because the prescribed distance is required, there is little space in the rooms themselves, so people are waiting outside in line, in the cold, rain, snow, high heat.

All this contributes to the modern client feeling dissatisfied, this way of organization increases his nervousness and stress, which he certainly has too much, living a modern fast-paced way of life and work. And he rightly demands more and more that he be allowed to choose the time and, if possible, the place where and when he will perform certain counter services.

Those who are in charge of the organization and cost-effectiveness of providing teller/counter services, are also realizing more and more, the problems that are accumulating, providing services in the classic traditional way. [2] Certain attempts to extend and shift office hours have only partially alleviated customer dissatisfaction. On the other hand, shift work has increased the cost of providing services. Thus, the organizers of these services are brought into a dilemma, whether to reduce the profit from services, or increase the prices of services. It

should not be emphasized that the latter would further increase the dissatisfaction of users of counter services.

All the above reasons contribute to the fact that the organizers of teller/counter services, as well as customers, think and increasingly use modern mobile digital technologies (software - hardware components). Normally to the line, that existing legislation allows them to do so. It is known that legal regulations are generally quite late for technology.

2. REASONS FOR THE GRADUAL TRANSITION OF ORGANIZATION OF TELLER/COUNTER SERVICES FROM CLASSIC TO MODERN AUTOMATED WAY

Some of the reasons have already been mentioned in the introduction. There is very little reason left to organize teller/counter services in the traditional way. The only real reason is the impossibility of quality automation, due to the specificity of the service provided at the counter.

There are many reasons for modernization: [3]

1. The desire of the service user for a flexible time in which he can receive certain counter services. In most cases, this desire comes down to the so-called 24/7 service, ie. that the service is constantly available.
2. The desire of the service user to, in addition to time, choose the place from where he will be able to receive the service. Most often, it is a house, office, but it can also be a restaurant, beach, hotel or any other place where the user happens to be and has the opportunity to request that service. This usually means an "online" service performed over the Internet.
3. For some types of services and depending on the level of technical education, common fear of virtual things, age, the client chooses to do it in the official place of the service provider, but automatically, via appropriate digital devices. It is enough for such clients to be able to choose the time of performing counter services, in order to avoid crowds. These types of services also involve setting up a 24/7 service.
4. Performing the service becomes expensive for both, users and service providers. Service users must spend their time (and time is money), bear the costs of transportation to the place of performance of services and the costs of the requested service itself. Service providers, on the other hand, have the costs of arranging the workplace where they provide services, the costs of human staff, and other costs such as security, video surveillance, heating, electricity, water, utilities and the like. When all this is added to the need to organize extended working hours, all this together results in an increase in the prices of services. That's a thing that will never meet with user approval.

5. Extending the working hours of providing services, as well as the flexibility of the place from which the service can be performed, significantly increases the possibility of servicing a larger number of services than is the case with the classic provision of services at the counters. Service providers are aware of this, but users are also slowly becoming aware of it. For example. let's say a user needs a certificate of citizenship. He remembers taking it out some time ago, but by coincidence, he doesn't remember where he could have left it. The user, in order to save himself the time of painstakingly rummaging through things and drawers around the house, makes the decision to retrieve the document again, as he passes by the digital device, where it is possible to retrieve the certificate quickly and without waiting in line. In doing so, he sacrifices to pay for the service again, but he does so because the price of the service is not high. The question is, would he have made a similar decision, if he had been forced to go to the municipal counter and wait in line, all during his working hours. The more automated and accessible the service is to the user, the more often he will decide to use it.

All these reasons contribute to the conclusion that it is time to consider the possibilities of automating, digitizing and robotizing counter services, so that they can be provided "online", without limiting the place and time of service. [4]

Below is an example of what is happening with banking services, which by nature have been over the teller/counter so far.

Figure 1 shows a typical architecture and block diagram of a modern bank information system. In addition to the central part of the bank, two channels of communication and performing the bank's business with clients are shown. These are through personal arrival and physical contact, and through remote access using mobile technologies.

Figure 1 clearly shows that over time, more and more customers will use remote access with the help of mobile devices for doing banking business. It clearly shows the Client migration path. This will increasingly weaken the strength and importance of individual branches, agencies and counters and parts of their networks. There will inevitably be a transformation of branches, agencies and counters. In doing so, some of these places will be turned into a combination of reception offices and self-service devices when performing banking operations. Some of these places will be completely closed. Reception offices will serve as suitable places where trained bank employees will perform the tasks of banking financial advisors to clients who want to do so through physical contact and who need this type of assistance. Complete closure refers especially to rented places, ie to premises that are not owned by the bank. After the migration of a sufficient number of clients to mobile technologies, the cost-effectiveness and sustainability of certain places where branches, agencies and counters are located will no longer be possible. [6]

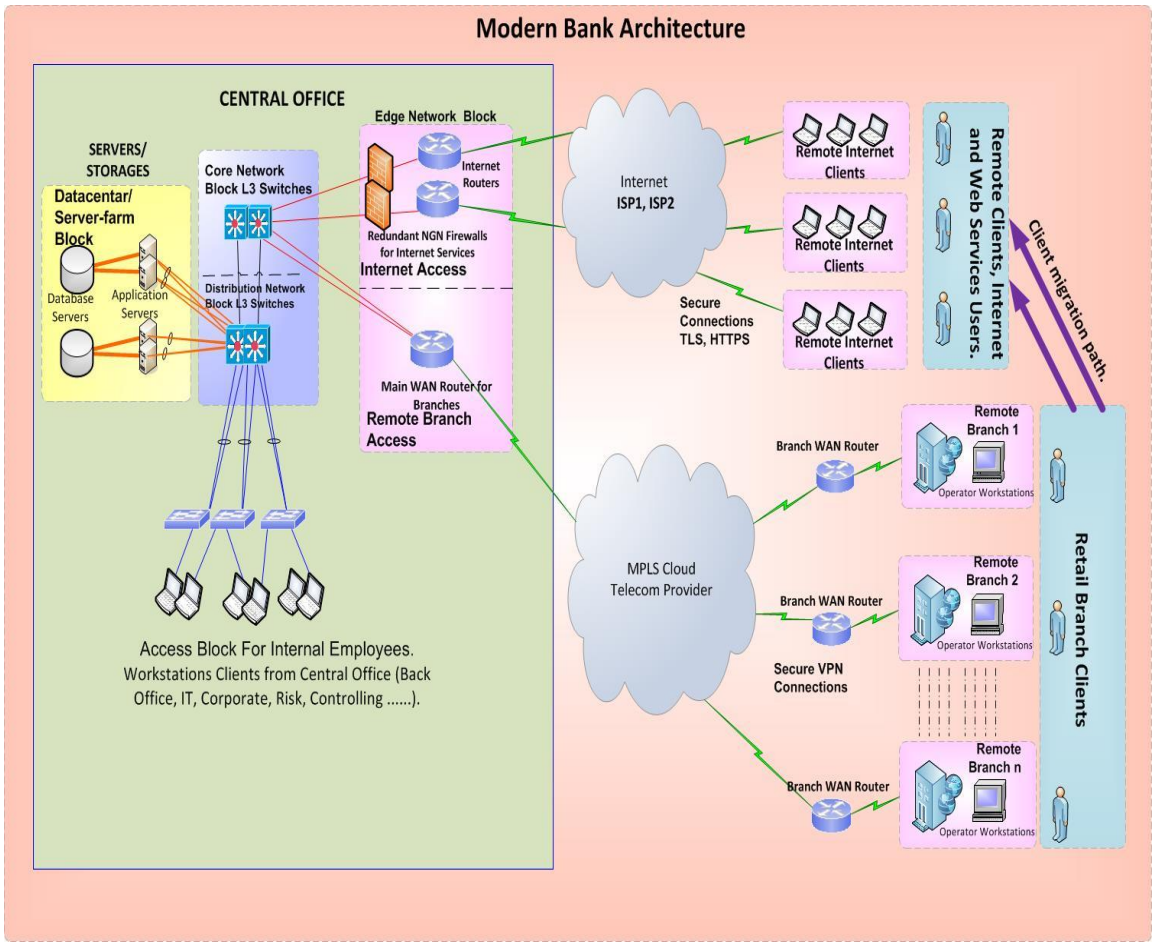

Fig. 1. Typical architecture and block diagram of a modern bank information system [5]

3. WAYS OF ORGANIZING COUNTER SERVICES WITH THE HELP OF MODERN MOBILE DIGITAL TECHNOLOGIES

Starting from the reasons stated in the previous chapter, it is clear that teller/counter services should be organized so that they are fully automated and available "online" on a 24/7 basis. Such services are already provided now, and in the future, there will be more and more of them, by various mobile applications, such as Mobile banking services. But the question is, in witch percent will be possible to automate such services in a certain region. [7]

Depending on the situation, different degrees of service automation should be considered and based on that the performance itself. For example in the Balkan region, still in most countries, a digital signature law either has not been enacted or has not taken root in practice. In that case, certain teller/counter services, such as the issuance of birth certificates, marriage certificates, etc., which are under the jurisdiction of municipalities and similar state institutions, cannot be organized "online" in full. It is also not possible to send a scanned confirmation of the amount of personal income, because it cannot be digitally signed, but the law prescribing personal delivery of the original or a certified paper copy is still in force.

In such a case, it can think about setting up multifunctional digital devices that are designed so that they can do the teller/counter work. They should be in the so-called "Zones 24", ie to be available at all times (24/7). In this case, the user of the service must come to the places where these devices are installed, which is a limiting circumstance for a certain number of clients.

Some customers (younger population who are good at mobile devices and who have good eyesight, due to the screen size on these mobile devices) will feel deprived there. However, there is still (and will be for some time) a significant number of users, who for security reasons feel safer and experience these services more credible, if they use them in places where the competent institutions for this type of service are located (banks, municipal buildings, state institutions etc.). Also, the choice to perform the counter service via a multifunctional digital machine, instead of via a mobile application, will be chosen by the elderly, with poor eyesight, people who either do not have sufficient control over technological devices, such as mobile devices. Or a group of people who still have a fear of "hacking" and do not trust this type of service ("online" service). Unfortunately, frequent psychological announcements (sometimes false, sometimes true) about how certain data on the Internet were stolen and the similar situations, contribute to this psychological state.

Also, in cases when the documents have to be submitted in the original, and cannot be digitally signed and sent via the Internet, partial automation can be performed. The institution providing the service should arrange for most of the necessary activities to be done "online", and then for the flow of physical documents to be done through delivery companies. For example. in light of the outbreak of the pandemic, which has been going on for the second year in a row, the performance of work "on line" has accelerated, ie at a distance. Suddenly, there are companies, schools, state, etc. institutions, came to the realization that most jobs can be organized remotely, without any major problems. Because the current technology allows it (internet, good communication connections, computers, mobile devices, various applications such as Skype, Zoom, Google Meet, etc.).

Thus, a large number of universities organized "online" lectures. However, many have stopped there, and it is technologically and legally possible to automate many more processes. One example is that a student enrolls in college without having to physically come. It is enough for the school institution to have the possibility on its website, for the student to send all the necessary scanned documents, proof of payment of tuition fees, and for the automated documents to be verified by the student service employee, to send the information back to the student. Now he needs to submit the same documents in the form of originals or certified copies, in some form of delivery. When these documents arrive at the student service, the student service prepares and sends by index and other necessary documents, which are certified by the school institution. It is clear that in addition to teaching "online", there are other technological devices that allow the student to be examined orally and in writing. It is normal that there are special cases here as well, where it is not possible to organize everything like this. This certainly

includes teaching that requires a special laboratory, studio, ie the physical presence of the student. Various other services could be organized in a similar way, such as delivery to persons with limited movement, personal documents (birth certificate, marriage certificate, real estate cadastral certificate, etc.), until the possibility of digital signature. All this can be very easily solved by a well-designed process realized with a good web application and connected delivery.

Some of the most common obstacles in trying to automate teller/counter services are legal obstacles. It has already been mentioned that the legislation, more or less, is behind the technology. This leads to cases where, due to outdated legislation, it is not possible to automate a counter service, although the demand for it is high, it is technologically feasible, and from the point of view of cost-effectiveness, it is desirable. An example is the existing regulations in Bosnia and Herzegovina, where certain documents such as birth certificates, etc., are printed in the proper form by certain authorized printing houses. Certain blanks are left on these forms, where the name, surname, date of birth, etc are filled in. And where is the problem with automation now? It is not a problem that some of the multifunctional digital devices, intended for the provision of teller/counter services, support it. However, each of these forms requires a separate tray in the printer, from where the sheet will be pulled out and the form filled out. It is no problem to create a convenient software solution that would fill these forms, with adequate data. But the problem is that, in the specific case in BiH, for printing only the birth certificate, a printer with 5 drawers must be provided. One for filling in the form, in Serbian Latin, the other for filling in the form in Serbian Cyrillic, the third for Croatian, the fourth for Bosnian language. Finally, the fifth drawer for the international birth certificate form. This seems complicated, because you need to get special printers within the multifunctional digital device, which have the ability to work with 5 drawers, the dimensions of the device itself increase. And most importantly, one device could only serve one type of certificate. And just a small effort that the competent services need to make and adapt the law on issuing documents to the digital era, would be enough for multifunctional digital device to be able to provide the service of issuing a whole range of different certificates. It is enough to give up making a ready-made form, but to format the text of the forms on the device itself, which would print the defined prescribed text on paper. Then, which would have a pre-printed header with all the necessary markings of the institution and everything else that needs to be placed in the header. And, to determine the numbering of each issued document and write it in the printing house. Now it is enough to put the appropriate stamps on those sheets and sign the sheets. The middle of such paper remains for various, pre-defined prints on the certificates, which would be combined with variable data (name, surname, date of birth, etc.). Such a device would be usable, from the point of view of efficiency, profitability and meeting the needs of users. In some parts of the Balkans, legislation is adapted to the digital age, so there is a practical implementation of the described solution, which is in use.

4. PRESENTATION OF A PRACTICAL SOLUTION OF A UNIVERSAL MULTIFUNCTIONAL DIGITAL DEVICE FOR PROVIDING COUNTER SERVICES

The proposed variant of the device, shown in *figure 2*, is multifunctional and can basically support a wide range of services.

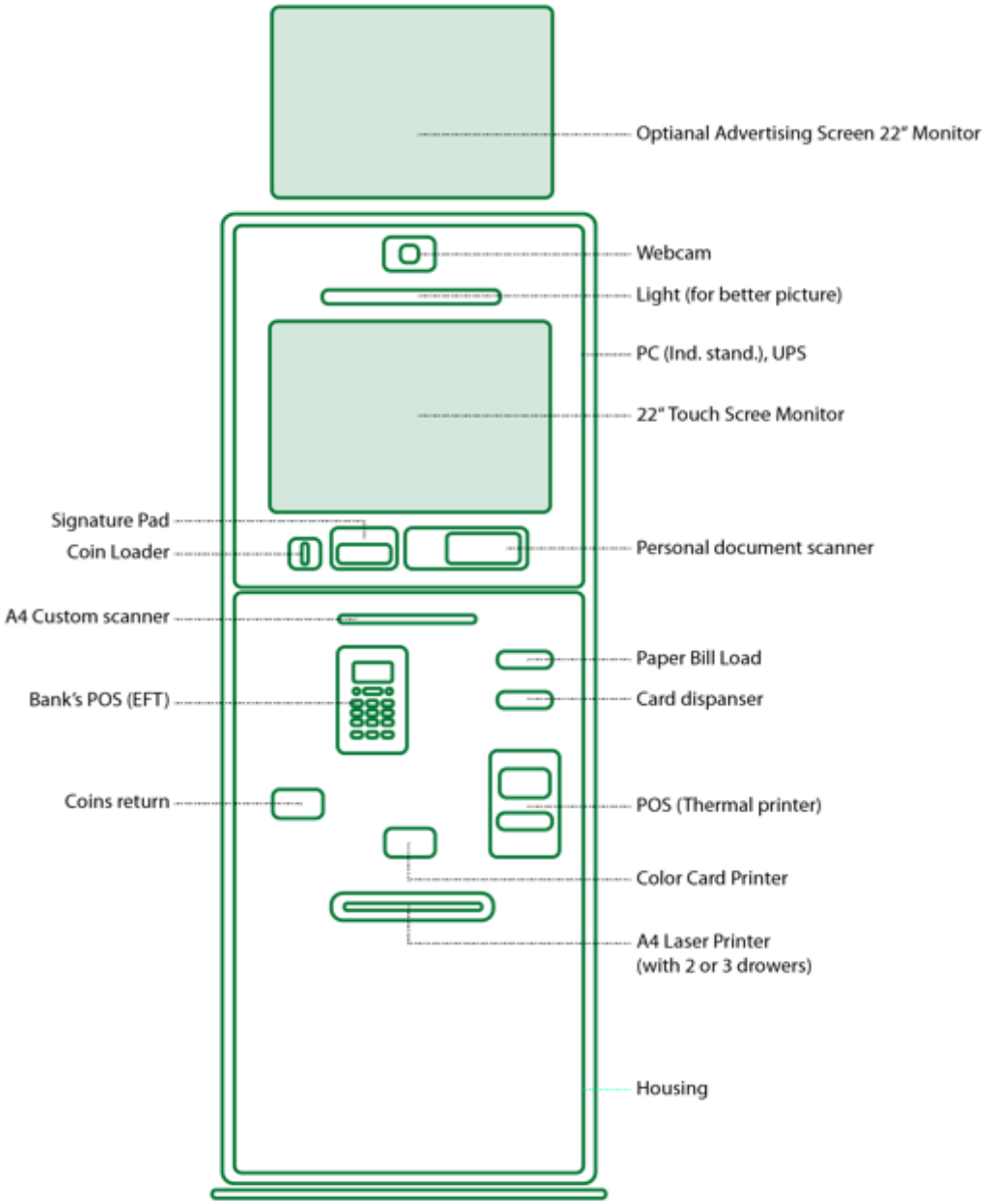

Fig. 2. Model and design of a smart universal multifunctional digital terminal / portal [5]

Some of these services already have practical applications or ready-to-use prototypes, such as: [8]

- Services in the banking sector;

- Services for providing various certification documents issued by city and state institutions;
- Automation of the hotel reception and similar facilities that rent rooms and apartments;
- Various tickets, i. tickets for concerts, theaters, public transport tickets, etc.;
- Attendance records and issuance of access electronic / magnetic cards;
- Personalized cards for mobile phones;
- Payments of invoices issued by companies providing services, such as utilities, payments for electricity consumption, water supply services, mobile operators, etc.

Which components will be installed on the device depends on its purpose, ie about the types of services that should be supported, the degree of authentication and the appropriate software solution.

5. CONCLUSION

Based on everything presented in this document, it is clear that the conventional, traditional way of providing counter services is disappearing. It is being replaced by more modern ways of providing these services, from multifunctional robotic digital devices to completely "online" services, realized by "cloud" technology. As in the past, when some jobs and crafts have almost completely disappeared (scribes, blacksmiths, etc.), now it happens with teller/counter services, which are performed by people in a physically specific place.

It was pointed out what are the factors that can influence the pace at which this transformation will take place. A set of valid legal regulations, the habits of users in a certain region, their technical skills in terms of working with new mobile technologies, fear of the virtual, age structure. Even the emergence of new technologies, which will enable the expansion of screen space, greater visibility on mobile devices, and thus a better interface in the mobile applications themselves. These are all parameters that will affect the speed of transition of the organization and provision of teller/counter business services to automation and robotization, without the need for the physical presence of man, when performing these services.

In the period where not all conditions are met, especially the accompanying legal regulations, certain advice was given on how to do it and to what level, to automate the existing teller/counter services. These tips are given based on concrete examples. A practical version of the multifunctional digital device, which is already in use, and which can satisfy a whole range of counter services in various branches of activity, has also been proposed.

The problem of the lack of digital signature possibilities was especially mentioned. Specifically, the law on digital signature has been adopted in BiH for a long time [9, 10]. However, given the conditions to be met by a body intended to be certified for the issuance of digital signatures to legal and natural persons, it has been shown that this body would be

unprofitable given the small market it covers. From this fact, it is clear that the state should find a way to invest in such a company, in order to establish a digital signature service in accordance with EU regulations. From the attached text in this paper, it is clear how much this would mean for the simplification and acceleration of automation and robotization of teller/counter services.

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WHO'S AFRAID OF THE BIG BAD WOLF? IS E-LEARNING EDUCATION SUCH A HUGE THREAT NOWADAYS?

Anamaria **FĂLĂUȘ**, Ramona **DEMARCSEK,** Luminița **TODEA**
North University Centre of Baia Mare, Technical University of Cluj-Napoca, Romania,
anamariafelecan@gmail.com, ramona_maria10@yahoo.com, luminitatodea@yahoo.com

Keywords: E-learning, education, types of learners, technology developments.

Abstract*: Technology is something that we've been taking for granted for quite a while now. We cannot imagine our lives without a smart phone or without spending hours online chatting with friends, searching for information, staying up-to-date with the latest news. However, when it comes to online education, reluctance, mistrust and suspicion are the key words normally and constantly associated with it. My paper, as a consequence, attempts to debunk the negative opinions that have grown up around E-learning methods and activities, focusing on the usefulness and effectiveness of such multimedia courses. It also intends to differentiate between different age groups or types of learners in order to emphasise the suitability of online training options in education for certain categories of learners.*

1. PRELIMINARY ISSUES

One cannot start the discussion on the issue of E-learning without setting the scene which actually led to the necessity of compulsorily using online educational techniques and methods to the detriment of the traditional face-to-face teaching and learning environment. 2019 was the year when people all over the world began being exposed to coronavirus disease COVID-19, the fifth documented pandemic since the 1918 flu pandemic. Being highly contagious, spreading rapidly and continuously evolving in the human population, the virus forced people to preserve a certain physical distance during their daily routines, the obvious, normal result being the transposition from the natural environment to the online, virtual reality of activities that lend themselves to it.

This, however, could not have been possible without the aid of technology. And fortunately, this (i.e. technology) is something that we can easily claim to be quite familiar with, having constantly surrounded us for quite a long time now, being, without any shade of doubt, an intrinsic part of our lives. Marshall Mcluhan's term "global village", coined in 1964, that sees society as a nervous system interconnected by the influence of electronic technology is still relevant today, if we are to believe Maiken Attwood's words:

> We receive news in real time, (rather than waiting for the 6pm news) and we can even communicate with nations on the other side of the world from our phones, or laptops and now even our watches, we have hundreds of apps and websites dedicated to sharing and bringing information to one another. What once was broadcasted on television is now uploaded on YouTube, shared on Facebook or streamed live from online news websites. The emergence of the Internet has influenced the global village, especially as we rely heavily on it due to the characteristics of electronic technology [1].

2. TECHNOLOGY AND EDUCATION

The educational process has not been deprived of the benefits of technology, either. Plenty of classrooms all over the world have been and still are equipped with data projectors, interactive whiteboards (IWBs), built-in speakers for audio material that is delivered directly from a computer hard disk and computers with round-the-clock Internet access. Whenever teachers want their students to do a bit of research on their own or find anything out, a search engine like Google is always at hand and the results can be shared among all the members of the classroom.

In his book *The Practice of English Language Teaching*, Jeremy Harmer [2] speaks about the so-called technology pyramid (*Figure 1*), bringing into view Jill and Charles Hadfield's 'reversed pyramid' of resources which attempts to arrange in a certain hierarchy (the highest position being dedicated to the greatest level of technological advances, while the lowest suggests a minimal level or no resources at all) all the technological means that might be available in the teaching-learning process or the ones that teachers might make use of in their attempt to transmit information and create and develop skills (in)to their students. However, the pyramid is just a tentative attempt to organize things at a certain moment in time, as the pace at which technological change advances is, as far as Jeremy Harmer [2] is concerned, "breathtakingly fast", some of the elements included on the list above having already become obsolete as we speak. The conclusion that Jill and Charles Hadfield reach, though, is that even if the resources that are presently available are definitely amazing, the human component is what really matters, being the "richest, [and] deepest seam of gold" that teachers have at their disposal [2], irrespective of all the other variables included in the process. And one cannot

ignore the fact that many classrooms in both, the 'developing' and 'developed' world do not have access to modern technology. As a consequence, online teaching or even a hybrid scenario that combines traditional and innovative educational techniques, giving thus the students the "best of both worlds in which to grow academically"[3] is not always possible. In addition to this, one should always keep in mind the fact that teaching outside the classroom walls has both advantages and disadvantages that can be applied to all those involved in the process.

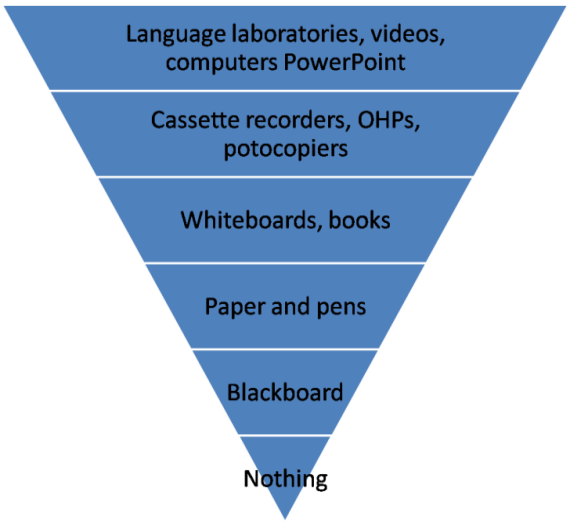

Fig 1: Reversed resources pyramid

Distance education can be defined as a form of education in which the main elements include "physical separation of teachers and students during instruction and the use of various technologies to facilitate student-teacher and student-student communication."[4] The same thing is also expressed by Lewis, Whitaker & Julian who see this form of education as the "delivery of the educational process to receivers who are not in proximity to the person or persons managing or conducting the process."[3] The literature in the field registers plenty of advantages or strengths that can be associated with this type of cyber learning environment.

3.ADVANTAGES OF ONLINE LEARNING

a. Student related

Gary James [5] begins his article that attempts to gather in an as thorough as possible list all the advantages and disadvantages which designing, developing and delivering web-based training might involve by postulating that "never before in the training world have so many delivery options been available with so much information and knowledge to convey to our trainees." The first advantages he registers are **extendibility, accessibility and suitability**, these three elements rendering the idea that any training programme that users might have in view can be proceeded through at the target audience's own pace and place. The material can

be accessed at any time and as much as needed. As Mike McNaughton claims, "distance learning affords educational opportunities to individuals unable to attend conventional classroom settings." [6] This category includes disabled people, those living away from universities and colleges, forced to commute daily or those with various time restrictions whose physical attendance in class may be prevented by their schedule. People with work or family responsibilities can also be included in this group of beneficiaries of online education systems. Focusing on the same accessibility and suitability direction, Chris Evans and Jing Ping Fan [6] speak about three main advantages of online learning:

a. learner-determined location for learning – students being in the position of choosing their own place of study;
b. learner-determined time of learning – students having the possibility to create their own individual learning schedule, without depending on a pre-established university timetable;
c. learner-determined pace of study – students being able to adjust their own rhythm of study without being conditioned by the pace of the other members of the study group.

Ease of participation is also seen as an "appealing attribute of the cyber classroom." [3] One cannot ignore the fact that the conventional classroom environment may sometimes seem intimidating for certain students, they refusing to actively participate in face-to-face classes. Student participation is, however, different in the online environment where "student chat-rooms and forums can provide these individuals with increased confidence and are often less intimidating." [6]

b. Technology related

Assuming that your audience has access to the Internet and the proper gadgets to connect to a browser, one can mention **easy and affordable training delivery** as another advantage of web-based training, along with **direct access to many other training resources** [5]. The Internet grants access to the largest library in the world, offering the students the possibility to get in touch with the latest findings and researches in the fields they might be interested in. Another advantage would be the **ease of content update** [5], as the changes that one may choose to make in relation to the content of the material they are delivering to their students are immediately available to the learning audience. The **collaborative and exploratory learning environments** are also worth mentioning among the strengths of online education as they provide students with the chance of networking with people across nations while facilitating their "exposure to other cultures"[7]. The **quicker and cheaper turnaround** of finished product is another advantage that Gary James adds to his comprehensive list, this element stressing the easiness of delivery of various assignments students are expected to submit as a result of the educational/instructional process they are attending.

c. Educational institution related

There are also benefits that the educational institution offering online education programmes can take advantage of. The **lower cost** involved and **no need for physical space** are two of the most important ones, the former pointing towards the increase in the number of students attending these courses, while using the same or fewer resources than traditional environments, while the latter underlines the lack of bureaucratic hassle generated by the constant need of enlarging the physical space especially in the case of large classes of students [8].

4. DISADVANTAGES OF ONLINE LEARNING

a. Student related

One cannot discuss the advantages of online learning without focusing on the other facet of the problem, i.e. its disadvantages. One of the greatest threats of online educational processes is the **risk of isolation** or the **loss of traditional classroom face-to-face interaction**. The question we should all ask is: Are computers actually replacing human contact? In his 1983 book *Frames of Mind: The Theory of Multiple Intelligences*, Howard Gardner [9] suggests that people learn differently depending on the specific type of "intelligence" they possess. He proposed seven types (linguistic intelligence, musical intelligence, logical-mathematical intelligence, spatial intelligence, bodily-kinesthetic intelligence, and the personal intelligences, i.e. the interpersonal and intrapersonal ones). In an article dedicated to this very theory, Kendra Cherry [10] updates the list of intelligences proposed by Harvard psychologist Howard Gardner by including a new type of intelligence, the naturalistic one. Returning now to the cyber learning experience, one can easily notice the fact that for certain types of learners, mostly those that learn via the tactile/kinaesthetic modality, learning online is not the ideal environment. These students value body movement, physical actions as well as creating things with their hands; they remember by doing rather than hearing or seeing. Lessons delivered through "abstract symbols, de-contextualized and cast on a two-dimensional screen" [11] are quite unintelligible to them. The same thing is true for those possessing an interpersonal intelligence. They are good at understanding and interacting with other people, resolving conflicts in group settings and creating positive relationships with others [10]. They benefit a lot from team-work and group-work activities, interaction being the one that facilitates, in their specific case, the learning process, and this is exactly what the online environment has difficulties is replicating, i.e. the student/instructor interaction as well as students interacting with their peers [6]. Online education thus becomes quite an impersonal environment that fuels students' feelings of isolation.

According to Stelzer and Vogelzangs [6], the above mentioned feeling of isolation directly impacts students' motivation levels. Sitting alone in front of a computer, they are more

prone to distraction, losing their interest and concentration, unless the online course material is interesting enough. However, students' motivation level and their ability to concentrate in front of an emotionless gadget go hand in hand with the age group they (i.e. students) belong to. If we are to paraphrase Jeremy Harmer's view on the matter of students' age and the differences that characterise different age groups in terms of learning abilities and preferences, we should begin by saying that age represents a decisive factor in teachers'/instructors' decisions about how and what to teach [2].

Thus, young children learn differently from older children, adolescents and adults. They learn indirectly rather than directly, which means they absorb information from everything around them, rather than focusing on the precise topic they are being exposed to, their understanding of a certain issue is not exclusively the result of someone explaining something to them but their ability to process everything they see, hear, touch and interact with. They crave attention and approval from the teacher, having a limited attention span which means that they can get easily bored, losing interest after a few minutes [2]. The adolescents' learning potential is definitely greater than that of young children, but they may be "considerably more difficult to motivate and manage, and it takes longer to build up trusting relationships." [12] The adult learners, however, are more disciplined than other age groups, being often prepared to struggle on despite boredom. They have a longer concentration span and they are also more motivated. Many adults, as Harmer [2] claims, are "able to sustain a level of motivation by holding on to a distant goal in a way that teenagers find more difficult." Adults take more responsibility for the learning process, getting involved into the proposed activities voluntarily, so their motivation seems to be "relatively stable" [12], depending less on the teacher's ability to make these activities attractive or provide incentives.

In the light of the above mentioned characteristics that define different age groups in terms of their learning abilities and preferences, one can easily claim that the online learning environment suits better adult learners who willingly get involved into the learning process, having their goals clearly stated from the very beginning. Penny Ur [12] associates the relationship between instructors/teachers and their adult trainees/students with a business relationship: the teacher has a commodity which the learner is willing to pay to acquire. The latter, consequently, knows what he/she wants and the level of concentration and motivation is relatively stable throughout the process.

The pace of study has already been mentioned as one of the advantages of online learning, giving students the possibility to set their own individual pace without being held up by slower students or vice-versa. However, this pacing mechanism can also be seen as a threat in the cyber classroom, many students not being able to preserve or stick to this self-imposed studying rhythm outside the typical college routine, the obvious tendency being that of dropping out of collage at a higher rate than their fellow students enrolled in traditional face-to-face learning environments [13].

The higher dropout rates registered during the last few years (especially since the pandemic outbreak) have been more and more often related to this unfriendly, unfamiliar and sometimes terrifying forced online experience. However, this does not seem to be the only cause of this harsh reality.

In our country's specific case (i.e. Romania) school dropout rates have always been a worrying issue. According to D.P.'s article "România educată, surprinsă într-o imagine statistică. Cifrele îngrijorătoare ale abandonului școlar"(„The educated Romania seen through statistics. The worrying figures of dropout rates") [14], Romania is the third country in the Eurpean Union, along with Malta and Spain in what concerns the high dropout rates registered, the number of boys dropping out school being higher than the number of girls, while only 36% of the children living in rural regions choose to attend school. The decreasing number of the country's population during the last decades has definitely influenced the school population: recent studies have found that the school population in Romania during 2019-2020 school year registered 3.5 million students, the number falling 18.5% in comparison with the figures recorded a decade ago. In addition to this, the rural regions occupy the highest position in relation to students' lack of participation in the educational process. According to Mihai Peticilă [15], dropout rates have increased at all levels of the education system, the country losing almost a quarter of a generation in eight years of school. National school dropout rates are still a reality and they can also be related to people being forced to use online education, at least in Romania's case. As a country with relatively little industrial and economic activity and where people generally have low incomes, the idea of students having online access, as well as frequent access to a computer, laptop, smart phone or other gadgets is still a desirable aim.

b. Technological implications

The **lack of access** either due to logistics or economic reasons, will exclude participants from the cyber class, this being one of the limitations for online programs that are reliant on Internet access [3]. Quality transmission is another problem that telecommunication systems have to face, the reality being that both trainers and trainees are still constrained by the available technology. If the content of the lesson to be delivered relies on a lot of video, audio and graphics and the quality of the Net delivery is poor, the learners will become frustrated, losing interest in the instruction.

Another disadvantage that is often ignored or taken for granted is **computer literacy**. The premise on which online learning functions is that both students and trainers (teachers/ professors/educators) are or have to be computer literate, which means they have to possess not only keyboarding skills, but also the ability to communicate proficiently through reading and writing, as "the majority of communication that takes place in an online environment is written" [6]. Lack of such expertise, however, brings about a "feeling of cognitive overload", as far as Brace-Govan and Clulow are concerned [6], which, is often the result of students experiencing

difficulties of learning the software for online courses and thus being unable of meeting deadlines and accomplishing tasks.

c. Instructor and course content related

As we have already mentioned, computer literacy can be applied not only to students but also to teachers. Not only do the latter have to be adequately prepared for the technology-rich learning environment they are supposed to create and deliver, but they should also be ready to assist students in case of technological problems. They have to dedicate time and effort to create online materials that might be appealing to their students, which means that those in charge with the designing and implementation of courses online not only have to be knowledgeable of the subject area they are teaching, but also acquire and possess new teaching skills, such as "learning to facilitate online interactions and assess students' online learning." [16].

In addition to what has already been mentioned so far, one should also keep in mind the fact that **E-learning** is **limited to certain disciplines**, being more suitable for social sciences and humanities, rather than scientific fields such as medical science or engineering where the degree of practical experience should be high.

d. Educational institution related

In the article "Distance education: advantages and disadvantages of the point of view of education and society", De Oliveira, Torres Penedo and Pereira [8] identify some of the disadvantages or weaknesses that might affect the educational institution offering online courses. The first mentioned is the decrease in the quality of the teaching process, as students no longer have the opportunity to actively contribute in the preparation and development of the lessons. During conventional classes, students can participate actively bringing their own experiences and subject expertise, asking questions and thus offering the teachers the possibility to accurately assess their level of knowledge. The direct consequence is the teacher becoming aware of his/her students' progress and their need (or lack of it) for extra consolidation. The online environment, however, does not offer the students the possibility to change the parameters of the lesson. The feedback the teacher gets takes longer, this being another drawback of the cyber learning experience. Another problem identified by the above-mentioned authors is the prejudice many students and teachers still have against online courses, they being considered ineffective when compared to traditional classroom activities.

As it became obvious up to this moment, there are both advantages and disadvantages of cyber learning. Being forced by the pandemic context to adopt the online version and due to the technological advances that have taken place in the information world, people have become aware of and better informed about the choices that exist for their education. Even if the education system provided via the Internet, mostly in the developed countries of the world, has already become a tradition, in the developing countries (such as Romania), forced by external

circumstances to resort to an online system, there are still doubts about the efficiency of such web-based programs and the quality they can provide.

In order to assess students' satisfaction in relation to the online experience they have been going through during the past two years, a research has been conducted covering a sample of 146 Philology students enrolled at Technical University of Cluj-Napoca, North University Centre of Baia Mare, Romania. The aim of the research was to find answers to several crucial questions, as follows:

1. Did you participate in the online activities organized by your institution during this pandemic period?
    a. Yes, in all of them
    b. Yes, partially (as I did not always have access to the Internet, computer, laptop, tablet, smart phone)
    c. No (as I did not have access to the Internet, computer, laptop, tablet, smart phone)
    d. No (I was not interested in this kind of activity)
2. Do you consider that cyber learning can replace the traditional face-to-face activity that normally takes place in the classroom?
    a. Yes
    b. No
    c. Can be an additional activity
    d. I am not interested in this kind of activity
3. How do you appreciate the online learning experience you have been through during the last two years?
    a. Attractive, useful, appropriate
    b. Unattractive, inappropriate
4. Which are the greatest threats/weaknesses of the online system?
    a. Professors' access to technology
    b. Students' access to technology
    c. Professors' low level of digital competence
    d. Students' low level of digital competence
    e. Inability to keep students motivated and involved
    f. Changing the course content and activities so as to suit the online environment
    g. Assessing students' progress and involvement
    h. The amount of work and high level of stress associated with cyber learning
    i. Managing time and deadlines
5. Do you think that once things return to normal cyber learning should remain a part of the teaching-learning process?

a. Yes
b. No

Based on the results of this research, indicative data for this form of education have been collected. The most significant findings are listed below:

- For the first question (*Figure 2*), 82% of the respondents chose the first option, clearly stating their interest and total participation in the online activities provided by their institution.

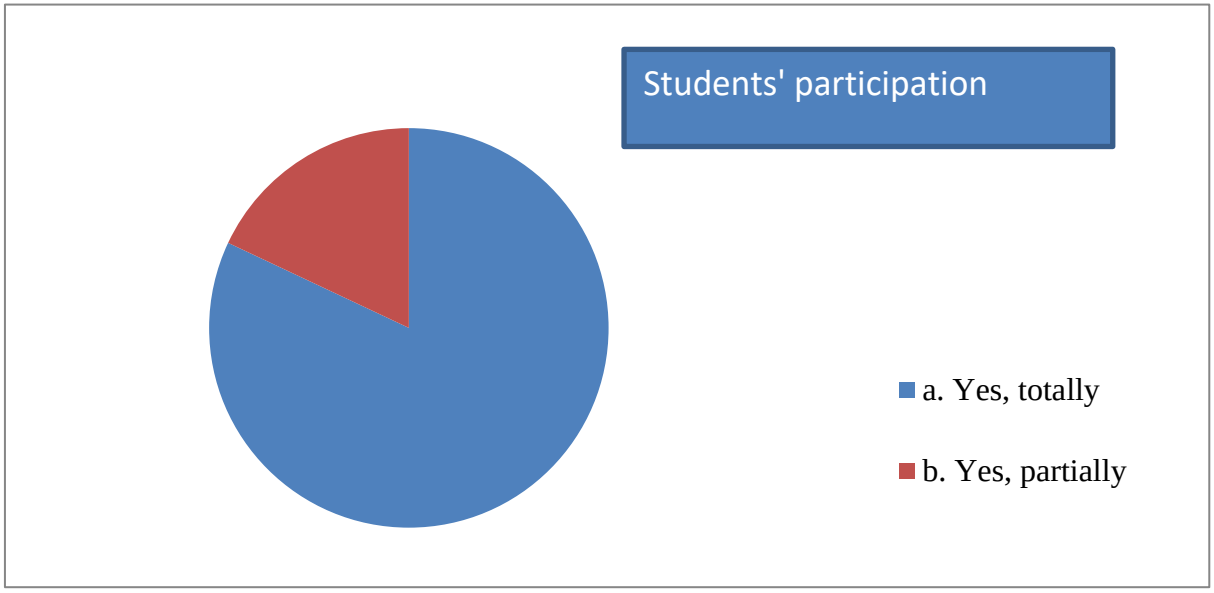

Fig 2. Students' participation

- The answers received for the second question (*Figure 3*) show that the great majority of students (59%) would rather see the online experience as an additional one, going hand in hand with the traditional face-to-face environment, while 27% see it as a viable option, ready to replace the on-site scenario.

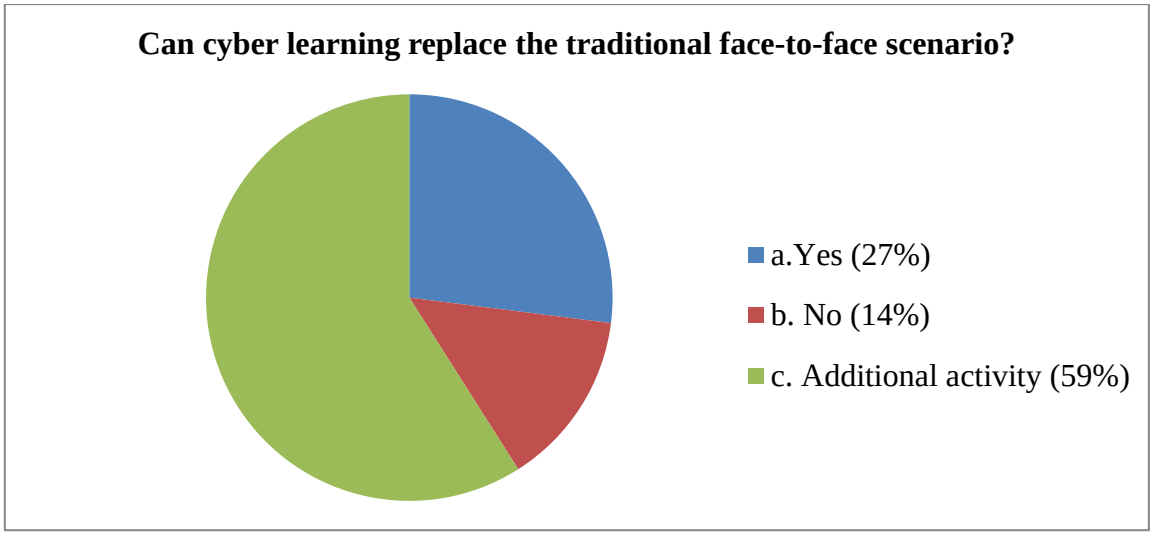

Fig 3. Cyber learning vs. Face-to-face

- The third question (*Figure 4*) underlines the idea that students (76% of the respondents) appreciated the online experience as useful and appropriate in comparison with only 24 % that resented it.

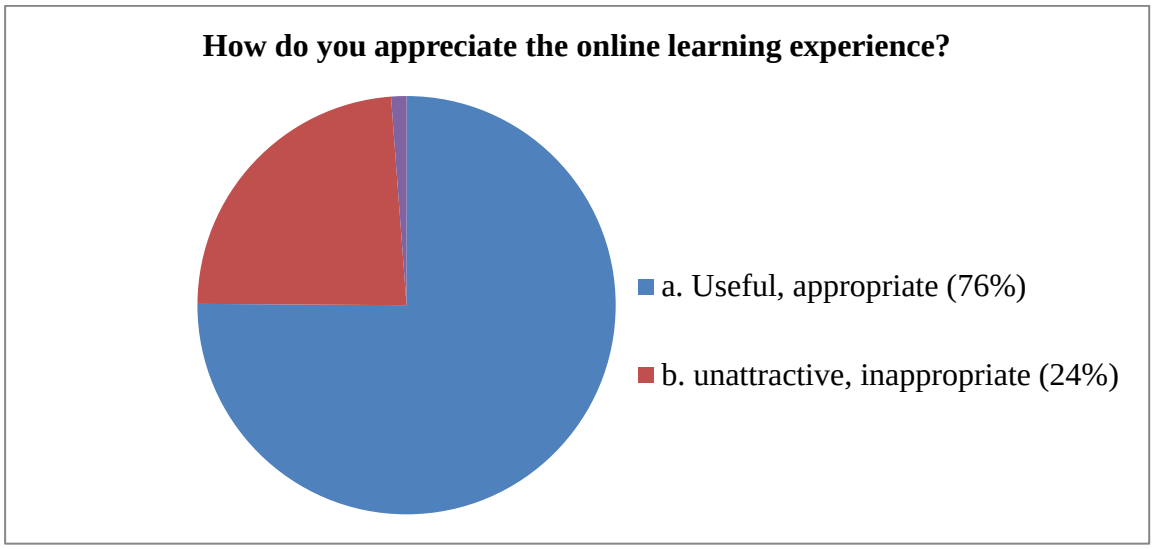

Fig 4. Online learning experience

- The fourth item (Figure 5) registered different options, the opinions of the students being quite varied, this fact underlining the idea that there are still improvements to be made if one is really interested in the success of this type of learning experience.

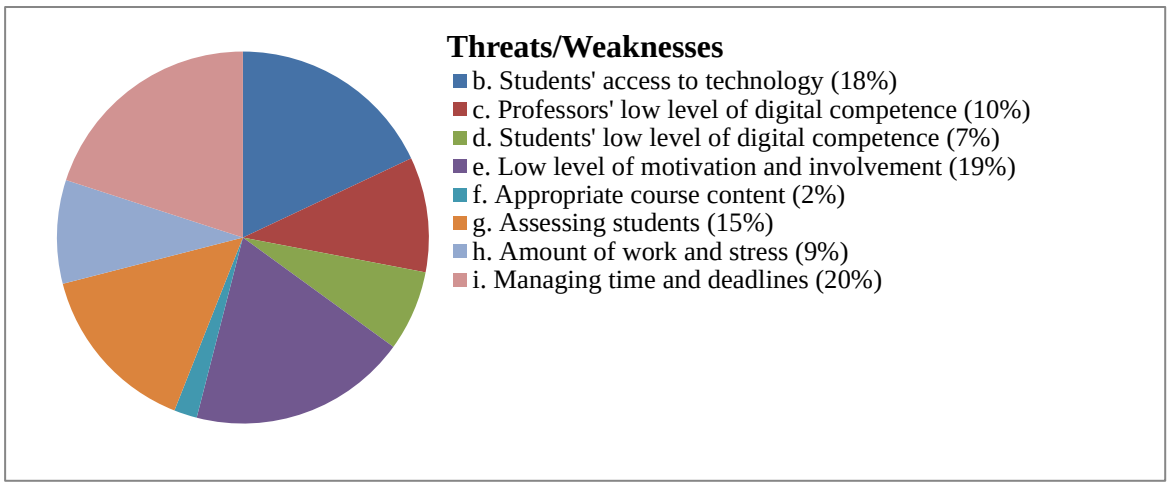

Fig 5. Threats and weaknesses

- The last question (*Figure 6*), however, stressed, once again, the positive opinions students had in relation to the cyber learning process they have been through during the last 2 years.

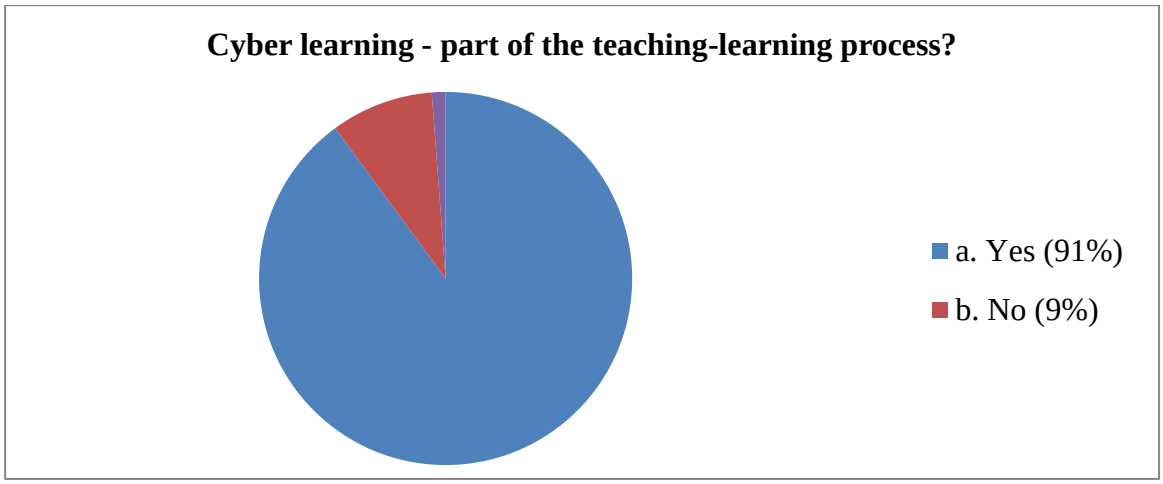

Fig 6. Cyber learning – part of the teaching process

The conclusions of the research show that in spite of the negative reactions and skepticism surrounding the topic of online learning experience, this form of studying still has a large number of advocates, the most important ones being exactly the beneficiaries of it, i.e. the students.

5. CONCLUSIONS

As this paper has tried to prove, there are both advantages and disadvantages of distance education. They are both important and worth considering if we are to assess correctly the situation we are now experiencing, that of being forced to adjust to external constraints that require social and physical distancing. The reality is that online education is suitable and works perfectly in the case of certain categories of people: adults with work and family commitments, shy students who see an opportunity in the online chat-rooms, these providing them with the confidence they lacked in the normal face-to-face environment, or students who can exert control over their own studying experience, mature, self-disciplined individuals for whom an online method of education can be a highly effective alternative. However, cyber learning is not the best option for younger learners (i.e. elementary and secondary school children) who can benefit a lot from their constant interaction with and supervision of their instructors, students who do not have access to the Internet and do not possess the gadgets that might facilitate their total participation in the web-based activities provided by their institution or, other students who are "dependent learners and have difficulty assuming responsibilities required by the online paradigm."[7]

Nevertheless, the constant technological advances that we have all been experiencing lately and the fact that the Internet has found its way into our daily lives and uses prove that the prospect of the Internet finding its way in the educational sphere is quite plausible. As a consequence, it is quite logical to expect that online studies will grow in popularity and the

"network of virtual faculties will keep spreading in the future."[17] The internet studies have managed to prove their viability, continuing to develop and benefit students and staff. If the direct change from a traditional face-to-face environment to an online one is too sudden, the hybrid variant could be the best option, this type of blended education system meeting the needs of both, students who are accustomed to a face-to-face format and students who prefer the online option.

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THE IMPORTANCE OF ENERGY RECOVERY TECHNOLOGIES FOR THE IMPLEMENTATION OF SMART SOCIETY AND SMART CITY CONCEPTS

Adina **POP-VĂDEAN**

Technical University of Cluj Napoca, Department of Mechatronics and Machine Dynamics, Muncii str., no. 103-105, 400641 Cluj Napoca, Romania,

adinaluciapopvadean@yahoo.com

Keywords: Internet of things, smart society, smart city, harvesting energy

Abstract: *An intelligently developed society is defined by a concept that integrates information technology in all its fields in which man is the direct beneficiary of this environmentally friendly process. Man is both the main actor and the direct beneficiary of the products and services of the intelligent society. This detail must be the determining factor for the development of any society from a classical to a smart one and here comes the concept of Human Informational Field (HIF) accompanies the human being in his interactions. But smart society is about connecting between people, systems, about sharing information and so we get to the Internet of things, or IoT a system of interrelated computing devices, mechanical and digital machines, objects, animals or people. The internet of things helps people live and work smarter, as well as gain complete control over their lives. Because IoT is a sensor network of billions of smart devices the problem of energy supply appears. Energy recovery or harvesting systems is a possible solution that could enable IoT nodes to scavenge self-sustaining energy from environmental sources. In this article we will review these systems and emphasize their importance in the development of smart society or smart city.*

1. INTRODUCTION

The concept of Smart City has more and more global followers becoming a "must have" of the big cities.It is a growing concept, and research is focused on creating an urban infrastructure that allows the implementation of SMART technologies and, on programs that can change invalid refractory mentalities to technological evolution. Because energy has an

extremely important role for the creation of the SMART City infrastructure Energy deserves special attention.A smart city will optimize energy resources and technological innovations in the field are no longer a purpose but a means of maximizing services for its citizens. Here comes the Internet of Things (IoT).

The energy supply of the Internet of Things (IoT) networks to ensure uninterruptible optimization of smart cities is a big problem that among other challenges has continued to focus efforts towards energy harvesting.During the pandemic pandemic, the imposed jams that almost paralyzed everyday activities in many corners of the world, the option of remote human interaction became imperative to impose distance. So the world has become aware of the importance of IoT devices, being intelligent components of the intelligent city. Energy harvesting is a sustainable solution that could allow iot nodes to capture self-sustained energy from ambient sources. In this article, we will analyze a part of the sources available in the city where the energy could be harvested, according to the literature. These energy sources can be specific to the application, so, if there are many free sources in the city, energy should be collected in close proximity to the need for different IoT devices or wireless sensor networks (WSNs) for city automation intelligent.In the intelligent city, there is web technology through which objects are connected to the Internet and become "intelligent" by allowing them to interact with them or the human factor [5].The Internet of Things (IoT) is simply a network interconnected by objects or people who relate to them through the cloud. IoT transmits data to physical devices that are connected to the Internet via sensors. thus allowing the interactions mentioned above, however, the intelligent city data is made available by IoT for autonomous planning and decision-making on the needs of such a city, with the clear purpose of improving the living standards of the inhabitants. This is illustrated in *figure 1*.

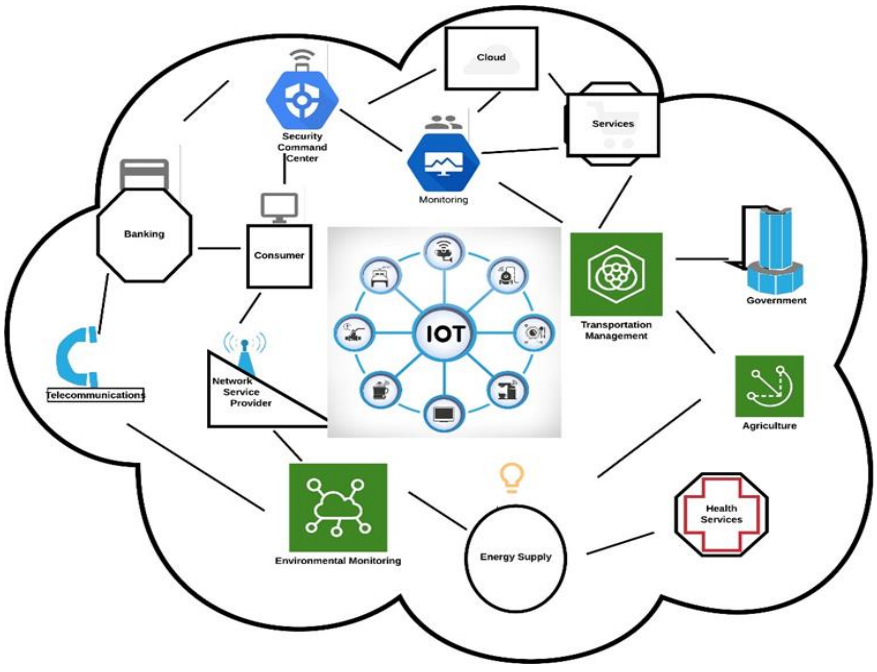

Fig. 1. The Internet of Things

2. IOT AND HARVESTING ENERGY – THE MOST IMPORTANT SOURCES

IoT technologies are now accessible to people of different categories. The Pandemy of Covid-19 and the blocking of activities accelerated the research and development of the Internet of Thing concept [9] .IoT and web technology have become indispensable for people to continue to live almost normally during this global pandemic [10]. I insist on the idea that IoT power supply is a very important requirement to ensure that connected devices are constantly working. Therefore, the problem in achieving the intelligent city and its sustainability is how iot nodes and / or connected devices could be fed to continue to provide intelligent city planners uninterruptible data.Researchers have made efforts to conduct studies focusing on the management and maintenance of energy supply at the first WSNs and currently at iot nodes [1]. Recent international research projects are focused on applying energy management systems to reduce the energy consumption of smart buildings. In 2002, the EU Parlament adopted directives on implementation methods for improving the energy efficiency of buildings, and later, scientists predicted that smart buildings will have over 500 intelligent devices connected in 2022 [11]. So it is essential to pay attention to the growing energy needs of Internet of Things.The challenge is to discover ambient energy sources that are available in a city and conversion mechanisms that can be used, and this will, instead, omnipresent and self-sustainable, with long-term energy sources . It is to limit the use of classical batteries because replacement of waste batteries is a major difficulty when IoT devices are implemented in inaccessible or toxic environments, and the maintenance cost decreases. Energy harvest techniques have many unique advantages and features for the future reported on IoT and wireless communications technology, with the emergence of 5G technology in 2020 and the future 6G. These advantages that can not be offered by existing batteries or network communications are: self-sustainable capacity, omnipresent energy, carbon footprint reduction and battery replacement and / or no links to electrical networks and are easy to use. deployed in toxic and / or hostile and inaccessible environments.Areas of application of energy harvesting techniques are; Internet of Medical Things (IomT), Internet of Mobile Things (IomobT), Internet of Remote Things (IorT) [13] and Internet of Environmental Things (IoenvT).The benefits of harvesting energy have been reported in the literature at different times [2]. So,we have revised and classified various energy harvesting methods that are available by analyzing the recent studies by different researchers. We have taken into account aspects such as the various transduction mechanisms that have been adopted to convert the energy and output power that can be achieved.

We have made the summary that is presented in Table 1 following the revision. The table indicates the type of harvesting machine model, the power density that can be obtained

and the sources of information.

Table 1. Current energy harvesters' technologies' characteristics summarized.

Harvester	Physical/Chemical Operation Mode	Power Density	Efficiency (%)	Mature/ Emerging	References
Photovoltaic	Photovoltaic effect	Outdoors: 15 mW/cm^2 Indoors: 10–100 µW/cm^2	Until 40	Mature	[17]
Piezoelectric	Piezoelectric effect	330 µW/cm^3 shoes insert	Until 30	Mature	[18]
Electromagnetic	Faraday's law	Human: 4 µW/cm^3 @ kHz Industrial: 306 µW/cm^3 @ kHz	Until 67	Mature	[18]
Electrostatic	Vibration-dependent capacitors	50 µW/cm^3 to 100 µW/cm^3	9.5–23.6	Emerging	[17]
Pyroelectric	Olsen cycle	3.5 µW/cm^3 at the temperature rate of 85 °C/s @ 0.11 Hz	1–3.5	Emerging	[14]
Thermoelectric	Seebeck effect	Human: 100 µW/cm^3 Industrial: 100 mW/cm^3	10–15	Mature	[15]
Magnetic	Ampere, Maxwell, and Faraday laws	1.8 mW/cm^3 with 400 A at 4 cm from conductor	0.1325	Emerging	[18]
RF	Ubiquitous radio transmitters	GSM: 0.1 µW/cm^2 WiFi: 0.01 µW/cm^2	50–70	Mature	[15]
Wind and water	Faraday's law	1.16 mW/cm^3 at the speed of 5 m/s 4.91 µW/cm^3 at the speed of 3 L/s	0.61–17.6 1.7–29.5	Emerging in small scale	[18]
Acoustic	Helmotz effect	1.436 mW/cm^2 at 123 dB	0.012	Emerging	[19]

In this short review, we will presented different sources from which energy could be harvested in a city.Potential sources for EH are grouped across different categories, depending on the type of mechanism used.We review the most important sources.

2.1. Photovoltaic Harvester's Technology and Devices

Photovoltaic harvesters [12] generate electrical power, converting sunlight or artificial light into electricity using the photovoltaic principle. The solar panel is a modular device, which is composed of n cell in parallel and in series. Thus, harvested energy is proportional to the surface area of the module and can be scaled to the desired size of power generation. The amount of energy that they gather depends on weather conditions and light/dark periods. Besides, efficiency limits photovoltaic harvesters' electric energy generation. The materials that compose the cell determine their efficiency. Current photovoltaic cells are classified into four categories based on their composition: multi-junction, crystalline silicon, thin-films and emerging. A comparison between different solar cell technologies is shown in *figure 2* [14].

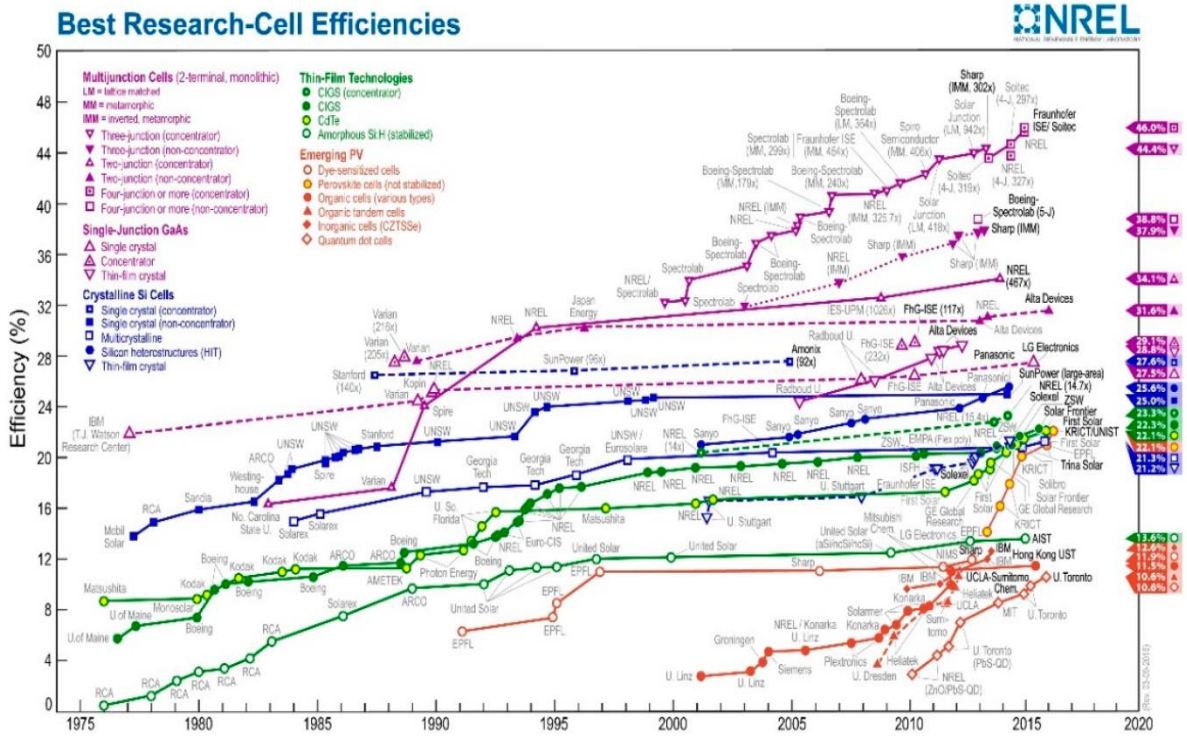

Fig. 2. Cell efficiencies research state

Photovoltaic cells designed for energy harvesting activities are suitable for both outdoor and indoor environments. Indoors light intensity is often much lower than outdoors. The sun generates power intensity far higher than that produced by artificial light sources such as an incandescent light bulb, fluorescent tube, or halogen lamp. Thus, it must be born in mind solar cell spectral properties to achieve the maximum feasible power, since spectral characteristics determine the operation range of each light type. Consequently, a photovoltaic cell would be

more efficient on a given wavelength range, depending on the material which it is made of. *Figure 3* shows the spectral operation range of different type of lights [15].

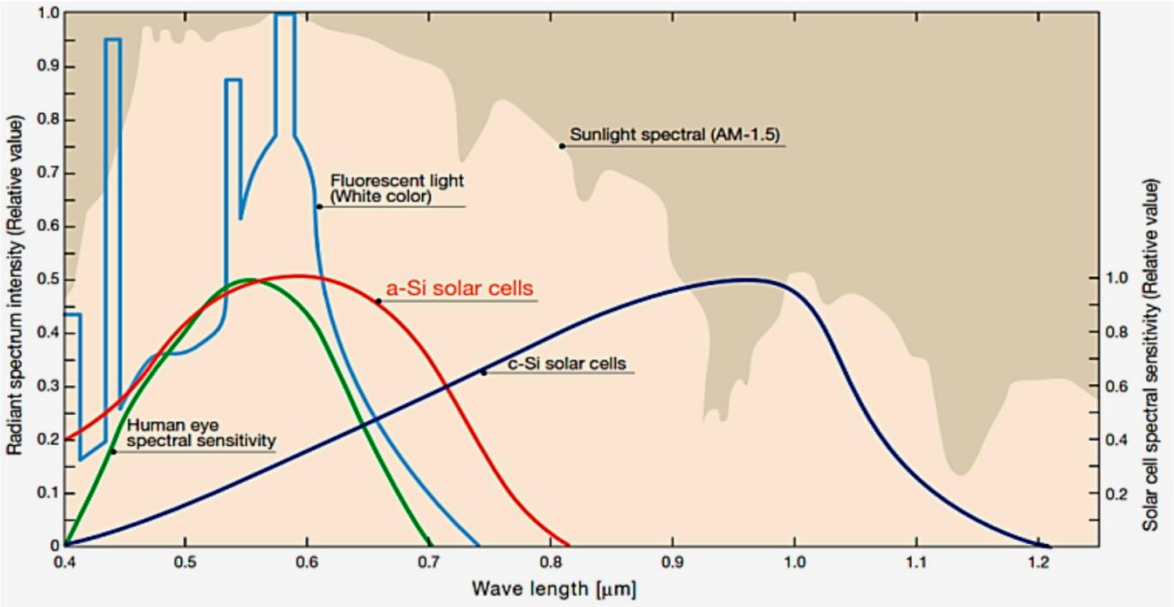

Fig. 3. Comparison of relative radiant spectra of sunlight vs. artificial light from incandescent bulbs and fluorescent lamps.

2.2 Kinetic Harvester's Technology and Devices

Kinetic devices convert mechanical energy into electrical energy through electromechanical transducers. The most common transduction mechanisms are piezoelectric and electromagnetic conversion. Kinetic energy harvesters have a resonance frequency that usually ranges from tens to hundreds of Hertz. In these conditions, they provide energy that ranges from tens to hundreds of microwatts.

Table 2. Comparison of various vibrational-harvesting technologies.

	Piezoelectric Devices	**Electromagnetic Devices**	**Electrostatic Devices**
Advantages	-high output voltages -high capacitances -no need to control	-high output currents -long lifetime -robustness	-high output voltages -low-cost systems -coupling coefficient easily adjustable high coupling coefficients -e reduction increases capacitances
Disadvantages	-expensive materials -coupling coefficient linked to material properties	-low output voltages -expensive material -low efficiency in low frequencies and small sizes	-low capacitances -high impact of parasitic capacitances -no direct mechanical-to-electrical conversion for electret-free converters

2.3. Piezoelectric Transduction

Piezoelectric harvesters [2] generate energy by bending mechanical elements, i.e., beams or membranes. The resultant mechanical vibrations oscillate at resonance frequencies which can range from tens to hundreds of Hertz.

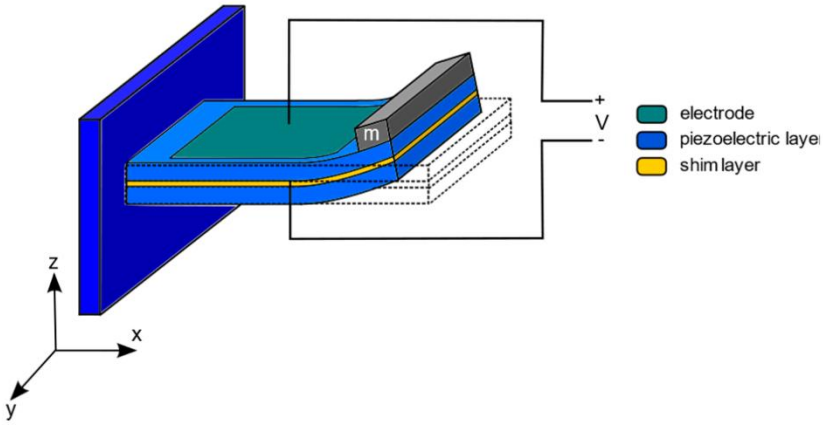

Fig. 4. Piezoelectric kinetic harvester

2.4. RF Harvester's Technology and Devices

Radio frequency (RF) harvesters [13] obtain energy from RF and wireless microwave power. The background RF radiation emitted by broadcast transmitters, cell phone towers, Wi-Fi nets or low power wireless networks, could eventually be used as energy harvesting sources. In this context, radio frequency waves include frequencies from 3 kHz to 300 GHz. The harvested power depends on the incident power density, the distance between the transmitter and receiver, the power conversion efficiency and the harvester antenna size. Thus, the intercepted power is directly proportional to the size of the antenna aperture. A coil and a separator compose an RF harvester, *fig. 5*.

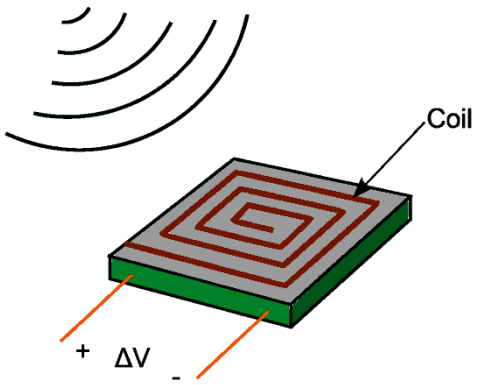

Fig. 5. RF harvester.

Table 3. RF energy harvesting experimental data

Source	Source Power (W)	Frequency (MHz)	Distance (m)	Power Harvested Rate (µW)
Isotropic RF trans.	4	902–928	15	5.5
Isotropic RF trans.	1.78	868	25	2.3
Isotropic RF trans.	1.78	868	27	2
TX91501 power trans.	3	915	5	189
TX91501 power trans.	3	915	11	1
KING-TV tower	960,000	674–680	4100	60

3. CONCLUSION

There are plenty of ambient energy sources in the urban environment that could be exploited to generate sustainable energy for IoT and WSN, especially IoT devices for the development of smart city

Ambient energy can be harvested directly from the system, as it is available in almost any place where there are vibrations, solar light, heat, wind, radio frequency, water, and many other natural sources. This will provide optimal benefits of EH systems in the intelligent city. Energy harvest systems have been presented as an avant-garde solution for ecological communications. The energy harvest capacity facilitates the development of smart cities through omnipresent interconnectivity of Internet of Things as long-lasting energy sources.

The use of renewable energy sources is one of the most urgent ways to solve the energy and environmental problems of large cities. These problems significantly affect the life of the population and require an immediate solution.

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TEACHING ESP TO STUDENTS IN MECHANICAL ENGINEERING VIA INTERACTIVE PLATFORMS

Minodora **BARBUL**
Technical University of Cluj-Napoca

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Abstract: *Teaching English for Specific Purposes is a challenging endeavor, especially during a pandemic that forced a new teaching/learning paradigm. The present paper aims to highlight the online tools and platforms that have been useful in order to provide an efficient and enjoyable learning experience. Considering the learning styles of the students and the skills needed for future engineers to become competitive on the labor market, we have comprised a series of sample activities that may be considered examples of good practice.*

1. THEORETICAL FRAMEWORK

The origin of English for Specific Purposes dates back to the years after the Second World War, a flourishing time for international economic activities and major scientific and technological advances. The reality of those days generated the massive need for a shared language that could facilitate business and technological exchange. English has become a sort of international currency, learned for the practical and specific purposes beyond its beauty and fashionable trends. There was also the revolution in linguistics that heavily characterized the field of English for Specific Purposes, as the scholars' focus shifted from the formalist view on language to real and practical language opportunities and contexts. In the late 1960s and the early 1970s specialists like Ewer and Lahore, Swales, Selinker and Trimble made significant attempts to describe the new interpretation of English as English for Science and Technology (EST). Maybe the third and arguably the most influential reason Hutchinson and Waters [1] invoked for the emergence of ESP has to do with psychology. They stressed the importance of considering the learner at the centre of the learning process. Therefore, more emphasis was given to the ways in which learners acquire language than simply focusing on the method of

language delivery. Learners were seen to have different learning strategies, to use different skills and to be motivated by different needs and interests.

Ever since the early 1960s, English for Specific Purposes has been the subject of numerous studies and classifications, definitions and reinterpretations, Hutchinson and Waters comprising five phases of development for ESP [2]. They stressed out that the course design process should be more dynamic and interactive - a prophetic word to be taken to a completely different level during the pandemic of the 2020s.

Nevertheless, there are some features that have been preserved along the years, such as the idea that ESP is actually language in context and the learning process revolved around the needs of the learners. The courses require real life learning situations that enhance students' skills and help them become more competitive. The subject is currently taught in universities around the world and it is employed by multinationals in the shared goal to raise the level of proficiency in specialized English for a more profitable and innovative future.

Students that choose mechanical engineering at Bachelor's level are fascinated by this field and highly interested in their professional and personal evolution. Their age range is between 18 and 45 years and the level of English knowledge usually varies between A2 and C1 on the Common European Framework of Reference. [3] As Hess N points out [4] teaching students that have different backgrounds and performance in a foreign language may become challenging when it comes to keeping them focused. Some authors [5] asserted that the use of smart devices is a distractor for students in situations when their level of English is insufficient or above the average one employed by the professor, the major switch to technology and the advantages of interactive learning generated by the 2020 pandemic being impossible to foresee.

The age of students plays an important role in their learning process, as people of different ages have different needs, competences and cognitive skills. For students who continue their education to academic level right after graduating high school, the process of learning is not a major challenge. It becomes more complicated for those who have a gap in formal education. As Jeremy Harmer [6] noted, adult learners can exhibit some traits that can easily make learning and teaching problematic. They might be critical of teaching methods, sometimes reluctant to engage in role-playing activities, or scenarios that might put them in an uncomfortable position. Adult learners can feel anxious or under-confident about learning a language and sometimes worry about their intellectual capacities. All these factors were amplified by the sudden adjustment of the educational environment in the beginning of year 2020, the immediate need to use technology and smart devices revealing the rift between "the digital natives" and "the digital immigrants" [7].

One vital aspect of English for Specific Purposes throughout the process is its focus on the learning strategies rather than teaching techniques. Therefore, students' learning styles are crucial for their successful professional growth. The idea that students learn best when the teaching methods match their learning styles, strengths, and preferences grew in popularity over the years, Neil Fleming's VARK model [8] being one of the most prominent. VARK is an

acronym made from the initial letters of Visual, Aural, Read/Write and Kinesthetic and it deals with perceptual modes, which means that it is focused on the different ways that learners take in and give out or express information. In a nutshell, a visual learner prefers charts, graphs and hierarchies, as patterns, designs and color are important in establishing meaning for them. The aural learner prefers information that is spoken or heard and they learn best from asking questions, a discussion, oral feedback or presentations, and talking with others. R stands for Read/Write and the learner is into information displayed as words, either read or written. Many academics and high-achieving learners have a strong preference for this modality, as these learners place importance on precision in language and are keen to use quotes, texts, handouts and manuals. The kinesthetic learner prefers the use of experience and practice through many senses (sight, touch, taste and smell) to take in their environment and to learn new things. Different schemes or models of learning styles that have been proposed over the years [9], a relatively comprehensive review described 71 different schemes, without claiming that their list was exhaustive [10]. In our approach to teaching ESP to students in engineering, we have considered the basic learning styles as main pillars to facilitate the educational experience which was severely affected by the lack of direct interaction in person between the teacher and the student.

Working with basic users of English is challenging, as students' knowledge only allows them to understand sentences and frequently used expressions related to areas of most immediate relevance, to communicate in simple and routine tasks requiring a simple and direct exchange of information on familiar and routine matters, and to describe in simple terms aspects of their background, immediate environment and matters in areas of immediate need. [11]. While studying engineering is accessible and enriching, English specialized terminology and highly professional interaction may become a stumbling block in their evolution within a globalized world. At the other end of the spectrum there are the students who have a solid linguistic background, acquired in more than ten years of serious study of General English. They can understand a wide range of demanding, longer clauses, and recognize implicit meaning, can express ideas fluently and spontaneously without much obvious searching for expressions. Moreover, they can use language flexibly and effectively for social, academic and professional purposes while producing clear, well-structured, detailed text on complex subjects, showing controlled use of organizational patterns and connectors. [11]

Confronted with such heterogeneous groups of students in mechanical engineering, the teacher plays an essential part in this complex equation, as the essence of ESP goes beyond the limits of teaching itself. Tony Dudley-Evans and Maggie Jo St John support the idea that the term "practitioner" is to be used instead of "teacher" due to the complexity of the work incurred by this job. In their view, the ESP practitioner has to embody five roles, namely that of a teacher, course designer and materials provider, collaborator, researcher and evaluator [12]. Usually a graduate of Philology, the practitioner is above all a teacher, whose standard duty is to help students learn. Therefore, the methods employed are similar to those used when teaching

general English, with the major difference regarding the content of the ESP course. While the teacher is proficient in terms of English language, the students are invited to bring valuable contribution to the classes by conveying their knowledge in the field of engineering. After carrying out a needs analysis stemming from learners, fellow professors and the business environment, the ESP practitioner can identify the proper courses, textbooks and materials that best answer the needs of their students. It goes without saying that being a collaborator is one of the greatest accomplishments of a practitioner, the professional growth in multiple directions being both valuable and rewarding. As researchers, the ESP practitioners need to be updated with the advances in the field they are teaching and provide adequate and accurate information in the knowledge exchange with the students. The role of evaluators place the ESL practitioners in the position of assessing whether the aims of the learning process meet the end results, in other words "to assess whether students have the requisite language and skills to undertake a particular academic course or career" [12].

Robinson [13] argues that flexibility is a key value needed for one to switch from being a teacher of general English to a teacher of ESP in order to comply with peculiarities of different groups of learners and adapt to their professional needs. Harding [14], on the other hand, claims that an ESP practitioner can make use of some general English teacher skills when planning the lessons, while stressing some professional differences. In other words, the ESP practitioners should think about what is needed by their students and avoid using random off the shelf course books. They should understand the nature of their students' subject area and work out their language needs in relation to their specialism. The ESL practitioner should use authentic materials within contexts, texts and situations in the field of study of their students while motivating them with varied and relevant activities.

2. TOOLS AND PLATFORMS

In their four semesters of ESP classes, students in mechanical engineering have been exposed to educational activities gradually, prioritizing the receptive skills in the beginning and finishing the practical course with the most demanding of the productive skills, namely writing. Our standard approach usually began from a written text containing both specialized vocabulary and basic grammatical landmarks, that essentially described a familiar process or some common knowledge for the students. They were expected to read the text out loud, to translate it using proper resources such as specialized dictionaries, to discuss and further explain the concepts interacting with the teacher or with each other and eventually to write a composition on the given topic. The pandemic forced the learning process in the online environment in a short period of time, the classroom setting being replaced by innovative and sometimes fragile remote interaction, so the need to adapt to the new educational reality was imperative.

The first essential step to preserve the contact between teacher and students in times of lockdown and physical distancing was identifying the most convenient platform for online communication. In chronological order, we chose to interact online with the students via Skype, KnowledgeBase and Zoom.

Skype is a popular web-based communication tool that allows people to take part in video conferences, make calls, send instant messages and a lot more. It was created by Janus Friis from Denmark and Niklas Zennstrom from Sweden in 2003 and it is a free software. It was the first appealing option, as most of us had already been using this free app for years and knew how it operated. Skype is very easy to set up and use, options like video-calling and chat being very accessible and useful for the virtual interaction. When teaching online, the chat feature can serve as a raise your hand method or as a whiteboard that allows participants to share notes or resources. A particularly useful characteristic of the chat feature is the opportunity to maintain contact with students beyond the standard program, so that potential queries or difficulties could be addressed individually and with great flexibility. The most important characteristic we have used is the screen sharing, which instantly makes materials available to the class and the lessons become more dynamic. Students can also share their screen, so their work may be visible and the feedback can be provided almost instantly. Files and assignments can also be sent back and forth between teacher and students during video calls. Skype facilitates listening, speaking and grammar-oriented lessons, all derived mainly from PowerPoint presentations. [15] One option is to use videos and podcasts that the student listens to during class and is afterwards required to answer some questions meant to check their comprehension. Speaking lessons can be taught by recording students reading, taking part in a role-play activity, repeating after the teacher, and then playing the recording back to them. Skype has a subtitle feature that can be enabled, so that the student can visually see the teacher's words and repeat them slowly. Grammar lessons can be also taught via Skype by using PowerPoints and screen sharing, or by sending short readings or exercises for the student to open and review. They can afterwards discuss the grammatical or linguistic mistakes identified in the educational materials.

KnowledgeBase is a *Learning Management System* (*LMS*) that was implemented in 2016 by Associate Professor Cosmin Sabo in the Technical University of Cluj-Napoca, with the purpose of facilitating and improving the teaching-learning process within the academic environment. When the pandemic prevented the direct contact among people, this Moodle platform that had been already established was the perfect solution to a less anticipated problem. KnowledgeBase enables the storage and delivery of learning content for the purpose of training and educating students, and currently hosts 10,000 users and around 50,000 activities dedicated to the students of the Faculty of Humanities, Faculty of Sciences and Faculty of Engineering located in Baia Mare (a division of the Technical University of Cluj-Napoca). KnowledgeBase has become the new classroom, students being enrolled in designated subjects of study and teachers having the opportunity to share their resources. The teaching stage in the learning

process was supported by the options the platform gave to instructors to upload educational materials within designated courses, such as books, files, or folders. Students benefitted from the practice and consolidate stage through activities and assignments associated with each topic. The modules enabled a teacher to communicate tasks, collect students' work and provide feedback and grades. The platform allows students to submit any digital content, such as word-processed documents, spreadsheets, images, or audio and video clips, so the tasks were diverse and adapted to the learning aims of each ESP unit. The main assessment tool we have used was the quiz activity, which enabled a teacher quizzes comprising questions of various types, including multiple choice, matching, short-answer and numerical. The teacher can allow the quiz to be attempted multiple times, with the questions shuffled or randomly selected from the question bank. A time limit may be set. Each attempt is marked automatically, with the exception of essay questions, and the grade is recorded in the gradebook. Assignments can be graded using a numerical or custom scale or an advanced grading method such as a rubric. Final grades are recorded in the gradebook. One of the options we found particularly useful was the attendance activity module, which enables a teacher to take attendance during class and students to view their own attendance record. The teacher can create multiple sessions and can mark the attendance status as "Present", "Absent", "Late", or "Excused" or modify the statuses to suit their needs. Reports are available for the entire class or individual students, so the virtual classroom spirit was as close as one can get in online education. We found BigBlueButton, the open source web conferencing system for distance education associated to KnowledgeBase, useful but limited, so we choose to use Zoom instead.

Zoom was founded in 2011 and the IDC MarketScape has positioned it in the Leaders Category for European Collaboration Tools for Education, 2020 [16]. It is simple and easy to use, one of its greatest advantages being the fact that participants do not need to have an account to join the class. Nevertheless, as with other videoconferencing tools, one needs a good internet connection to use audio and video options to their full potential. Beside the basic features like chat box and screen sharing, we have frequently used the annotate your screen option together with the whiteboard feature. The annotation tools allow teachers to really engage with their teaching and learning materials by drawing, writing and highlighting anything on the screen, so that learning is more accessible and visually appealing. Screen annotation tools can be used to guide students and explain some concepts, and the remote control option makes the interaction extremely easy, as if literally passing the whiteboard marker from the teacher to a student. Zoom allows the teacher to explore and assess students' four skills in a more complex way, making the lessons more interactive, and it is great for larger classes, as up to 100 participants can join the basic package. One of our favourite options was the utility of breakout rooms, to set up small team activites similar to the ones in a standard learning environment. As the host of a meeting, the teacher can manage participants in a complex way, using features that can greatly benefit the educational process. As the instructor, one can join breakout rooms, broadcast messages to the breakout rooms, and end the breakout sessions when it is time to regroup. Using

the chat tool can encourage engagement by allowing more students to interact within the live activity, its main advantage over the traditional classroom being the large number of responses that a teacher might get instantly and almost simultaneously, without students influencing each other. The non-verbal feature of raise hand also facilitates communication and students taking turns without interrupting the meeting.

Having found the most convenient and efficient channels to facilitate the online interaction with students in mechanical engineering, we have expanded towards online tools and platforms that add value to their learning experience. We shall further provide a series of ideas ESL practitioners could find useful in the teaching process.

PowerPoint Presentations are maybe the basic element in online teaching, as they easily introduce information and represent a starting point for any kind of activity. Microsoft PowerPoint is a presentation program, created by Robert Gaskins and Dennis Austin and released on April 20, 1987. It was initially developed for business use, but in time it has grown to have wide applications for schools and community organizations. The program was packaged as a stand-alone product, but its inclusion in the best-selling Microsoft Office suite assured its near-total dominance in the presentation-software market. [17] The slides can basically accommodate text and images, so they fast replaced handouts. Moreover, they facilitate interactive content and allow complete freedom for teachers to introduce topics and design the presentation in a suitable and enjoyable manner.

twinkl.co.uk is a platform created in 2010 by Susie and Jonathan Seaton with the purpose of helping those who teach. All Twinkl resources are **teacher-made** and can be used by anyone and anywhere, with the aim of **making learning accessible to all**. Although the resources are typically addressed to learners of general English, we made use of those designed for the subject Design and Technology, which is compulsory for the native speakers of English in their Key Stage 3 and 4 according to the National curriculum of England. [18] Given the topic of Materials, we have introduced students in mechanical engineering to texts that organize their knowledge and introduce specialized terminology in their field of interest [19] as well as consolidate terminology through quizzes [20], differentiated homework worksheets [21], crosswords [22] and reading comprehension activities [23], and ultimately revise the chapter [24]. Some of the resources are provided as such, others can be adapted to more specific needs, and others are interactive and perfectly suit the online learning process. Most of them can be adapted to individual, team, group, or whole class tasks.

Another lesson creator platform that allows teachers to structure a learning unit around a video is TED-Ed [25]. Aiming to enhance the listening skills of the students and their comprehension, this tool can be adapted for the teaching phase, formative assessment, or summative assessment purposes by altering the types of questions associated to the video. The steps towards creating a lesson start with the teacher finding a suitable video for the field of interest of the students and their average level of English knowledge. One can customize a TED-Ed Animation or import one from YouTube or other sources. Once it is uploaded onto the

platform, the teacher may add questions, discussion prompts, or any other additional resources. The option of Creating a lesson takes the teacher through a series of stages that begin with giving the lesson a tile, followed by the option to write an introduction (Let's Begin), insert a series of multiple choice or open-ended questions (Think), add supplementary resources to encourage further exploration (Dig Deeper), facilitate an interactive class discussion (Discuss), and end it with a closing moment (And Finally).[26] Once the students cover the lesson with the teacher's supervision and support, their progress can be monitored. If the students work independently and the teacher is only notified when they have completed the lesson, comments and reviews of their performance can be provided individually. TED-Ed is a tool which contributes to the motivation of students and represents a fair assessment of their progress if the videos available are consistent with the curricula.

In 2005, Ulla-Maaria Koivula, a Ph.D student at the University of Helsinki in Finland, had the idea to develop a tool where she could integrate information and links directly into images, so she founded an education and media technology company. ThingLink is a digital tool that provides an easy way to improve the learning experience of children, including those with learning disabilities. This innovative tool has been selected to receive the 2018 UNESCO King Hamad Bin Isa-Al Khalifa Prize for the use of ICT in Education.[27] It is a platform that improves engagement and learning results because of its options to operate with interactive media such as images, videos, virtual tours, 3D models and simulations. It is a visual learning solution, as the teacher may start from the image of an object to which interactive tags may be added in order to engage the learners into discovering the specialized terminology in English. The tags may consist of different types of texts, descriptions, definitions, charts, detailed photos or videos imported from an external source or original ones generated by the teacher for the sole purpose of the lesson. While this tool is ideal to introduce information and enhance students' receptive skills, there is a Poll tag option that allows teachers to collect anonymous feedback or get learners' opinions using single choice questions.

As practice and consolidation are the keys to success in assimilating and mastering knowledge in English, we shall further refer to the interactive platforms we found most efficient in our educational endeavor during the pandemic.

The idea of Wordwall began in a secondary school classroom in London (UK) in 2008 with the attempt of a teacher to replace the laminated words traditionally used to support literacy with a program that comprised a list of words for the same purpose. [28] Wordwall.net was launched in 2016 and it can be used to create both interactive and printable activities, its strong point being the template system that facilitates the teacher's job by allowing the creation of a fully interactive activity in just a couple of minutes. It is fast and easy to use, especially in educational activities that focus on specific terminology. Once an activity on a given topic is created, the teacher can switch it to a different template with a single click. For example, after a Quiz is created for students in mechanical engineering in order to consolidate their knowledge regarding composite materials, it can be instantly turned into a Wordsearch activity, or a

Crossword may be transferred into a Match activity comprising the same concepts. There are several types of subscriptions for a teacher to access the options provided by the platform, but we consider the basic option which is free of charge to be enough when combined with other interactive platforms, as it provides the following 18 basic templates that can be used as assignments: Quiz, Match up, Random wheel, Open the box, Group sort, Labelled diagram, Find the match, Missing word, Random cards, Wordsearch, Gameshow quiz, Unjumble, True or false, Anagram, Matching pairs, Maze chase, Flip tiles, and Image quiz.

iSLCollective.com stands for Internet Second Language Collective and it is a community of language teachers from around the world who share their home-made PowerPoint presentations and worksheets on this free-to-use platform set up in 2009 by Peter Laszlo, Adam Laszlo and Benedek Princz from Hungary. The best feature of this platform is the video quiz generator, a tool that allows teachers to create a popup quiz in just a few minutes. The learning opportunities are very complex, as any video on YouTube can be turned into a listening comprehension exercise, with a focus on specialized terminology or grammar. As the practical course of ESP dedicated to students in mechanical engineering encompasses a chapter on composite materials, we have used a ready-made quiz [29] to review such specific vocabulary. The video is actually an advertisement for a composite material used in Formula 1 and there are fill-in-the-blanks type of exercises inserted every few seconds, to check students' listening and comprehension skills. Such vocabulary booster type of activity addressed to students of B2 level of English is a sample of real-life situation they might encounter in their future job in this field. The transcript can be further used to support the pronunciation and the reading skills of the beginner students, as well as to encourage the speaking skills of the advanced ones within a session of debates.

Quizlet is a digital learning tool that contains sets of study materials and has a section dedicated to mechanical engineering [30]. They can be used free of charge by students who want to self-assess their knowledge both in their field of study and in terms of English language. In the first stage of designing the educational material, the platform imports information provided by the teacher and converts it into flashcards. [31] The second phase within the set of study converts that information into six different study modes making it useful for any type of learner. One of the strong points of this platform is the fact that it facilitates an inclusive learning process, so that students with learning disabilities can acquire, retain, and use specialized terminology and information. [32] The Learn section facilitates the association of a definition with a correct answer that must be checked in a multiple-choice type of activity. The Write section asks the learner to write the translation of the definition associated to a flashcard that is not visible. The Spell mode asks the learner to type what he/she hears. The Test section comprises true/false questions, multiple choice questions, matching questions and written questions. The last two sections are labeled as Play through Match and Gravity, the former asking the learner to drag corresponding items onto each other to make them disappear, and the latter encourages the students to protect the planet from asteroids by writing the correct

translation of the text written on the falling asteroid. When teaching mechanical fasteners for example, Quizlet can be a useful and enjoyable tool employed in the learning process.

Liveworksheets is a platform that allows teachers to transform traditional printable materials into interactive online exercises, therefore a standard piece of paper or a plain doc, pdf or jpg can quickly include sounds, videos, drag and drop exercises, join with arrows, multiple choice and even speaking exercises. Although there is an extensive collection of thousands of interactive worksheets, the materials needed for students in mechanical engineering are quite limited, so the platform is best used to create educational content rather than to import some already made ones. [33] There is a category of worksheets and online exercises on the topic of Mechanics [34] and Engineering [35] that one may select in order to check the available resources, but we chose to create ESP content that provides learning opportunities customized for students' needs. The simplest way to use the interactive worksheets is to create them on the platform and send their generated link to the students, who do the tasks and afterwards send the answers back to the teacher directly from the platform. Although the activities generated by the platform are predominantly individual tasks, one of the advantages we have identified is the fact that students are graded automatically at completion of a worksheet, so each learner can have instant and individual results. There are no templates or restrictions in terms of the materials one can transform into interactive worksheets, which allows teachers of ESP great flexibility to design the suitable content.

The stage that closes the educational cycle and generates new learning opportunities is the assessment. According to Bransford, Brown, and Cocking [36] assessments and feedback must focus on understanding, and assessments that emphasize understanding do not necessarily require elaborate or complicated assessment procedures. Even multiple-choice tests can be organized in ways that assess understanding.

Quizizz is a very popular and free of charge online tool that allows teachers to create assessment activities that can be presented live as a timed competition or used for homework with a specific deadline. It has a straightforward layout, and operating the interactive tasks is intuitive. A valuable feature is the fact that students can review their answers, and the immediate feedback can be used by teachers to revise and adapt the learning activities by putting a larger emphasis on specialized concepts that students struggle with. While the Quizizz library provides almost 60,000 results for the search of the keyword Mechanics and over 76,000 results for the search of the keyword Engineering, we consider the platform offers the best learning experience when the tests are customized according to the exact topic of study and the English level of the participants. Each quiz can include any of the following types of exercises: Multiple choice, Poll, Fill-in-the-blank, Open-ended, Draw and Slide. A further step implemented by the learning platform is to allow the creation of interactive lessons that incorporate the already set quizzes together with new Media content including embedded web pages.

LearningApps.org is another platform that can generate a vast range of interactive activities, the design of the educational content being in the teachers' hands. The process is fast

and easy, as the templates just need to be added with content and shared with students. There are several types of activities that can be created and adapted to the level of English knowledge of the students, the main options being the following: Matching pairs, Group assignments, Number line, Simple order, Freetext input, Matching pairs on images, Multiple choice quiz, Cloze test, Audio/video with notices, The Millionaire game, Group puzzle, Crossword, Word grid, Guess that word, Pairing game, Matching matrix, Fill table, and Quiz with text input. [37]

One of the most complex and useful interactive platforms we have identified and started using during the pandemic is Nearpod. It is a very useful tool for teachers because it facilitates the creation of interactive lessons that work for in-person, online, or asynchronous learning. Besides the ready-to-teach or customizable lessons, it provides dynamic media experiences, as it allows flexibility and creativity in content design. The platform can simply act as a substitute for other presentation tools, as one may import PowerPoints, Google Slides, PDFs, videos or pictures, or it can become the virtual space for interactive teaching, consolidating students' knowledge and organizing formative or summative assessments. Students have the option of keeping up with the lesson at their own pace, as teachers can easily switch between synchronous and asynchronous teaching modes within a single Nearpod lesson, video, or activity. Teachers may select a group of slides or activities from their lesson for Student-Paced work and can revert back to Live Participation anytime. Thus, students who are ready for the next step move forward in the lesson while those who need more time can benefit from it without feeling left behind. This is particularly important in groups of students that have significantly different levels of English knowledge. ESP for students in mechanical engineering requires a lot of visual material, so the lessons would usually begin with a video with subtitles, followed by descriptive slideshows and other relevant web content. The Collaborate Board is very convenient for brainstorming activities and writing tasks, while Time to climb and Memory test bring a joyful experience while stirring competition. The teacher can create customized Quizzes, Polls, Open-ended Questions or Matching Pairs to check students' understanding of specific terminology and can also make adjustments or provide immediate support and clarification when needed. All results are included automatically in a report Nearpod creates, so that the individual progress and group dynamic can be monitored constantly for a more efficient educational process. The 'Open-Ended Questions' feature allows the teacher to launch a question or a scenario for the students to respond to, encouraging creative writing tasks.

One of the most complex tools, that facilitates the transition from educational assignments to job related tasks is Genial.ly. This is an online tool that can be used to create still, animated, or interactive visuals, such as posters, infographics, quizzes, and presentations. It is mainly addressed to students, who are required to create visuals that may be under the form of general presentations, dossier and report, learning experience, gamification, interactive image, horizontal infographic, vertical infographic, guide, video presentation, personal branding, social, story, or blank creation. Starting from the premises that it is easier to

understand visual and interactive content [38], the founders of this platform stress the importance of interactivity that makes people explore and discover information on their own. There are free templates, a rich resource gallery and other features that are included in the free of charge basic option for those who are interested in education. Given the complexity it provides, the platform set up in 2015 in Spain offers online tutorials and ongoing support through Genially Academy, a feature that assists learners in their journey. Students in mechanical engineering can use this tool in order to describe and promote various types of equipment and technology used in their field of activity, and the platform can increase their engagement in learning and allow them the freedom to express their knowledge and develop their communication skills.

3. CONCLUSIONS

Given the constant challenges and changes determined by the pandemic we are currently experiencing, the learning environment is becoming more interactive and efficient than ever, with rapidly and creatively invented and improved platforms and tools. The pandemic has accelerated and amplified trends in education that were already in motion. In the 1960s and 1970s the business environment started offering computer-based trainings through Plato, which was developed by Control Data and the University of Illinois back in 1963. During the 1970s and 1980s TV based technology was employed to support live training. As technology evolved, the 1980s and 1990s brought CD-ROM trainings and the Learning Management Systems (LMS) in education, the computer-based courses being an important landmark for the evolution of the current interactive learning experience. Christopher Pappas, the Founder of eLearning Industry Inc stated that "Blended learning, and eLearning as a whole, has seen rapid change in the past two decades, beginning in 1998 with the first generation of web-based instruction. Computers were no longer just for organizations and the wealthy few, but for the masses." [39] The technological boom of the 21st century has transformed blended learning into a complex experience that allows students maximum flexibility, and the pandemic that facilitated online learning, e-learning and blended learning represents a point of no turning back in the evolution of education.

Boelens, Van Laer, De Wever, and Elen defined blended learning as "learning that happens in an instructional context which is characterized by a deliberate combination of online and classroom-based interventions to instigate and support learning" [40] while Garrison & Kanuka, [41] stressed the fact that the online element should not solely be an addition to classroom-based teaching, as blended learning should be the result of effective integration of both virtual and face-to-face methods.

Studies by López-Pérez, Pérez-López, and Rodríguez-Ariza [42] and Boyle, Bradley, Chalk, Jones, and Pickard [43] noted that the introduction of blended learning in higher

education courses improved retention and correlated with improvements in students' attainment. Additionally, Stockwell Brent, Stockwell Melissa, Cennamo, and Jiang [44] found that blended learning courses improved attendance at face-to-face classes, in self-report measures of student satisfaction, and in examination performance. Once we had to transfer the practical course of ESP in the online environment during the pandemic, we have also experienced a higher level of curiosity and interest in the interactive activities from students in mechanical engineering.

Garrison and Kanuka [41] argue that blended learning is effective because it questions the traditional lecture-based teaching model, allowing classroom time to focus on more active and meaningful activities. Moreover, Delialioğlu [45] found that problem-based, rather than lecture-based, blended learning had higher levels of student engagement. In the current context of hybrid learning, with some practical activities being held in face to face format and theoretical courses being delivered online, our ESP practical course could benefit fully from both approaches. The online activities can be used to both reinforce learning undertaken in the classroom, and to serve as a basic introduction to topics before they are covered in more depth in class.

Whilst blended learning is a valuable tool which enables students to work independently and develop their receptive and productive skills, individuals respond differently to the challenges depending on many factors. In a study conducted by Wivell and Day [46] students reported that self-motivation, self-reliance and the ability to work independently were essential to their success on the blended learning course. However, students who already struggled in the face-to-face delivery struggled to adapt to the demands of the blended program as well. Moreover, Pérez and Riveros [47] found that whilst a blended learning program generally increased students' autonomy and responsibility for their learning, a common complaint from instructors was that some students did not engage with the online activities or complete the online assignments. Similar conclusions were reported by Chen and DeBoer [48], who found that the most successful students were those who engaged more frequently with the online materials. The practical course of ESP offered in the university during the pandemic and blended learning programs depend on some factors that are less related to the educational drive and more to the mere access to technology and reliable internet providers.

According to a 2021 survey by Qualtrics, commissioned by Zoom, "Many respondents have a preference for in-person learning going forward, but are open to virtual when in-person is not available." [49]. The experience of learning remotely during the pandemic left students with a positive attitude towards online and hybrid courses. Education in a post-pandemic world has to combine the advantages of e-learning with important pedagogical goals associated with in-person teaching. Therefore, we consider that blended learning is the best form of education in terms of ESP addressed to students in mechanical engineering.

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INTELLIGENT FINGERPRINT-BASED ACCESS SYSTEM WITH CAMERA

Marina Daniela **SAS**
Technical University of Cluj-Napoca, Department of Electrical, Electronic and Computer Engineering
sas.marina8@gmail.com

Keywords: camera, fingerprint sensor, artificial intellingence

Abstract: *The paper presents a theoretical study and a practical realization of a system for access based on the imprint of a room and keeping track of people who are unauthorized. The assembly is done on a small scale (at the model level). For the practical realization we used the FPM10A fingerprint reader module, the Arduino AT Mega 2560 control unit equipped with the AT mega2560 microprocessor and an ESP32Cam camera equipped with the ESP32 microprocessor. The role of the fingerprint reader will be to check and recognize the fingerprints already stored in his memory, to the people who will want you to enter the rooms. The role of the camera will be to take a picture of the person whose fingerprint is not recognized. To view the allowed or not allowed access status, we mounted the 1.8" TFT LCD display. For the power supply of the assembly I used a 12V source that supplied my electromagnetic lock and from this source with the help of a low voltage converter you could power your Arduino board and ESP32Cam board, these being necessarily supplied at 5V voltage. The advantage of this application is that it secures the entrance to a room and can keep track of remote unauthorized persons who have tried to enter the room.*

1. INTRODUCTION

In recent years the technology has evolved a lot being used in various fields of activity to simplify and make people's work easier to ensure better home comfort, jobs and other areas.

One of the areas in which technology has evolved a lot is the field of access system of a room, of a property. This term access control actually refers to restricting the entry into certain rooms only of authorized persons.

In the past, this access control secured a space or property performed by a person (guard, receptionist), by certain mechanical means, such as locks, keys or access based on a card.

This control of conditional access by an individual would mean how that the person will decide who can have the right in the room or when he is allowed to. From the point of view of Historically, this access was often made on the basis of keys, which was owned only by triage staff for access.

Thanks to technology, which has evolved in recent years, access control in spaces has become a control based on an electronic system aimed at better security of access restriction unauthorized persons.

In order to replace those mechanical keys, the electronic access control will be based on accreditation based on the presence, when the person receives the access consent, the door will be opened. When the person's access is denied, the door will remain blocked and your access attempt may be registered.

This presence-based system could monitor your door with an alarm when the door it is open or held too long after it has been opened.

2. DESIGN AND IMPLEMENTATION

In this paper, I will represent the practical part of the proposed topic. For to highlight this aspect I will present the hardware connection diagrams of the different components and the software part, both contributing to the proper functioning of the chosen works.

2.1 The chosen theme of the fingerprint access system

This paper is entitled “Intelligent Fingerprint Access System with camera”, presents the realization of a secure access system based on fingerprint with use of a camera. (seems to be using the fingerprint camera).

The main feature of this system is the ability to have a system as much as possible well secured, when the person who wants to enter the room is not the fingerprint is recognized, the camera will take a picture of it, save it on a card, and from this card you will be able to view the picture with the help of the web interface created by Esp32.

2.2 Schematics of the fingerprint access system

Figure 1 shows the block diagram of the system, in which we also highlighted connection to the user of the ESP32Cam development board.

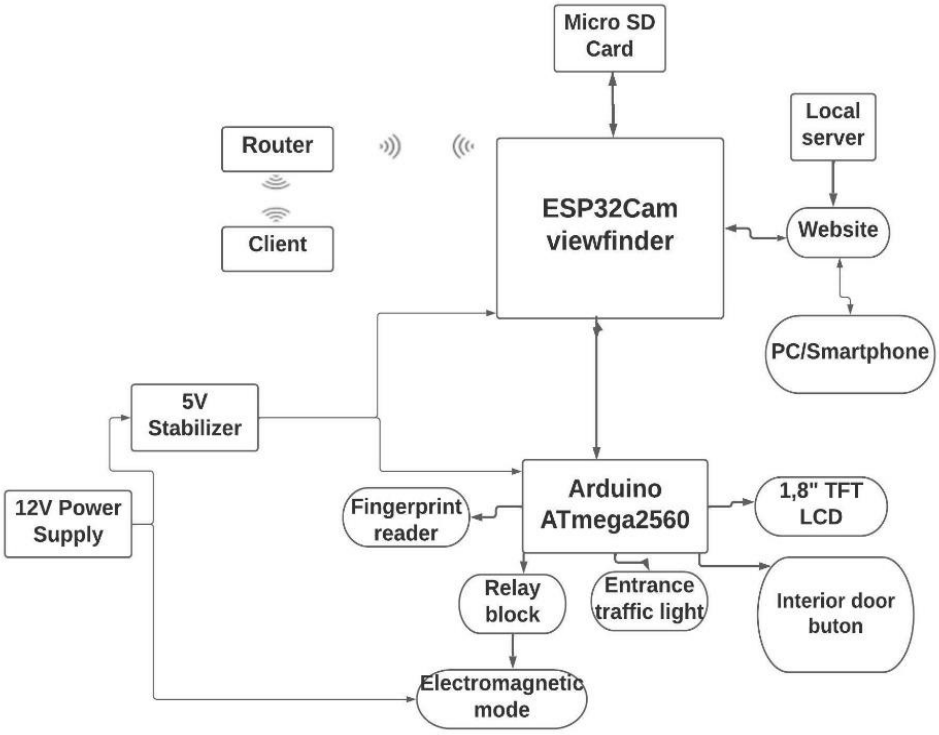

Fig. 1. Block diagram of the camera-based access system

To understand the operating stages of this project, we made a diagram with the functional blocks in which we highlighted and the connections between them. The stages of the block diagram represent the operation of the project presented as follows:

- ✓ the Arduino microcontroller took your data from the fingerprint reader, sent it to you decode then sends you the command of the relay block where it gave you the control of the electromagnetic yale to open or remain closed depending on the degree of resemblance of the fingerprint to the stored one.
- ✓ the LCD will retrieve your data from the Arduino when it recognizes you or not fingerprint and display certain messages
- ✓ the input traffic light also takes the data from the microcontroller, it will signal visually whether access is allowed or not
- ✓ the button on the interior door took over your data and activated the yala in inside the room
- ✓ Arduino microcontrols transmit data to the ESP32Cam microcontroller
- ✓ ESP32Cam takes over and sends you data to the micro SD card, and then all this data will be transmitted to the web interface via the WI FI connection
- ✓ The block diagram of this system we mentioned above, being represented in *figure 2*, in which we also represented the connection with the user of the board ESP32Cam development.

Figure 2 shows the electrical diagram of the access system.

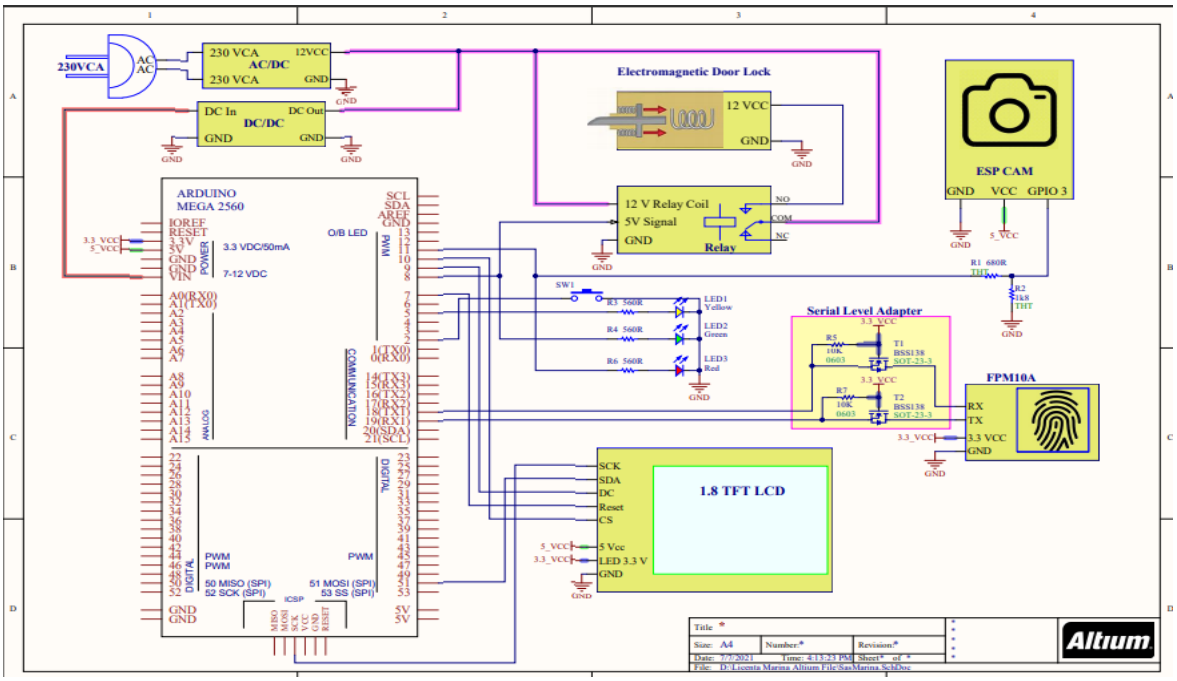

Fig. 2. Wiring diagram of the fingerprint access system

Figure 2 above shows the wiring diagram of the access system to understand how to design the access system, this diagram shows the connections from an electrical point of view.

This system is powered by a 12V source, it will supply you with the electromagnetic yala that will be controlled from the Arduino microcontroller via the relay block. The Arduino board will also be powered from this source by a low voltage converter that will convert your voltage from 12V to 5V so that it can be powered.

The fingerprint reader communicated to you via a logic level converter to the Arduino board, because it is powered at 3.6V, and from the Arduino board we can only supply 3.3V or 5V.

The LCD will communicate with the Arduino board via the pins dedicated to SPI communication, and it will be powered from the Arduino board.

The input traffic light is connected to the digital pins so that it can indicate the state in which the fingerprint reader has recognized the fingerprint or not, or it is in the fingerprint verification state, it is also powered by the development board.

The button is connected to a digital pin to be able to open the yala from the inside, this button on the Arduino board is also connected to ground.

The operating algorithm of this access system is presented in *figure 3*, the software being carried out in the following order:

Start:

• When the access system is powered on, microcontroller pin assignment operations are performed, thus establishing their role as output pins and how to write them (LOW or HIGH).

Fingerprint is expected:

• When the project is powered on, the fingerprint reader will wait for you until the user brings your finger close so that the fingerprint can be checked.

Fingerprint check:

• After the user puts their finger on the fingerprint reader, it will start comparing the user's fingerprint with the previously stored fingerprints, the result of the comparison will give the diagnosis whether or not it is valid.

Green LED / Red LED

• The green LED or the red LED are used to indicate when the fingerprint is recognized by the reader or when the fingerprint is not recognized by the reader.

LCD message:

• After the fingerprint is checked and the indicator lights have been turned on depending on whether the fingerprint is valid or invalid, a message will appear on the screen, consisting of "Access allowed" or "Access not allowed".

Picture taken:

• If the fingerprint is not recognized by the fingerprint reader, the camera will take a picture of that person, save the picture to a Micro SD card, and then the picture can be viewed using the WEB interface.

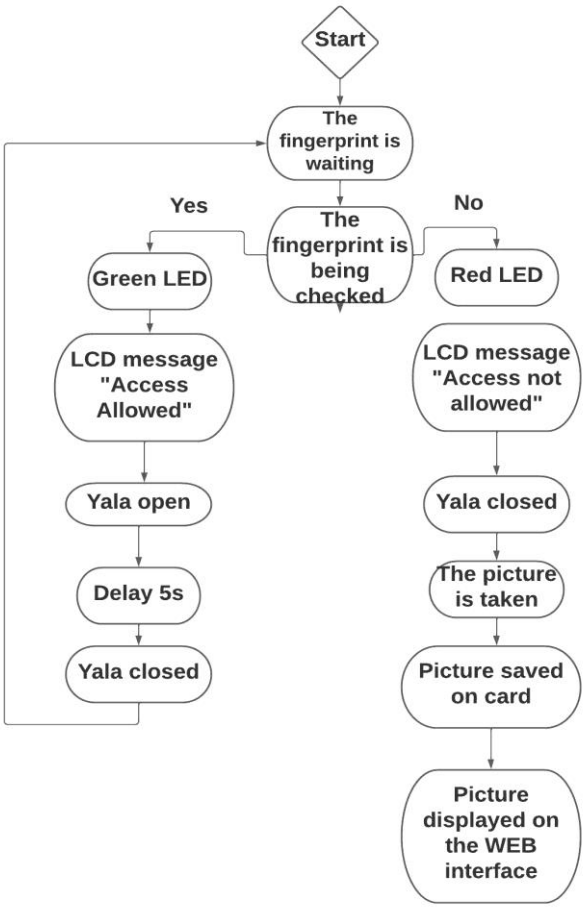

Fig. 3. Logic of the fingerprint access system

3 HARDWARE IMPLEMENTATION

Interfacing the FPM10A fingerprint reader with the Arduino AT Mega2560 development board is useful because the board has dedicated pins for serial communication, and the module uses the same communication interface. In order to work, I only had to identify the dedicated pins for the serial communication of the board and make the direct connection with the module pins, according to the diagram shown in *figure 4*, the power supply of the module is also provided by the Arduino AT Mega2560.

In order to be able to communicate the hardware of the Arduino board with the fingerprint reader module, we connected the serial communication module, RX to digital pin 18, and the reader's TX pin to digital pin 19, these development board pins being dedicated to serial communications.

This fingerprint reader is powered at 3.6V, and on the Arduino board we have 3.3V and 5V power pins respectively, and in order to be able to power this module from the Arduino board we used a logic level converter with I2C. *Figure 4* shows the connection mode of the module with the development board.

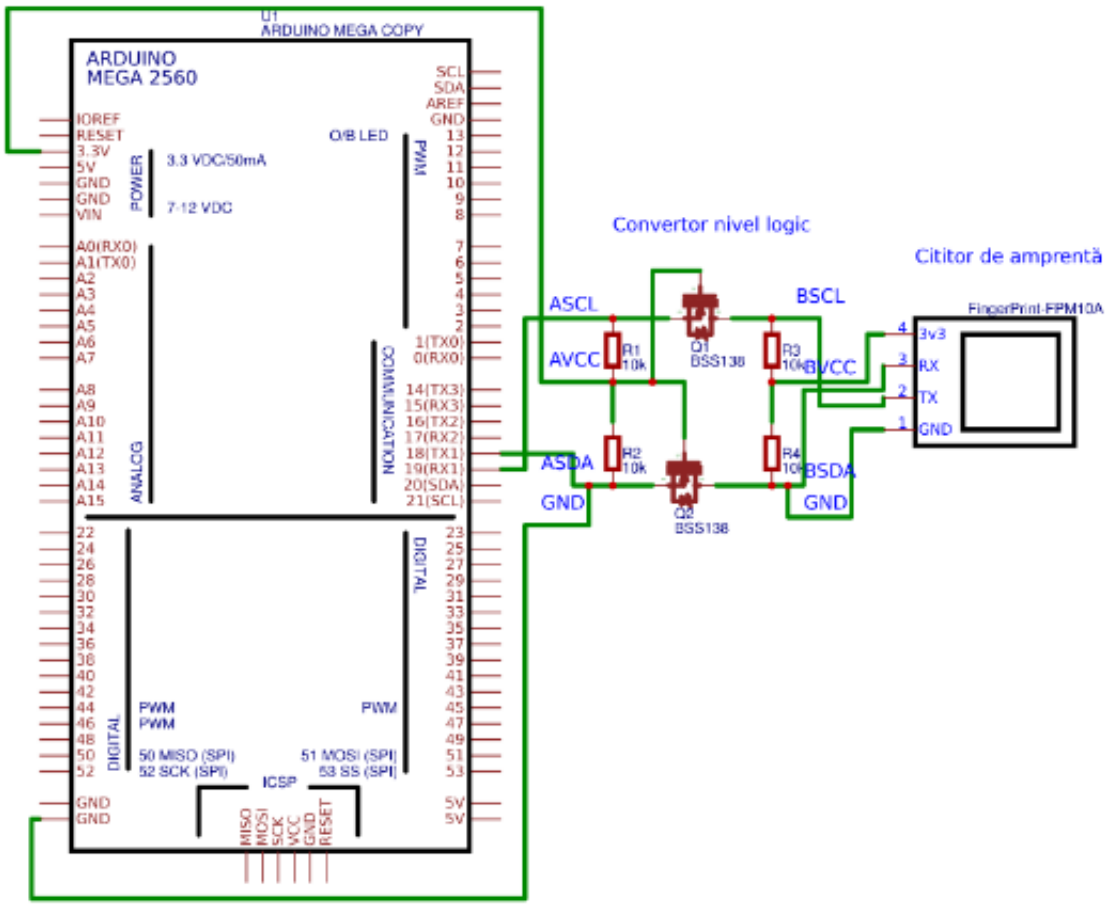

Fig. 4. Fingerprint reader connection diagram

And this time, the presence of dedicated pins for communication via the SPI protocol of the Arduino board proved to be useful, due to the simple interface between the LCD module and the board. For the pin that performs the function of "select chip" we chose the digital pin number 10, the other pins were connected according to the TFT library, already existing in the IDE, namely the MOSI pin (Master out slave in), to the digital pin 51 of the board Arduino and the MISO pin (Master in slave out) of the LCD mode, to the digital pin 52 of the Arduino board, as can be seen in *figure 5*. Power supply to the LCD mode was provided by the Arduino AT Mega development board.

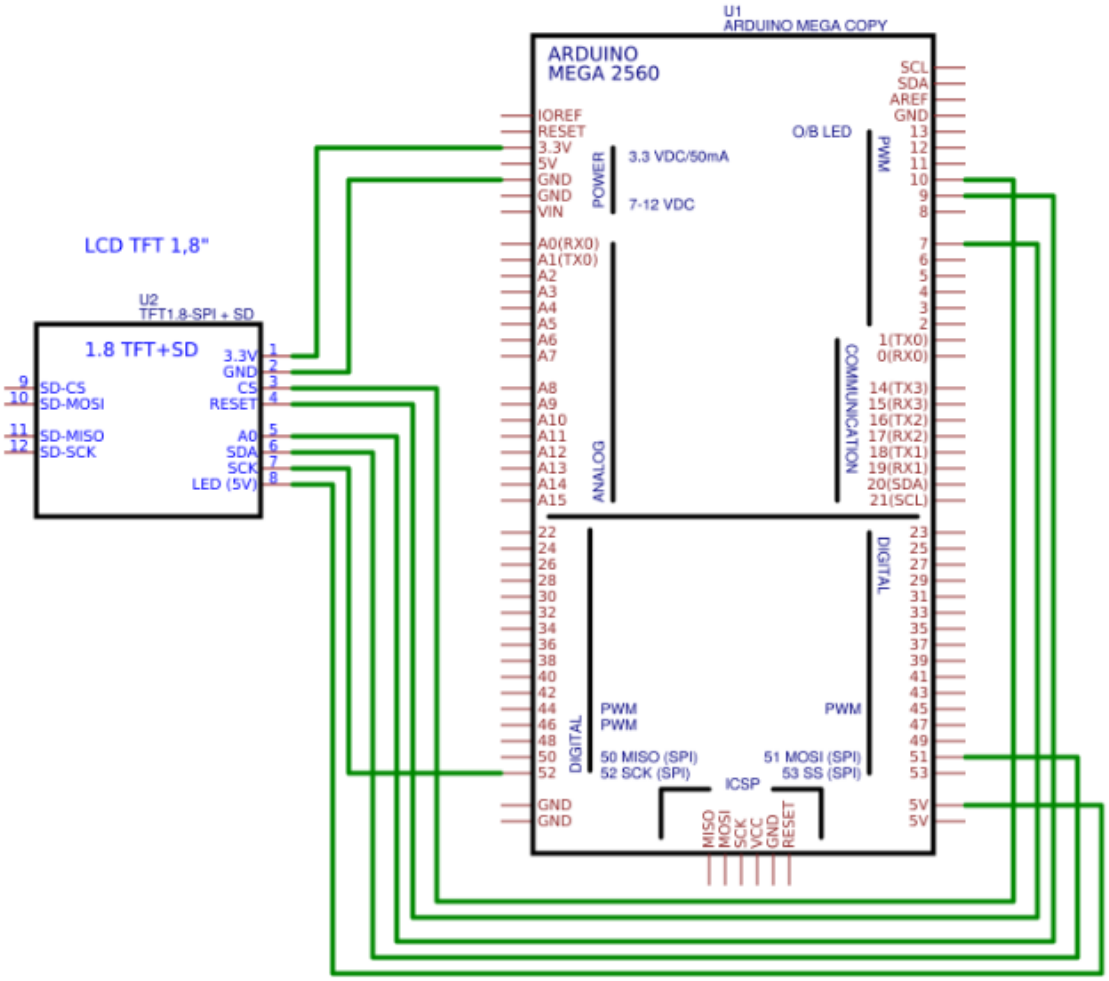

Fig 5. "TFT LCD connection module to Arduino board

The communication mode of these two boards is hardware, this communication is done through a GPIO that received a pulse from Arduino in LOW (0 logic) or HIGH (1 logic) mode when it had to take a picture.

Since the ESP works on 3.3V to power the GPIO pins, we did a level conversion using a voltage divider, this divider is made with the help of two resistors of different values, 1.8kΩ and 680Ω respectively.

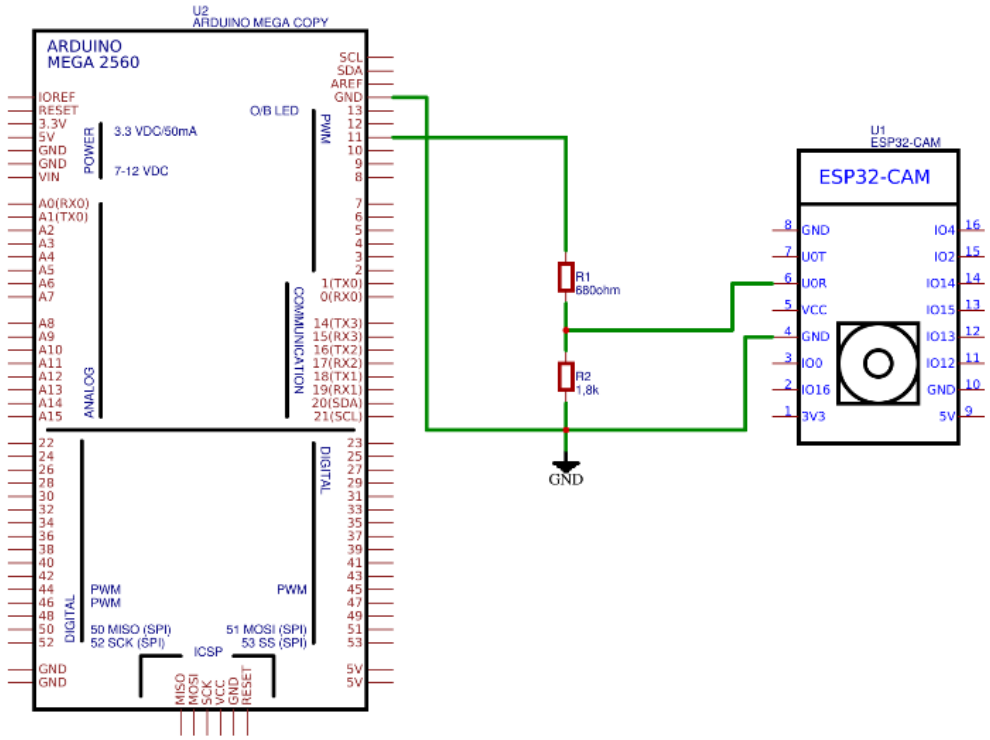

Fig. 6. How to connect the ESP32Cam board to the Arduino AT Mega2560 development board

In order to be able to program the electromagnetic yala module, we used a 2-channel relay to be able to communicate the yala with the Arduino development board.

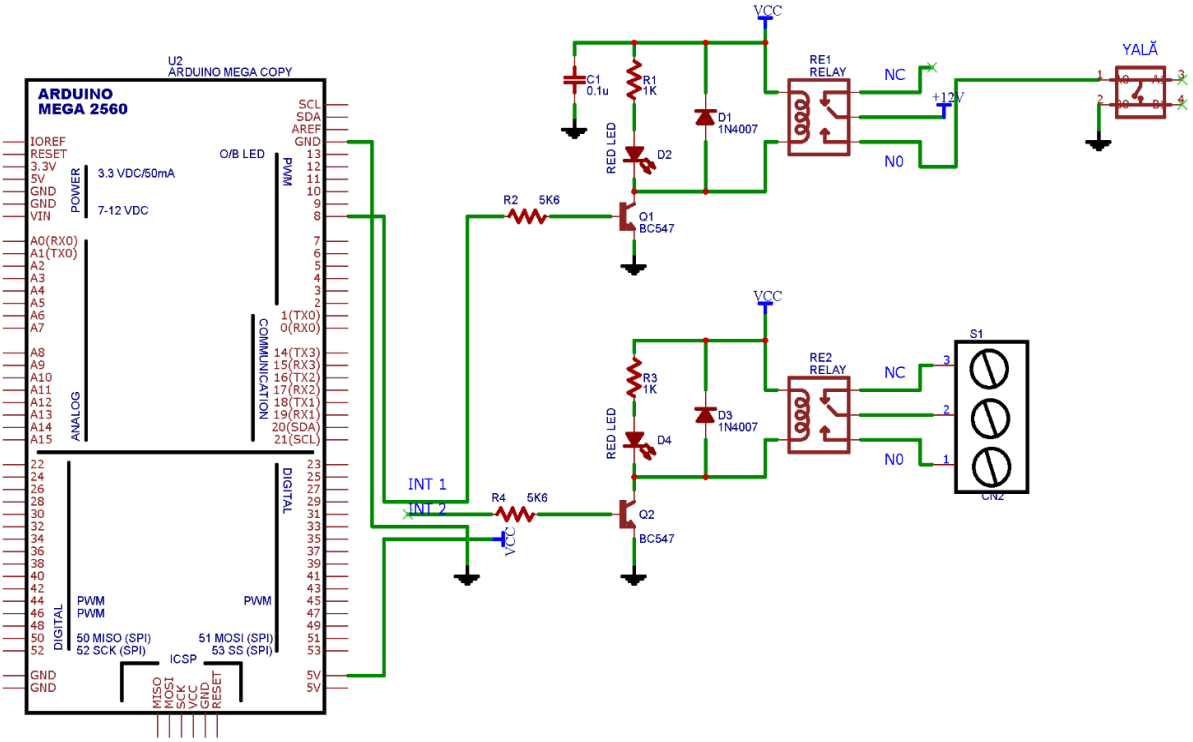

Fig.7. Connecting the yale module to the Arduino board

The Yala would have connected to the Arduino board with the relay, the Yale plus would have connected to the K1 connector on the relay, the Yala minus would have connected to the minus of the power supply, and the surplus would also have connected to the K1 connector.

The Arduino relay will communicate in reverse logic mode, if we give a LOW to the relay it will open the yala, and if we give it a HIGH it will not open the yala.

The pins connected from the relay to the Arduino are as follows, the INT 1 pin from the relay is connected to the digital pin 8 of the Arduino board, the relay module will be powered from 5V from the Arduino board.

To obtain the 5V voltage from the actual 12V power supply of this assembly, I needed to use an LM2596 low voltage converter. It is used to power the Arduino AT Mega 2560 board at a voltage of 5V, connecting it as shown in *figure 8*.

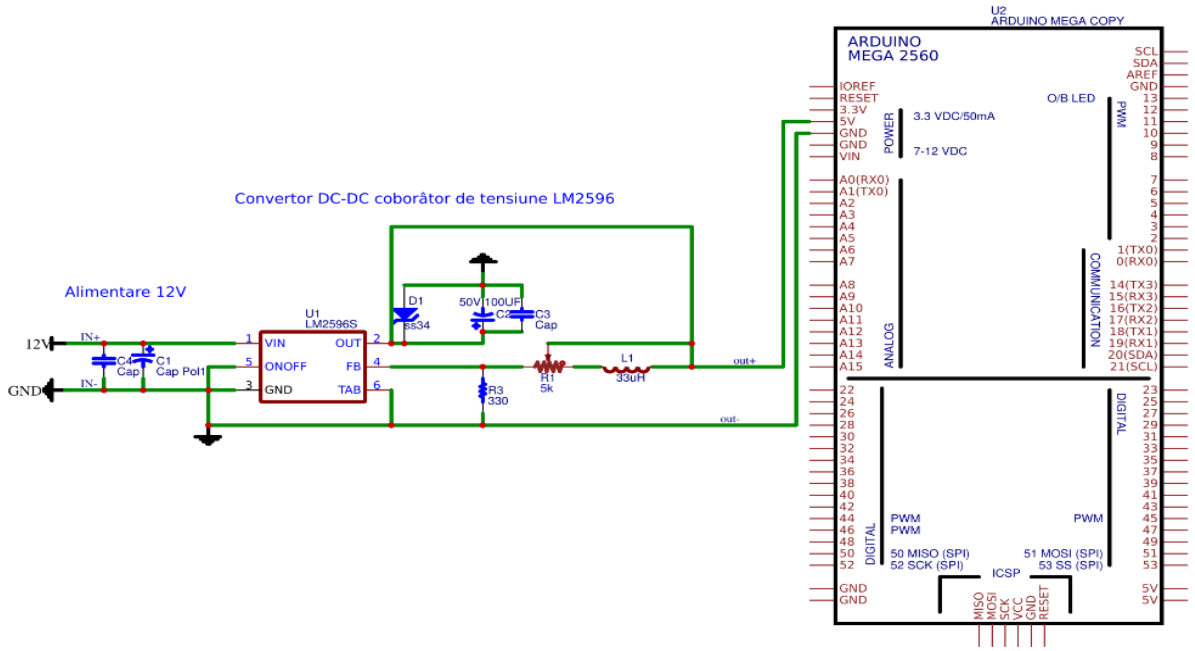

Fig. 8. Connecting the Voltage Converter to the Arduino Board

4. CONCLUSIONS

- Following the layout of this system, the web interface and the code, the camera-based fingerprint access system and the web interface work to the desired standards.
- After executing the code, the web interface displays the settings required by creating this job, and the camera-based fingerprint access system meets the desired requirements.

- The model can be implemented on a normal scale so that it can be used on a normal large scale for an entrance door, involving changing the power supply module with an appropriate module.
- It is possible to change the code to store more pictures on the card when people who tried to enter the room were not recognized.
- You can implement email notification or create an application that can be used remotely to view pictures taken by the camera.
- During this project I also encountered the problem of screen communication with the ESP32 module for displaying the picture on the screen, as a solution to the problem I went to create the web interface, the screen later mounting on the Arduino AT Mega2560 development board.

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DIGITALISED DELIVERY OF LANGUAGE. AN APPROACH TOWARDS MACHINE TRANSLATION TECHNOLOGY

Ioan Beniamin **POP**
Technical University of Cluj-Napoca, Faculty of Letters,
North University Centre of Baia Mare, România
pbeniamin@yahoo.com

Keywords: machine translation, automated translation, built-in linguistic rules, statistics-based, rule-based

Abstract: *Unquestionably, in today's language professionals, the use of information and communication technology (ICT) is already taken for granted and electronic handling as well as digitalized delivery of language services are standard client facilities. The present paper, while taking into the discussion the progressive stages of machine-assisted human translation (MAHT) and human-assisted machine translation (HAMT), analyses the present-day realities of Machine Translation.*

1. INTRODUCTION

For a considerable amount of time, humans have been struggling to accurately translate a statement from one language into another. It may appear forthright at the outset since translation is the process of converting or transposing a text from a source-language into a target-language one. The process, however, is not as straightforward as it seems as it gives rise to a complex situation. In fact, several questions may appear at this initial stage. Some of them can be asked along the lines articulated by Poibeau (2017:13): 'What does it mean to "transpose a text"? How do we go from a source language to a target language? How does one find equivalent expressions between two languages? Should the translation be based on words, chunks of words, or even sentences? And, more fundamentally, how can one determine what the meaning of a text or an expression is? Does everybody have the same understanding of a text? If not, how can this issue be handled in the translation process?' [1].

2. ELECTRONIC TRANSLATION TOOLS

One of the most difficult subtasks is to choose the optimal translation from among numerous viable alternatives for each source word. Bilingual lexicons have been progressively replaced by modern electronic translation tools. However, the term ‘electronic translation tools’ does not always mean ‘machine translation’ (MT). There are many different types of translation tools, and MT systems are only one of them. Indeed, it is debatable whether MT systems produce translation at all since they ignore the communicative, cultural, and encyclopaedic components of translation. As Hutchins (1995:431) notes, ‘although the ideal goal of MT systems may be to produce high-quality translation, in practice the output is usually revised (post-edited)’ [2].

The widespread usage of current communication technology has triggered numerous changes in today’s communication processes. In the recent years, it has become increasingly evident that there exists tremendous expansion in information technology, which has brought with it benefits such as swiftness, simplicity of use, and, perhaps most of all, the almost astonishing cost-effectiveness when considering the advantages. Telecommunications, networking, and computer businesses have all worked together to convert industrial civilization into the Information Society we know at present. Simultaneously, as the global market develops, industry and commerce operate on a larger scale than ever before. This phenomenon in itself entails greater autonomy and flexibility in terms of product and service exchange. There is absolutely no soul nowadays who can imagine daily life without a form of a personal computer, since it has grown into a versatile communication and information-processing device that is utilised in all activities. The computer is turning into a universal standard for communication and collaboration. With its ubiquitous availability to knowledge and fast connection amongst users, people all over the world have been given physical and geographical flexibility that was before unthinkable, all due to the internet and the freedom it has generated for translators.

Nevertheless, computer technologies are no substitute for human translation. There is no computer-assisted process that can turn a bad translation into a good one. It has become evident over the years that the end product is far from a flawless translation, but the merit still remains: computer technologies are perfectly capable of producing translations, be they as imperfect as they are. When utilized correctly, however, the right tools may assist competent translators in improving the productivity of their work as well as, at the same time, making it more accurate. Undeniably, the key criterion in terms of evaluating electronic translation technologies is quality. This is still achievable when considering literary translations since they pose exceedingly significant challenges for MT to accurately identify the subtleties and intricacies or poetry, for instance. However, when it comes to commercial brochures, technical

manuals, scientific texts exhibiting rather technical and specialized language, the computational analysis are well within the reach of MT systems.

The obvious reality of our society is that the usage of information and communication technologies in the lives of today's language professionals is a fact. It is no longer an issue of whether translators should employ computers and networks. Exposure to the correct techniques in utilizing electronic tools will result in bottom-up automation of the translator's workplace, allowing translators to considerably improve the quality and efficiency of their professional services. Language services are now handled electronically and delivered digitally as ordinary client services.

Computer concordances are other electronic tools which can be employed to handle texts for translation. They are especially practical when translating texts containing specialized materials, exhibiting vocabulary specific to technical contexts, for instance. Concordances therefore entail algorithms creating word-processing programs that generate all the specific occurrences within a certain corpus having as main purpose the identification of patterns which would be illegible to the human eye. They would thus give the translator more control over the text, regardless of it being short, long or complex, and, thus, providing terminological consistency.

Instant access to relevant and trustworthy online and offline material has emerged as a critical issue in the retrieval of encyclopaedic and linguistic knowledge required for the activities at hand. The increasing need for high-quality translations of technical materials cannot be addressed without the use of computer-based technologies. There are various advantages to using electronic resources. The print culture has been gradually replaced by a new one, a screen culture which retrieves documents and information straightforwardly. All the data are promptly accessible and are well within reach. Due to the rapid production of domain knowledge in some creative subjects, most of the material of specialised tools which appear in paper form, such as dictionaries for instance, may have become obsolete even before the volumes find their place on the shelves or desks. Electronic dictionaries, on the other hand, - available in a variety of formats, including computer software, CD-ROMs, or through the Interned- may be published instantly online or offline, and they can be readily updated through the Internet. That is why many specialized encyclopaedias and scientific publications, which have long been useful resources for translators, are no longer printed and are only available online. Czulo and Hansen-Schirra (2017:3) note that ‘translation scholars use corpora and strive for empirical models of the translation process (including translation strategies or specific properties of translated text). For professional translators, multilingual corpora serve as reference works that enable quick interactive access and information processing’ [3].

The range of electronic translation tools includes a wide range of cutting-edge computer programmes. Spellcheckers as well as machine translation systems, word processing software, and terminological databases, electronic encyclopaedias or online dictionaries, HTML editors and software localization tools, they are all included. The range of computer translation

technologies available may be as perplexing as it is impressive. Machine translation is the application of computer and language sciences to the construction of systems that meet practical demands, rather than a field of abstract intellectual investigation.

Human translation is often avoided because it is seen to be too costly. One of the possible reasons for it being rather expensive is in part due to the fact that a person's output is essentially restricted. The present reality has shifted rather dramatically, and the once-familiar antiquated notion of a solitary translator holding just a pen in his hand or aided by an old typewriter, while, at the same time, walled in by already outdated books, is no longer realistic. The need for translations is now unmet for several reasons, one of the possible explanations relying on a lack of human translators, or, if we consider the beneficiaries of the translated output, there are times when they do not view translation as a difficult action requiring a great degree of ability, and hence are unwilling to meet the financial demands on the part of the human translators. To that extent, nonetheless, the concept of an autonomously operating, always free translation machine is similarly impractical and will not become a reality for a long time, if ever. The field of translations where people and computers collaborate to improve the overall quality of professional translation is of particular interest. As Somers (2003:31) notes, 'the idea is that the translator can consult a database of previous translations, usually on a sentence-by-sentence basis, looking for anything similar enough to the current sentence to be translated, and can then use the retrieved example as a model' [4].

Depending on whether humans or machines do most of the translation, we refer to machine-assisted human translation (MAHT - translation assisted by text-processing software, terminology databases, or electronic dictionaries) or human-assisted machine translation (HAMT) (HAMT- translation memories, which come empty and initially have to be filled with translations from human translators, or MT systems that require extensive human pre- and post-editing). Both MAHT and HAMT are frequently used interchangeably and are generally coined computer-assisted translation (CAT) as they employ a plethora of tools to aid the translator perform his job swiftly and accurately.

3. MACHINE TRANSLATION

MT research has experienced some ups and downs throughout time. However, in the recent years it is undergone significant divergence of topics of interest. Machine translation (MT) fascinates people the most, the interest being highest particularly among non-translators. MT strives to compile all of the data required for translation into a single programme, allowing the translation of any text without the need for interaction from any human being. The public's opinion of MT oscillates between two extremes. Some believe that MT is completely worthless and a waste of time and money since the quality of output from an MT is often quite low, rendering it useless in practise.

A second view sees MT as a technique that will break down all language barriers, jeopardising translators' livelihoods. It makes use of the computer's calculation power to assess the structure of a text in the source language, divide it into pieces which are easy to translate, and then generate a text in the target language with the same structure. It has been posited that in only a few years, computer translations will be as excellent as human translations.

Reality, as is so frequently the case, lies somewhere in the middle, and the fact is that both ideas are incorrect. The entirely negative opinion shows an underestimation of MT's capabilities, whereas the entirely positive evaluation understates MT's limitations. The assertion that MT is ineffective in practise is definitely far from reality. The fact that multiple MT systems are used on a daily basis across the world refutes such arguments. The latest advancements highlight the fact that MT research and MT systems employ a large array of approaches to address the whole spectrum of linguistic phenomena. They include misspellings, grammatically unacceptable utterances, intricacy of constructions and terminology, to mention only a few. Other professional uses of MT comprise quality-improvement tactics such as pre- and post-editing, as well as dictionary update, which need a translator's human competence. In this regard, MT opens up new opportunities for translators as it makes use of the computer's calculation power to assess the structure of a statement or phrase in the source language, break it down into easily translatable pieces, and then generate a statement with the same structure in the destination language.

The terms 'fully automatic high-quality translation' (FAHQT), 'fully automatic machine translation' (FAMT), 'human-assisted machine translation' (HAMT),'machine-assisted human translation' (MAHT), and traditional ‘human translation’ (HT) describe the degree of automation or human involvement in the translation process.

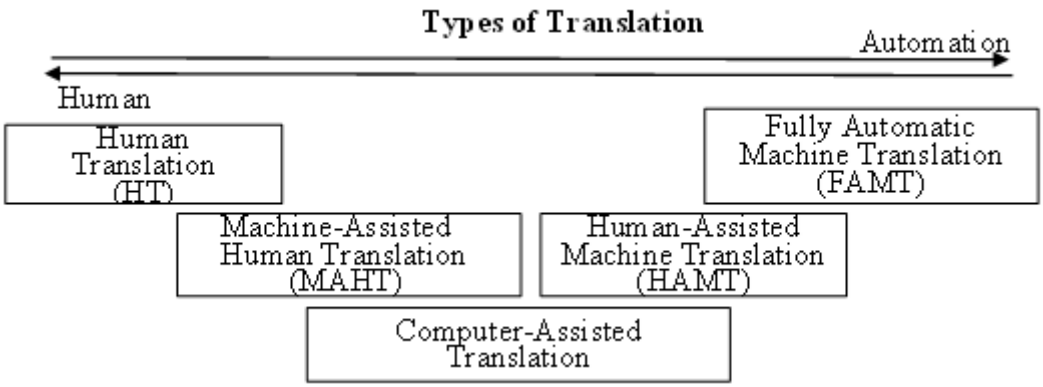

Fig. 1. Types of Translation. Human and Machine Translation

The radical notion of ‘fully automatic high-quality translation’ (FAHQT) was popular during the early stages of MT research, and it was predicated on the belief that MT systems could produce translations of human-like quality, but it was quickly abandoned. To accomplish high-quality human-assisted machine translation (HAMT), nearly all MT systems now in use rely on the aid of human operators. In this situation, the technology decodes and analyses the

source text rather than the human operator, whose job is to help in the translation process. Human participation can occur before, during, or after the translation process. If teachers, scholars, scientists - who want to have their papers published in another language-, translators or other professionals are interested in the linguistic accuracy and the correct rendering of their publications, then they have to be aware that a significant amount of time should be allotted to the thorough and meticulous process of text preparation. Moreover, this undertaking in itself can rarely be completed in just one sitting and it generally entails several stages:

- Pre-editing, comprising the concept of getting the source text/input ready;
- Interactive mode, namely the interaction between the system and the human operator;
- Post-editing, i.e., correction and modification of the target text or output.

As seen above, it becomes obvious that the translations created by MT systems are neither intended for on-the-spot use nor are they proficient at generating instantaneously operational texts. If none of these options are practicable, the translation process will produce 'raw' (unrevised) translation output from systems with no limited or regulated input. 'Fully automated machine translation' (FAMT) is another term for this use of MT systems.

The employment of assistance such as electronic dictionaries or translation memory systems is referred to as ‘machine-assisted human translation’ (MAHT). Unlike HAMT and FAMT, the translator is responsible for decoding and analysing the original material due to the fact that languages are extremely dependent on context and the many words and word combinations which can be encountered in the text give rise to numerous denotations and connotations. Both HAMT and MAHT are frequently referred to as ‘computer-aided translation’ or ‘computer-assisted translation’ (CAT), as the computer provides a novel method to both source and target text processing. It is rather complex and it is supported by means of specific tools and technology which can be tailored to the translator’s needs.

The general organisation or abstract arrangement of an MT system's many processing units is known as the architecture. In time, there have been numerous approaches to MT, the most significant methods being essentially two: Statistics-based Machine Translation (SMT) and Rule-based Machine Translation (RBMT). The majority of RBMT systems in use today are based on one of three architectures: direct, transfer, or interlingua translation (cf. Hutchins 1995, Stein 2013, Poibeau 2017, Berndtsson 2015, etc.) [2] [5] [1] [6].

Chronologically, direct architecture is the initial method employed in most first-generation MT systems. 'Direct' in this instance denotes that there are no intermediary steps in the translation process, therefore the words of the source text are more or less instantly substituted by their target language counterparts. In other words, as Stein (2013:8) notes, the direct translation merely replaces ‘words on a word-by-word basis and only rely on parallel dictionary – so they neither do analysis nor transfer or generation’ [5]. This is accomplished using morphological data, bilingual dictionaries, and target language reordering rules, all of which are centred on basic parsing techniques.

The system does not perform a comprehensive analysis of the source language sentence since no complicated linguistic theories or parsing procedures are employed. The source sentence's analysis is reduced to the bare minimum necessary for accessing a bilingual dictionary, such as identifying parts of speech, plurality or singularity, tenses, therefore involving only a minimum of linguistic theory. This method is based on a dual relationship source language- target language which has been predefined. According to this approach, each word in the source language is unidirectionally connected to a similar unit in the target language.

The direct method is gradually becoming outdated. The trend in MT research is to construct transfer systems, which is why MT was centred on direct architecture until the mid-90s. A new generation of translation software has arisen that has all the features of a full-scale transfer system. However, as Stein (2013:8) mentions, 'regarding the complexity of these rules there are no limits and tens of thousands of rules, combinations and exceptions may be coded. But in practice there seems to exist a point where higher complexity does not indicate better results anymore. Instead, internal conflicts and contradicting rules produce arbitrary new errors' [5]. The transfer approach, in contrast to the direct architecture, centres on the theoretical concept of 'level of representation'. It makes use of three stages: analysis, transfer, and synthesis or generation.

The first stage, namely the assessment one, employs a source language dictionary while linguistically evaluating the source material. The source language sentence is morphologically analysed, utilising the source language vocabulary and grammatical rules. The end outcome is portrayed as an internal structure that is abstract. The abstract source structure is then lexically and structurally converted into an abstract target language structure in the next stage, namely the transfer stage. It is the place where all the conclusions and results identified in the analysis stage are transformed and the linguistic and structural counterparts between the two languages are determined. This intermediate stage is the only one encompassing bilingual rules. Using a target language dictionary and grammar, the abstract target language structure is converted into a target language surface structure during generation. This constitutes the last stage in the transfer strategy. The generation step uses a target language dictionary to create a document in the target language based on the linguistic data of the source language.

Nevertheless, individual grammatical or syntactic rules are not the only ones employed in transfer systems which extensively employ comprehensive linguistic conceptions and theories. As a result, they outperform direct MT systems in terms of translation quality. The analysis and generation components can be utilised for other language pairings if they are rigorously separated and do not involve bilingual rules, and if the representation is abstract enough. Multilingual transfer systems may be designed thanks to the separation of the various modules.

Interlingua architecture, unlike the transfer technique, has only two steps, since the transfer stage is skipped. The source text is analysed and transformed into an interlingual or

language-independent representation, from which the destination text is created directly. This technique has the benefit of being able to use the interlingual representation for any language, eliminating the requirement for language-specific transfer modules. In itself, the Interlingua 'universal language' is somewhat based on the idea of a neutral language which could render all meaningful information in every language.

Nonetheless, since it is difficult to create entirely language-independent representations devoid of aspects that are reliant on the source or destination language, the transfer approach is frequently preferred over the interlingua method. Another reason is that the analysis and generation grammars are intricate as the presentations are so dissimilar to the characteristics of the source and target languages.

While dealing with translation memories (TM) in machine translation (MT), Berndtsson (2015:10) [6] analyses the workflow of a convertus syllabus translator (CST) as in *figure 2* below:

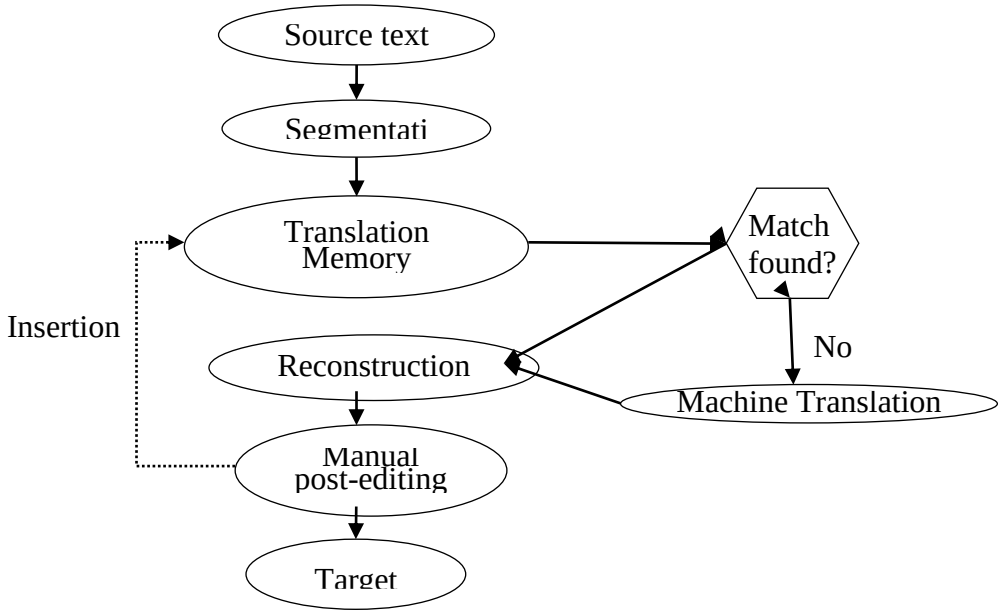

Fig. 2. Translator's work flow (adapted from Berndtsson 2015: 11) [6]

As seen in the figure above, the source text undergoes the process of segmentation, namely the text is investigated and then segmented into units corresponding to sentences, list items, etc. Within the process of segmentation, each segment is ascribed to the TM in order to look for a compatible match. When and if this process is achieved and a compatible translated segment exists in the TM, it is retrieved and sent 'directly to the reconstruction step, where all the translated segments are combined to form the full target text. If no TM match is found, the segment is translated by the MT system, and the target segment is automatically post-edited and sent to the reconstruction step' (Berndtsson 2015:20) [6]. These steps are then repeated for each and every segment, since the translation in itself has not reached the final stage and the target text has to undergo a technical human process carried out by human translators, namely

the manual post-editing of the text. As Berndtsson (2015:10) further notes, 'after all corrections have been made and the translated text has been approved, all the source and target segment pairs are inserted into the TM, and the finished translated text is delivered to the user' [6].

On the other hand, Statistics-based Machine Translation (SMT) functions on different coordinates than RBMT, making use of substantial parallel corpora rather than employing the use of complex rule sets specific to RBMT. SMT implies considering all possible and impossible sentences in the target text as potential translations for the source text. For instance, in order to translate a statement from French, called 'f' for convenience' sake, into an English statement, dubbed 'e', all feasible and unfeasible English sentences 'e' may be perceived as prospective renderings of 'f'. Not all combinations would render the output as acceptable, nevertheless, the principle at core being that certain translations are more likely to be accepted as the end product than others. When analysing this possibility, it can be reduced to p(e|f), which can be rendered as the probability that 'e' is the proper translation of 'f'. On investigating the way in which SMT operates, Poibeau (2017:76) [1] as well as Stein (2013:9) [5] point out the fact that 'the concrete probabilities used by the computer are estimated with Bayes' Theorem:

$$Pr(e/f) = \frac{Pr(e)Pr(f|e)}{Pr(f)} \tag{1}$$

Therefore, the purpose of SMT can be described as focusing on the pattern of identifying the original sentence 'e' which is perhaps the most likely and probable translation. There is one flaw, however, in the previous statement, namely the inability of retrieving all sentences of a target language and an immediate solution had to be identified. The answer at hand was for the SMT to no longer try to access all sentences but instead to operate employing approximations or translation models. This process entails the concept of regarding every word as a possible translation of all the other words, but the actual probability of achieving the envisaged result lies with the words they are aligned to in the predefined bilingual corpus.

Bayes' Theorem as applied in 1) above can be further re-examined and, as Stein (2013:9) notes, the 'sentence can be reduced to the search of the maximum value of the terms Pr(e) ("Probability that e has been said by someone") and Pr(f|e) ("Probability that someone would translate e to f")' [5].

$$\hat{e} = argmax_e\,[Pr(e) * Pr(f|e)] \tag{2}$$

The language model comprises a supplementary corpus, a monolingual one in this instance, which purportedly encompasses the entirety not only of words but also word collocations and associations capable of producing grammatically and semantically acceptable sentences. The 'highest product of the values sentence validity (language model), word

translation and word order (translation model)' (cf. Poibeau 2017:77) [1] are therefore established by the search algorithm which identifies the sentence as the SMT output.

4. TECHNIQUES FOR IMPROVING THE OUTPUT QUALITY OF MT

As Kremer et al. (2017:147) suggest, 'machine-supported human translation is an open field with ample potential for creative strategies to combine the complementary strengths of man and machine' [7]. To evaluate the effectiveness of MT systems, we must first admit that today's technology cannot attain the ultimate fully-automated high quality translation (FAHQT). Nonetheless, the user is given options for increasing the MT output quality wise. Pre-editing (including controlled language), updating the system's dictionaries, post-editing, and human-machine interaction are all ways for improving quality (interactive mode). These measures are not mutually exclusive and can be used in conjunction with one another. Pre-editing refers to the input text, whereas post-editing pertains to the output texts, respectively, whereas the additional methods have an impact on the program's operation.

The dictionary component of an MT system can be customised to meet the demands of the user. In turn, it entails making changes to current entries or adding phraseological terms to the user's domain. These newly introduced phrases can be presented with morphological, semantic, and phraseological information if the dictionary's entry structure is sufficiently complex. Linguistic knowledge may be included into the algorithm, potentially improving translation quality. As Habash et al. (2011:133) note, 'the most important resource in the SMT approach is the corpus of paired source and target texts or parallel corpus. An initial step before a parallel text can be used involves cleaning it and pre-processing it to a representation that allow us to learn from it optimally' [8]. When analysing an MT system, one should always consider the complexity of the dictionary component. However, it is important to remember that the complexity of the entry structure is proportional to the expectations placed on the user: the more complicated the structure, the higher the demands.

The extent of how MT-friendly the input is dictates the quality of the output of MT. Thus, pre-editing entails identifying possible problems and therefore arranging a source text or an input to avoid issues from the start. As a result, the MT system may be affected and sometimes incapacitated by word omissions, i.e. ellipsis, idiomatic expressions, as well as structures which are syntactically rendered as too complex. The main idea, therefore, is to highlight and, whenever possible, eliminate or change beforehand any string of text which could pose difficulties to an MT system. Another factor to consider while pre-editing is the usage of simple and direct language to avoid semantic ambiguity. The combined process is supposed to produce better results in terms of both readability and translatability of the source text (ST). If there are, however, contexts where translatability and readability are not congruent with each

other and do not entail synonymous relationships, ‘translatability will be given priority’ as far as MT is concerned (cf. Reuther 2003:129) [9].

According to its core definition, a Controlled Language (CL) entails a plethora of restrictions (both grammatical and lexical) whose sole purpose is to disambiguate the text when there is sufficient vacillation as to the intended meaning in the SL. A text exhibiting high levels of complexity is deemed undesirable from a MT perspective and in direct contrast to CL. Controlled language may be a source of frustration for technical writers, who believe it limits their originality. One of the principles of controlled language is that each word has only one meaning, that each word belongs to only one word class, and that complicated syntactic structures such as conditional clauses should be avoided. Predictably, source materials written in controlled languages frequently outperform those produced in uncontrolled languages when MT is used. Even if the source content was written in a controlled language and thus entailing pre-editing, the target text must be post-edited to ensure high-quality translation.

'Special languages,' which are employed in certain technological disciplines, are a more general manner of constrained input. In technical manuals, for example, instructional forms predominate. These kinds of languages share several attributes such as lexical items which are clearly specified and, at the same time, some grammatical constructions are employed to a greater extent in comparison to others. This means that, with specific syntax, semantics, and pragmatics, the MT system may be tailored to those structures.

Another stage in the overall translation process is post-editing. As the name itself implies, post-editing occurs after the translation has been carried out by the machine. It is a process which edits, changes, modifies, alters and at times even corrects the target text, or the raw output produced by the MT system. ‘This task poses specific problems as compared to purely human translations’, according to Čulo (2013:35), ‘as the post editors have to deal with output that can be erroneous on multiple levels: morphology, syntax, semantics and last but not least pragmatics. Also, the cognitive load is heightened with respect to focus: when postediting, translators have to focus on both the source text as well as the MT output’ [10]. The amount to which post-editing is performed and to which extent the target text undergoes ‘polishing’ is primarily determined by the quality demanded by the user. It can turn into a fairly delicate process entailing significant cognitive effort, being time consuming and inefficient especially when no expert assistance is employed. As Allen (2003:298) notes, ‘few benchmark tests have been conducted to estimate the productivity gain or loss of the post-editing process in comparison with the human translation process’ [11]. Pre- and post-editing activities should be delegated to professional translators who are not only conscious of MT limitations, but they are also aware of the cross-language transfer of concepts while mastering the technical resources necessary when context dictates.

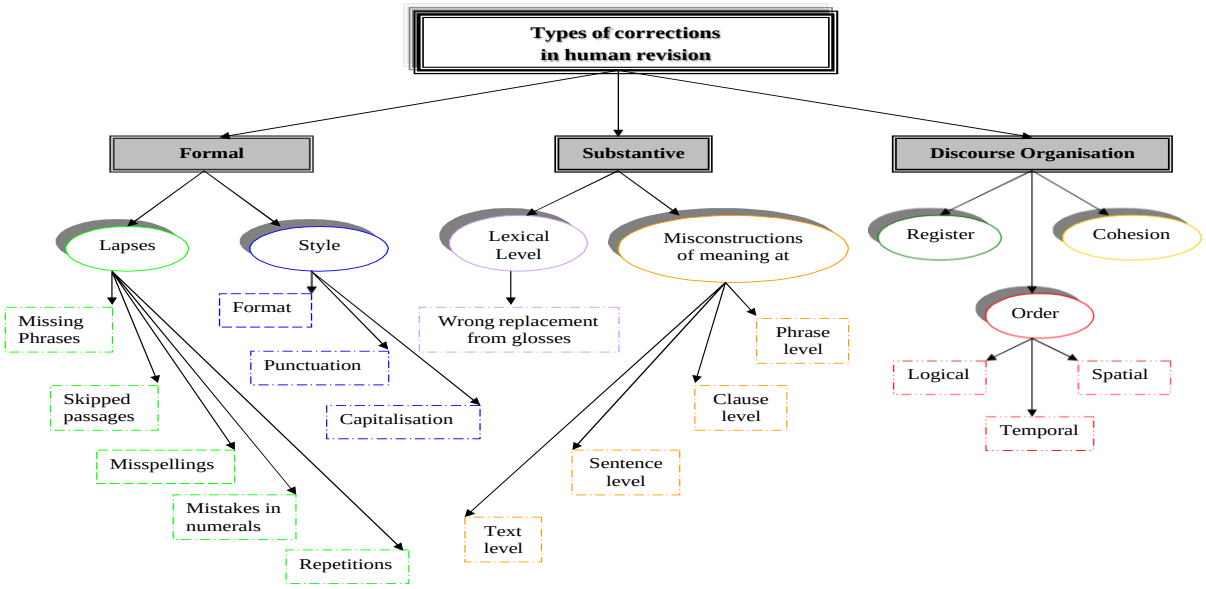

Fig. 3. Types of corrections in human revision (adapted from Martinez (2003:26)) [12]

5. ADDRESSING THE MOST COMMON ISSUES IN MT

Word order may at times pose problems in terms of Machine Translation. Syntactically, the order of elements within the sentence can be problematic especially when the object or subject of the sentence does not assume the standardised position and thus generates several readability challenges. Passive voice might also sparingly raise numerous issues when considering general stylistic recommendations, therefore the universal norm would be to keep to standard, formal English in which grammatical relationships are conveyed clearly. Employing passive constructions may contribute to a style of writing promoting ambiguity and vagueness. Active voice, on the other hand, eliminates confusion. If ambiguity is not removed, the machine translation engine will struggle especially when there is duality of meaning within the sentence.

Individual words are subject to lexical ambiguity, which happens when a single word can have more than one meaning. Polysemy and homography are key concepts in this setting. As they belong to separate grammatical groups, homographs are frequently mistranslated. This is not an issue for the MT system in brief syntactic contexts, but it can become one if the context is complicated or incomplete. Specific approaches such as spell-checkers are not always the solution since the words are not misspelled as such, but rather miswritten in the given context. Other contexts where they would be perfectly acceptable can be easily constructed. However, as Somers (2003:96) notes, 'for a spell-checker to correct this type of error would require sophisticated computational linguistics software that would analyse and, in some sense, "understand" the text it was checking' [13]. The disambiguation of homographs, on the other hand, is usually easier to achieve than that of polysemes. The latter refers to two or more words

that are classified as belonging to the same grammatical category yet having diverse meanings. When the translation of a word varies depending on its meaning, polysemes become important in MT.

Unlike lexical ambiguity, structural ambiguity concerns sentence syntactic structures and representations. Confusing constructions have a detrimental impact on the clarity of the text and the output, and, when this happens, the reading and translation processes are rather complex. This problem is significant in any CL use case. Ambiguities may arise from the fact that phrases, usually prepositional ones, can be assigned more than one location in a sentence.

Another noteworthy aspect involves pronoun usage. Since they are referential, ellipsis of pronouns when preceding verbs, or, for that matter, omission of relative pronouns leads to the system generating erroneous structures, affecting not only the translatability of the text but also posing a challenge in terms of the comprehensibility of the output. This principle applies for all elliptical constructions. As Jurafsky and Martin (2021) as well as Sejnowski (2018) note, when the machine encounters such situations, the mechanisms assigned for parsing processes attempt to recreate the missing components. Whereas human analysis may solve these kinds of issues substantially successfully, machine translation achieves solutions resulting in failed parses in no insignificant situations [14], [15].

Avoid splitting separable English verbs since idioms, idiomatic phrases and colloquial constructions are difficult to manage in an MT system because their meaning cannot be fully comprehended from the individual meanings of their components. Idioms must be treated as single units of translation in MT systems, which is generally accomplished by adding them in the system's dictionaries. As Lopez (2015:25) points out, 'if the idiom is in the bilingual dictionary of the system, the machine translation will be better than the translation by a professional who, for not having understood the context, translated it literally or too freely' [16]. Idioms, fortunately, are uncommon in special language texts, which constitute the vast bulk of texts submitted to MT. However, it is safer and less time consuming to avoid using idioms entirely, which is why this is one of the key principles in the pre-editing stage.

During MT analysis, complex syntactic structures are a typical cause of error. Complexity causes issues not only for human but also for machine analysis, affecting the source text's readability and translatability. If the system is unable to fully analyse the construction and assign the appropriate grammatical categories, it must resort to the robust mode, which involves translating word-by-word and duplicating the structures of the source sentence (cf. Jurafsky and Martin 2021 [17]). The more complicated a structure, the less probable a precise match will be discovered in the translation memory of the system. The human translator, on the other hand, should encounter less challenges in the process, provided they have grasped the meaning of the text, according to Munday (2016) and Ionescu [18] [19]. Although advanced technology can handle extensive structures, sentence construction should thus be kept clear, straightforward and explicit.

6. CONCLUSION

The MT system is essentially still short of perfection and there are heated debates amongst researchers, scientists, and translators who at times are apparently rather dissatisfied with the output. Nevertheless, while they are still deliberating, an increasing number of consumers find the flaws, if not palatable, at least acceptable, and exhibit no frowning on welcoming the technology.

The construction of a functioning MT system is unavoidably a long-term 'engineering' endeavour requiring the use of well-known, dependable, and time-tested methodologies. The best concluding remark, however, can be drawn along the following lines: ‘while academics debate linguistic and statistical approaches to MT, organisations in the public and private sector are putting it to work […]. The breakthrough is market-driven rather than technical: MT is not perfect, but it has become an economic necessity. We must learn how to use it and how to optimise its benefits in practical environments’ (Van der Meer 2003) [20].

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MOVEMENT IN VIRTUAL REALITY

Paul **TĂMAȘ**, Andreea **POP**
Technical University of Cluj-Napoca, Department of Electrical, Electronic and Computer Engineering,
paultamas32@gmail.com, andreeapop05@yahoo.com

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Abstract*: In this paper we talk about the user's movement in virtual reality. The programmable part of the application is made in the C ++ programming language, and as the engine for running the graphic image we used Unreal Engine developed by Epic Games. Fragments of code appear in the paper for the calculation and positioning of the user in space, on a two-dimensional plane. The work also contains instructions to be able to make the settings so that the application can be controlled by the glasses levers. The whole project is developed for HTC VIVE PRO virtual reality smart glasses.*

1. INTRODUCTION

The technology that facilitates the operation of complex systems, consuming information and turning it into knowledge (that most valuable of human resources), is the realm of virtual reality. This special issue of IEEE Computer Graphics and Applications brings together articles describing virtual reality technology and applications being pursued worldwide. We felt the time was right for a peer-reviewed special issue because the field has produced an enormous amount of hype. This can damage credibility and obscure the real industry achievements and the extraordinarily important work being done.

Although the terms cyberspace and virtual reality have been around for years, virtual reality as an industry is in its infancy. (Evans and Sutherland demonstrated the first head-mounted stereo display in 1965). The term “virtual reality” is credited to Jaron Lanier, founder of VPL Research: earlier experimenters, like Myron Krueger in the mid-l970s, used phrases like *‘artificial reality.” William Gibson coined “cyberspace” in his 1984 science fiction

novel, Neuromancer. Few technologies in recent years have evoked such fiery discussions in the technical community, and fewer still have sparked such passionate involvement of the humanities and the cultural sector. Maybe the humanities community reacts because the VR interaction is so tightly coupled to the human senses. Perhaps the cultural sector clamors for a role in the evolution of VR because the technology is finally interfacing with the human, rather than the human interfacing with the technology. Whatever the reasons, VR is more a convergence of previously disparate disciplines than a whole new branch of technology. It simply takes a fresh look at human interaction. Evolving from user interface design, flight and visual simulation, and telepresence technologies, VR is unique in its emphasis on the experience of the human participant. VR focuses the user's attention on the experience while suspending disbelief about the method of creating it. We feel that neither the devices used nor the level of interactiveness or fidelity determine whether a system is "VR." The quality of the experience is crucial. To stimulate creativity and productivity, the virtual experience must be credible. The "reality" must both react to the human participants in physically and perceptually appropriate ways, and conform to their personal cognitive representations of the microworld in which they are engrossed. The experience does not necessarily have to be realistic-just consistent. Articles by Stephen Ellis and by John Latta and David Oberg consider the frequently forgotten human side of VR systems.

Virtual reality today bears a striking resemblance to the early stages of computer graphics in the mid-1960s to the early 1970s. The products seem to be "a solution in search of a problem." As with early computer graphics products, the entry-level costs are relatively prohibitive. A complete VR environment, including workstations, goggles, body suits, and software, is in the range of $50,000 to $100.000. In an attempt to suggest low-cost methods, a new magazine called PCVR: Virtual Reality and the IBM Personal Compiiter (Gradecki Publishing, Laramie, Wyoming) publishes articles such as how to build a head-mounted display for under $500. The serious limitations of the technology give rise to a number of apologists. At one VR meeting in 1992, the general attitude was, "Although the pictures aren't very good, we really don't need great pictures to achieve our objectives. They don't have to be in real time, and they don't need to be terribly realistic.'' We see a strong analog to the early days of computer graphics, when all that was affordable was a fairly static, monochrome, storage tube display. The early rationalization was that we didn't need color or dynamics. Time has shown that once the technology became affordable, color and realism were much preferred. We believe the VR community will reach the same conclusion as the technology progresses. Much research into the various elements of VR technology remains to be done, for example, control and navigation metaphors for HMD point-of-view applications. We need to find a comfortable way for a user to move a POV while attempting to interact with objects and simultaneously control and gather information. Mark Bolas' article discusses these issues. To accommodate both "immersive/inclusive" experiences and multiple serial users, Bolas suggests the headcoupled boom-supported stereoscopic display.

Many application areas require this type of capability to integrate a VR system into the work environment. As the price comes down, these systems will surely see success in many fields.

2. CREATING MOTION CONTROLS

In order to be able to create the movement of the character through the camera, it is first necessary to take over the characteristics of the camera and to make the connection between the C ++ code and the Blueprint in which the character was created.

The camera features are taken over by the following UCameraComponent command (this command takes over the camera components), because it does not need to be visible in the entire application source, it will be private. The syntax for declaring this feature of the application is as follows:

private:
UPROPERTY(VisibleAnywhere) Classic
UCameraComponent The room;*

That *Camera creates a reference of the application components. The reference will be used in the program file, where the data processing will be done, so that the motion effect can be created. "UPROPERTY(VisibleAnywhere) "is the method by which the component is assigned the visibility property throughout the program file, after inclusion. This property is only required for the latest Unreal Engine versions (Unreal Engine versions 4.15 and later). It must be put before each function that we implement in the header.

In the program file, we must first set the attachment, and the parent class will take the basic components by yourself.

In order to make it possible to move the character in the application workspace, we need to think of that plan as a two-dimensional (2D) axis system (*figure 1*). Suppose we want to make a forwardbackward motion, this involves moving on one of the axes of the plane, preferably the "Y" axis is chosen. In order to be able to perform movement, in C ++, we need a function derived from the parent class, which takes data from the forwarding vector (forwardVector) and transmits them to the class defined in the header. For the forward-backward movement we can do it by incrementing or decrementing by one or more pixels depending on the speed with which we want to move. Increment or decrement can only be done with an integer, i.e. it cannot be done in half pixels.

„For right-to-left or reverse movement, the procedure is quite similar. It involves the movement on one of the axes of the plane, different from the axis we chose for the front – rear motion, preferably choose the "X" axis. In order to be able to perform motion, in C ++, we need a function derived from the parent class, which takes data from the targeting vector (rightVector) and transmits it to the class defined in the header. As with the previous function, you cannot increment or decrement by half a pixel.

Fig. 1. Example of movement plan

For the physical controllers part, we will use the levers included in the HTC VIVE PRO virtual reality package. Setting them and setting specific buttons for movement is done by Unreal Engine: Settings -> Project settings -> Input -> Bindings. More precisely, it can be seen how the settings in the following set of figures are made.

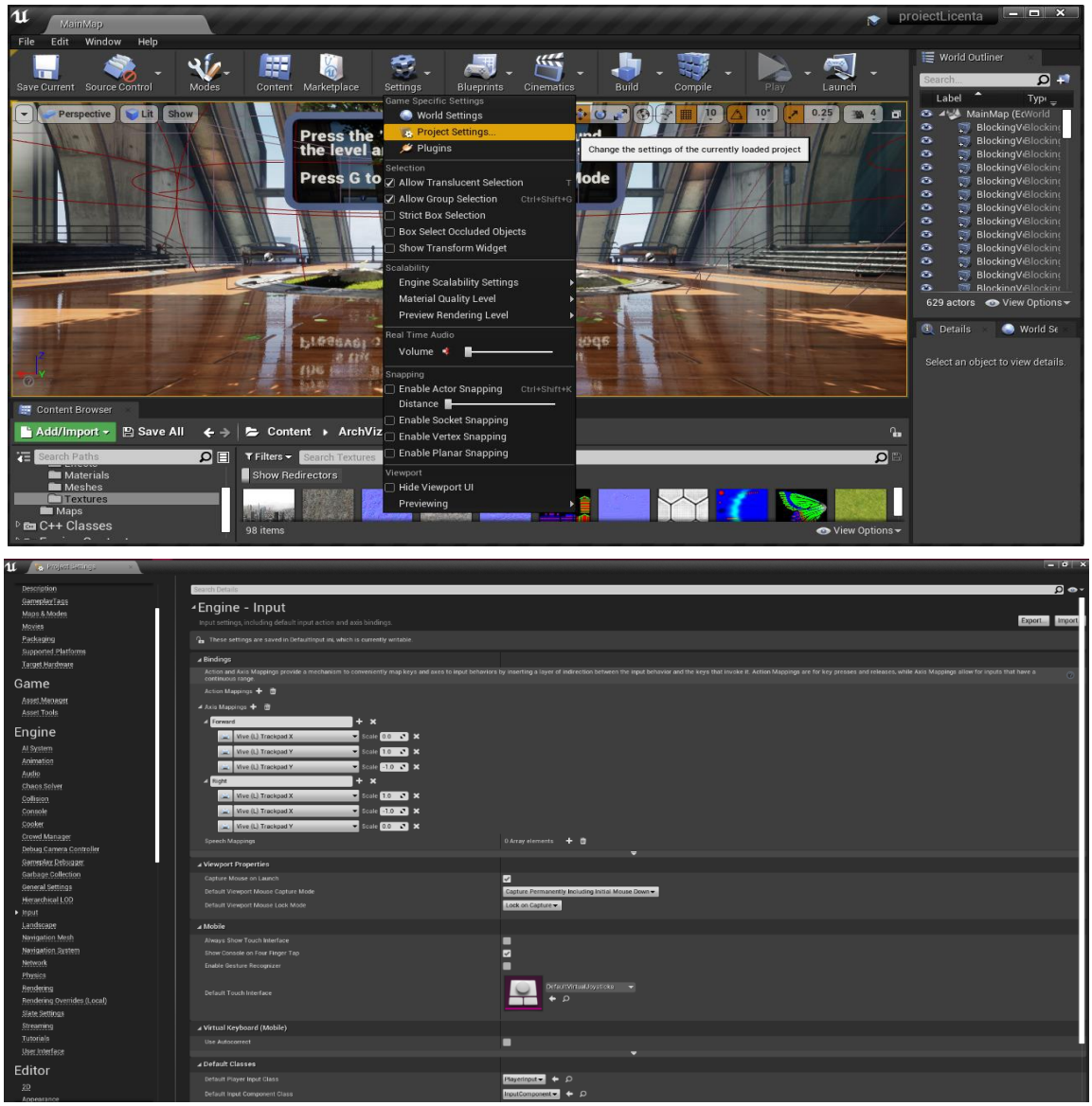

Fig. 2. Lever controller setting

To add functions (axes) we click on "+" next to "axis mappings" and a place will appear where we can enter the name of the axis, this name must be identical to the reference we gave-o in C ++ code. From *figure 2* it can be seen that we named the axes "forward" and "right". For the "forward" axis I set the "Y" axis of the trackpad on the left joystick, and for "right" I set the "X" axis of the same trackpad. Since after several tests the movement was diagonal, I noticed that for each "forward" or "right" axis, the "X" or "Y" axis, which is not used for movement, must be set to 0.

The following set of figures exemplifies some of the code in C ++ for capturing controls on levers.

```
    // Called to bind functionality to input
    virtual void SetupPlayerInputComponent(class UInputComponent* PlayerInputComponent) override;
private:
    void UpdateDestinationMarker();
    void MoveForward(float throttle);
    void MoveRight(float throttle);
private:
    UPROPERTY(VisibleAnywhere)
    class UCameraComponent* Camera;
```

Fig. 3. Header file

```
AVRCharacter::AVRCharacter()
{
    // Set this character to call Tick() every frame.  You can turn this off to improve performance if you don't need it.
    PrimaryActorTick.bCanEverTick = true;
    //Camera =CreateDefaultSubobject<UCameraComponent>(TEXT('Camera'));
    VRRoot = CreateDefaultSubobject<USceneComponent>(TEXT("VRRoot"));
    VRRoot->SetupAttachment(VRRoot);

    Camera = CreateDefaultSubobject<UCameraComponent>(TEXT("Camera"));
    Camera->SetupAttachment(GetRootComponent());

    DestinationMarker = CreateDefaultSubobject<UStaticMeshComponent>(TEXT("DestinationMarker"));
    //DestinationMarker = CreateDefaultSubobject<UStaticMeshComponent>(TEXT("DestinationMarker"));
    //DestinationMarker->SetupAttachment(GetRootComponent());
}
```

```
// Called to bind functionality to input
void AVRCharacter::SetupPlayerInputComponent(UInputComponent* PlayerInputComponent)
{
    Super::SetupPlayerInputComponent(PlayerInputComponent);
    PlayerInputComponent->BindAxis(TEXT("Forward"), this, &AVRCharacter::MoveForward);
    PlayerInputComponent->BindAxis(TEXT("Right"), this, &AVRCharacter::MoveRight);
}
void AVRCharacter::MoveForward(float throttler) {
    AddMovementInput(throttler * Camera->GetForwardVector());
}
void AVRCharacter::MoveRight(float throttler) {
    AddMovementInput(throttler * Camera->GetRightVector());

}
```

Fig. 4. Program file

3. CONCLUSION

To develop an application that serves the field of architecture, you need a team of

people who can create textures and objects, to be able to assemble them in order to come up with a useful application.

What we did in the app is the motion control part, the adjustment part collisions, introduction and modification of existing objects and the part of the user's interaction with objects in the application by inserting virtual hands using the controller.

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