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Effect of the lactic acid as a substrate on the butyric acid production by *Clostridium beijerinckii* 4A1 - preliminary data

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Abstract: In recent years, interest in butanol and butyric acid as a potential substitute for traditional fuels has grown. Microbiological production of butanol and butyric acid from carbohydrates is not economically advantageous due to several process defects. The cost reduction potential of the product is related to expanding the substrates used and optimizing the process' economics. The metabolism of the strains *Clostridia* is in two stages - acidic and solvotogenic. In the beginning, carboxylic acids are formed, and afterward, these acids induce the preparation of solvents.

The aim of this work is to study the effect of unusual substrate on butyric acid production by *Clostridium beijerinckii* 4A1. The experiments performed were based on a Reinforced *Clostridial* medium, using different concentrations of lactic acid as carbon source, at $T = 37^\circ\text{C}$, and anaerobic conditions.

Keywords: BUTYRIC ACID, LACTIC ACID, UNUSUAL SUBSTRATE, CLOSTRIDIUM BEIJERINCKII

1. Introduction

Nowadays, butyric acid (butanoic acid) is predominantly produced from petrochemical feedstocks via chemical synthesis. Butyric acid is widely used in chemical, food, and pharmaceutical industries. Its production from renewable, low-cost biomass has attracted large attention in recent years.

The butyric-acid fermenting bacteria were divided into two groups: those producing mostly butyric acid as a final product and those producing mostly butanol as a final product. The latter process—called acetone–butanol–ethanol (ABE) fermentation—was one of the oldest known industrial fermentations. [1; 2].

Traditional ABE fermentation methods employ mainly glucose as the substrate. The use of other substrates such as corn, or molasses has also been reported. However, with the rising price of these substrate materials, the feedstock cost has become a major factor determining the total economics of the ABE fermentation industry [3].

Low-price renewable feedstock and various biomass hydrolysates have been used as substrates in batch ABE fermentation [3 - 8].

Various studies have investigated and reported enhancing butyric acid production by fermentation of second and third generation substrates. An interesting substrate for butyrate and hydrogen production is a post-distillation slurry solution from alcoholic beverages. Millions of tons are discharged annually as a byproduct of alcohol manufacture. The slurry solution contains acetic acid, lactic acid, succinic acid, and other components including fiber and protein. The solution is with a very low pH [9].

Lactic acid has wide industry use, mainly like a polylactic acid (PLA), a biodegradable polymer used as environmentally friendly biodegradable plastics. Lactic acid is produced commercially either by chemical synthesis or by microbial fermentation. Approximately 90% of the total lactic acid produced worldwide is made by bacterial fermentation and the rest is produced synthetically by the hydrolysis of lactonitrile. Lactic acid fermentation is a well-studied process that makes lactic acid available as a promising substrate for the production of butyric acid and butanol.

Many anaerobic microorganisms can produce butyric acid from sugars and other carbon sources. Most studied butyric acid producers are the facultative anaerobic bacteria such as *Clostridium*, *Enterobacter*, and *Escherichia* which convert glucose to hydrogen gas, carboxylic acids, and alcohols. [2].

Two physiological stages must be taken into account for *Clostridia*: one for the acidogenic phase, and one for the solventogenic phase. Under batch conditions, the fermentation process of solvent-producing *Clostridium* strains starts with the production of biomass,

hydrogen, carbon dioxide, acetic acid, and butyric acid (acidogenesis). As the acid concentration increases (pH decreases), the cell metabolism shifts to solvent production (solvotogenesis). The acidogenic cells – able to reproduce themselves – enter the solvotogenesis state undergo a morphological change. During solvotogenesis, the active cells become endospores unable to reproduce [10].

Lactic acid is not investigated as a suitable substrate for ABE fermentation.

In this study, we investigate the production of butyric acid with lactic acid as the only carbon source.

2. Materials and Methods

A newly isolated strain identified as *Clostridium beijerinckii* 4A1, isolated from chickpea fermentation was used. Reinforced *Clostridial* Medium (RCM) as a basic medium for the strain maintenance was used. RCM contains (g / l): glucose - 15; yeast extract - 13; peptone - 10; soluble starch - 1; sodium chloride - 5; sodium acetate - 3; cysteine hydrochloride - 0,5; pH = 6,8. The medium was sterilized for 20 minutes at 121°C .

The inoculum was prepared by growing 1 ml cells' suspension in 10 ml sterile culture medium by incubation for 24 hours at 37°C and anaerobic conditions achieved with Anaerocult® A (Merck Milipore, Germany). Thus prepared inoculum was used in all subsequent experiments.

The effect of lactic acid as a substrate was assessed by adding four different concentrations (5; 10; 15; 20 g/l) to the referred starting media (RCM), keeping the constant concentrations of the other components in the media. The initial pH was adjusted to 6,8 and the medium is distributed in 300 ml Erlenmeyer flasks (200 ml in the flask) and sterilized.

The concentration of the substrate and the products (respectively lactic acid and butyric acid) was determined by HPLC. An Aminex HPX- 87H, 300x7,8 mm, column, and 0,01 N H_2SO_4 as mobile phase at a flow rate of 0,6 ml/min was used.

The biomass concentration was determined by optical density measurements at 620 nm with a spectrophotometer VWR UV-1600PC.

3. Results and Discussion

Experiments for butyric acid production by *Clostridium beijerinckii* 4A1 were carried out with standard RCM where glucose was substituted by the lactic acid.

The results of the experiments with lactic acid as the substrate compared with the results obtained with glucose substrate are presented in Fig. 1.

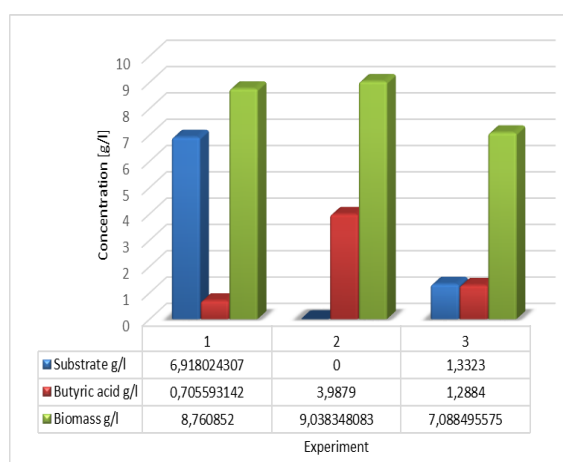


Fig. 1 Concentration of Substrate, Product and Biomass after 72 hours. 1- substrate 15 g/l glucose, 2 and 3- substrate lactic acid, 5 and 10 g/l respectively.

It can be seen (Fig. 1) that the accumulation of the target product varies depending on the type and concentration of the carbon source. The most complete consumption of the carbon source is observed in the experiments with 5 g / l lactic acid. In the experiments with a higher concentration of substrate, namely 15 g / l glucose and 10 g / l lactic acid, good microbial growth was observed, but significantly lower production of butyric acid. At a lactic acid concentration of 15 and 20 g / l, inhibition of the butyric acid production process was observed.

Fig.2 and Fig. 3 represent the growth of *Clostridium beijerinckii* 4A1 strain, the production of butyric acid, and the depletion of carbon source during fermentation with glucose (15 g/l) and lactic acid (5 g/l).

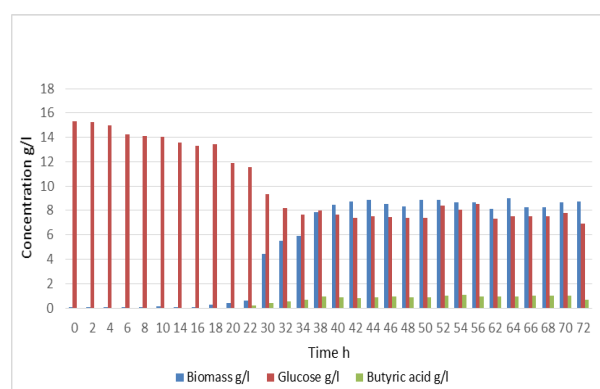


Fig. 2 Time course of biomass and butyric acid production, and glucose depletion.

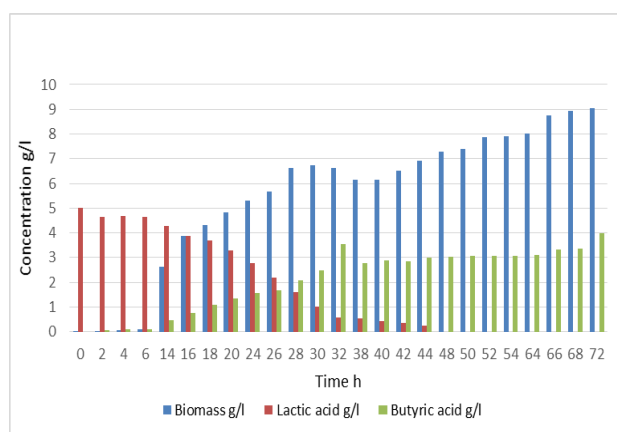


Fig. 3 Time course of biomass and butyric acid production, and lactic acid depletion.

As can be seen at both carbon sources, the biomass grows, the exponential phase starts at 25 hours at 15 g / l glucose, while at 5 g / l lactic acid as a substrate, the fermentation is significantly faster (about 14 hours). The stationary phase continues 30 and 45 hours in two processes.

4. Conclusions

The present study has shown that lactic acid can be successfully used as a carbon source for butyric acid production. A process with a low initial concentration of lactic acid as a carbon source is very promising, and a 100 % transformation of the substrate into a product is observed. The experiments with a higher concentration of the substrate, lead to slow growth of the bacterial strain *Clostridium beijerinckii* 4A1 and a significant reduction in the butyric acid production. A concentration of lactic acid as a carbon source higher than 10 g / l inhibits the growth of microorganisms and butyric acid production.

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5. References

1. D. Jones, D. Woods, *Microbiol Rev*, **50**, 484 (1986).
2. J. Zigová, E. Šturdík, D. Vandák, S. Schlosser, *Process Biochem*, **34**, 835 (1999).
3. L. Huang, Y. Xiang, J. Cai, L. Jiang, Z. Lv, Y. Zhang, Z. Xu, *Korean J. Chem. Eng.*, **28**, 2312 (2011).
4. RZAN Ada Rephaeli, *Drug Dev Res*, **50**, 379 (2000).
5. H. Grupe, G. Gottschalk, *Appl Environ Microbiol*, **58**, 3896 (1992).
6. B. Ennis, I. Maddox, *Bioproc Eng*, **4**, 27 (1989).
7. D. Vandak, M. Tomaska, J. Zigova, E. Sturdik, *World J Microbiol Biotechnol*, **11**, 363 (1995).
8. J. Masset, M. Calusinska, C. Hamilton, S. Hiligsmann, B.Joris, A. Wilmotte, P. Thonart, *Biotechnology for Biofuels*, **5**, 35 (2012).
9. X. Ye, S. Morimura, L. S. Han, T. Shigematsu, K. Kida, *Biosci. Biotechnol. Biochem.*, **68**, 551–556 (2004).
10. D. Jones, D. Woods, *Microbiol. Rev.*, **50** (4), 484–524 (1986).

Assessment of quality parameters of blueberries and cherry tomatoes treated by micro torch of cold atmospheric pressure plasma.

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Abstract: The cold atmospheric pressure operating plasma /CAPP/ offers attractive opportunities for various surface decontamination treatments of both food products and non-food materials. The technology is especially considered as promising mild but efficient surface treatment of fresh food products in order to extend their shelf life and sustain quality. Here we report evaluation of the effect of CAPP micro torch treatment of Canadian blueberries and cherry tomatoes related with the fruit quality and possible cell wall damages and changes of the total anthocyanins content of treated fruits. The problems and opportunities for further application of plasma jet generated CAPP treatment for fresh fruit decontamination are discussed. The research is funded by the Bulgarian National Science Fund under Grant DN08/8-2016.

KEYWORDS: COLD ATMOSPHERIC PRESSURE PLASMA, PLASMA JET, MICROWAVE DISCHARGE, FRESH FRUIT TREATMENT, FRUIT QUALITY

1. Introduction

The increasing consumer demand for high quality, fresh and safe food products led to the development of novel nonthermal technologies including “cold” atmospheric pressure plasma /CAPP/ technology [1, 2]. Generated at ambient temperature and atmospheric pressure CAPP offers an attractive opportunity for the decontamination of fresh food products as berries and vegetables [3-5]. The decontamination effect of CAPP is attributed to microbial death or cell injury following the oxidation and damages of membrane and vital components of microbial cells by the CAPP species including ions, radicals, photons, reactive oxygen and nitrogen species [6, 7]. The CAPP treatment could be carried out under different operation modes [3]. In previous study we reported that CAPP treatment of small fresh fruits via microwave-sustained plasma micro torch in argon at atmospheric pressure results in partial inactivation of bacteria presence on fruit surface [8]. The study shows that the CAPP treatment doesn't reduce significantly the level of antioxidant activity of the fruit, but the decontamination efficiency depends from the kind of the fruits and is most pronounced for Canadian blueberries. Furthermore, the thermal imaging of the treated fruits shows some increase of surface temperature in the fruit surface directly treated by the torch, which may affect the fruit metabolite composition and especially anthocyanins. Here we report further assessment the effect of the CAPP micro torch treatment through the evaluation of possible cell wall damages and changes of the total anthocyanins content of treated Canadian blueberries and cherry tomatoes

2. Materials and Methods

Experimental Setup

The experimental setup of plasma jet generated microwave-sustained plasma micro torch in argon at atmospheric pressure, used in the present study, is described into details in [8]. Briefly, the solid-state microwave generator operating at 2.45 GHz (Sairem, Neyron, France, GMS 200 W) was connected to a commercial electromagnetic surface wave resonator (Sairem, SURFATRON 80). Microwave (MW) power was adjusted to 9 W. The surfatron resonator was cooled by the ambient air flow of 4 L/min. Argon (purity of 99.999%) flow of 7 L/min was controlled by Omega FMA-A2408 mass flow controller. The discharge was created inside a quartz tube with 8 mm outer diameter and 3 mm inner diameter. The end of the quartz discharge tube was 2 mm outside the surfatron resonator and the plasma jet length was 9 mm. The ambient air (temperature of 25 °C at a relative humidity of 35 ± 2 %) was surrounding the plasma effluent just behind the resonator.

The system axis was installed vertically with the gas flow from top to bottom.

Plant Material and CAPP Treatment

Canadian blueberries were purchased from the market and yellow cherry tomatoes were collected from experimental field of AgroBioInstitute. Fruits with intact surface and uniform size were selected for the experiment. The fruits were divided into 3 groups (each one representing one repetition) of 5 pieces and treated by exposure of CAPP micro torch for period of 1, 2 and 4 minutes. Each group of fruits was placed in a lid of a sterile glass petri dish. All fruits were treated individually with the plasma torch as the petri dish was moved slowly in a manner that the CAPP plasma to get uniformly in contact with the upper fruit's surface.

Electrolyte Leakage

Following the CAPP treatment, the fruits were transferred to 50 glass tubes and left for 5 min at room temperature. Then, 25 mL of deionized water were added to the tube and the fruits were incubated for another 5 minutes at room temperature. Untreated fruits, processed in parallel, were used as untreated control. After the incubation, each tube was briefly shaken by hand and the electrical conductivity (EC) of the liquid was measured using HI 8733 Conductivity meter (HANNA Instruments, USA), providing electrical conductivity values of treated (EC_{tr}) and control (EC_{con}) samples. The glass tubes with the samples were further autoclaved for 20 min. at 121°C and cool down to room temperature. Then the electrical conductivity of each sample was measured again providing maximal (EC_{max}) value related to complete disruption and maximal electrolyte leakage of each sample. The obtained experimental data were further used for calculation of Index of Injury (Id) for each treated sample as described by Schön et al. 2019, [9]. Briefly, $Id = 100 \times (R_{tr} - R_{con}) / (1 - R_{con})$, where $R_{tr} = EC_{tr} / EC_{max}$ for each treated sample and $R_{con} = EC_{con} / EC_{max}$ for control sample.

Determination of Total Anthocyanins

Three hours after treatment, treated and untreated control samples were frozen in liquid nitrogen, stored at -80°C and prior analysis homogenized using the TissueLyser (QIAGEN, Hilden, Germany). One hundred milligrams (fresh weight) of the obtained powder, placed in a tube, were extracted with three hundred microliters (weight/volume ratio of 1/3) 70% aqueous methanol. The extraction was conducted on a multi vortexer (VWR) at 1000 rpm for 1 h at room temperature. After the extraction, the samples were centrifuged at 12,000 rpm for 15 min and the supernatants were further analyzed for their anthocyanins content. Total

anthocyanins were determined by the pH-differential method based on structural changes of the anthocyanins chromophore and anthocyanin pigments colour with pH, according to Lee et al. 2005, [10]. After pH of samples were adjusted to pH 1.0 and pH 4.5 they were read at 520 and 700 nm using 96- well microplate reader CLARIOstar Plus, (BMG Labtech GmbH). Results were calculated according to Lee et al. 2008 [11] and were reported in equivalents of cyanidin 3-galactoside.

3. Results and Discussion

Preserving intact the tissues of treated fruits, their color and content of health-related compounds is an essential requirement for further practical application of the decontamination treatment of fresh plant and food products. Beside the surface decontamination, CAPP treatment may cause cell wall damages in the tissues directly exposed of the micro torch. The CAPP treatment may also reduce the contents of anthocyanins, which have lower thermostability and could interact with reactive species present in the cold plasma. In order to assess the possible negative impact of CAPP micro torch treatment and evaluate the levels of the possible plant tissues and cell damages we compare the levels of electrolyte leakage from treated and untreated samples for each of the tested treatment. Accordingly, the obtained data were used to determine the Index of Injury (Id) for the samples obtained by each treatment. The results, described in Figure 1, demonstrate low level of tissue and cell damages after CAPP treatment, which increase with the length of treatment, reaching Id of 0.43 ± 0.069 % after 4 min. treatment of blueberries and 0.12 ± 0.032 % for cherry tomatoes, Table 1. The determined indexes of injury related to levels of electrolyte leakage from damages cells and tissues of CAPP treated fruits are significantly lower than reported from application of other treatments like decontamination of tomatoes via aqueous ozone washing techniques [12] or treatment of sodium hypochlorite [13], or gamma irradiation of blueberries [14].

Table 1: Index of Injury determined for blueberries and cherry tomatoes treated with CAPP micro torch for 1, 2 and 4 minutes. *Note: Average and standard deviation values of the Index of Injury for each group of treated fruits presented in percentage.

Fruits	Duration of CAPP micro torch treatment		
	1 min	2 min	4 min
	Average value (%) of the Index of Injury*		
blueberries	0.00 ± 0.007	0.29 ± 0.05	0.43 ± 0.069
tomatoes	0.03 ± 0.007	0.09 ± 0.003	0.12 ± 0.032

Anthocyanins are pigments which largely determine blueberry color quality and health promoting effect. CAPP treatment may affect and reduce the anthocyanin content in the blueberries due to the elevated temperature of fruits upon treatment or their reaction with reactive oxygen species present in the plasma [15, 16]. To evaluate the possible negative impact of applied CAPP micro torch exposure on quality of treated blueberries we compare of the total anthocyanin content of treated and untreated fruits. The results demonstrated no significant changes and reduction the anthocyanin content after applied CAPP micro torch treatment Table 2, and suggests it is a mild treatment preserving fruit quality. Similar results also reported for CAPP treatment of blueberries using diffuse coplanar surface barrier discharge plasma unit [7].

Table 2: Anthocyanin content of CAPP treated blueberries based upon fresh weight of berries. *Note: Anthocyanin concentration based upon cyanidin-3-glucoside as standard and presented as milligrams per 100 grams of sample fresh weight.

Fruits	Duration of CAPP micro torch treatment			
	untr.*	1 min	2 min	4 min
	Anthocyanin content (mg/100 g)*			
blueberries	118.8 ± 2.7	119.0 ± 2.1	118.4 ± 2.9	118.9 ± 2.5

The results of present and earlier [8] studies of CAPP treatment of small fresh fruits using microwave-sustained plasma micro torch in argon at atmospheric pressure demonstrate that this CAPP generating unit could be used for mild and quality preserving decontamination of fresh fruits. At the same time the partial reduction of microbial load on the surface of the treated fruits [8] suggests the main challenge for converting of this type of CAPP treatment into fresh fruit decontamination technology will be the development of micro torch based CAPP unit providing uniform treatment of the fruits at elevated productivity. Accordingly, the development of effective CAPP units involving array of plasma jets [17-19] and/or scale up the plasma jet nozzle [20] will be an essential step toward related technology development and application.

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4. References

1. M. Gavahian ,A.M. Khaneghah, Critical reviews in food science and nutrition. **60(9)**, 1581-1592 (2020)
2. R. Mandal, A. Singh ,A.P. Singh, Trends in Food Science & Technology. **80**, 93-103 (2018)
3. G.G. Bovi, A. Frohling, N. Pathak, V.P. Valdramidis ,O. Schluter, Journal of food protection. **82(7)**, 1233-1243 (2019)
4. X.Y. Dong ,Y.L. Yang, Food and Bioprocess Technology. **12(8)**, 1409-1421 (2019)
5. S.C. Min, S.H. Roh, B.A. Niemira, G. Boyd, J.E. Sites, X. Fan, K. Sokorai ,T.Z. Jin, Food Research International. **108**, 378-386 (2018)
6. E. Feizollahi, N. Misra ,M. Roopesh, Critical Reviews in Food Science and Nutrition, 1-24 (2020)
7. N. Pathak, G. Grossi Bovi, A. Limnaios, A. Fröhling, J.P. Brincat, P. Taoukis, V.P. Valdramidis ,O. Schlüter, Journal of Food Processing and Preservation. **44(8)**, e14581 (2020)
8. T. Bogdanov, I. Tsonev, P. Marinova, E. Benova, K. Rusanov, M. Rusanova, I. Atanassov, Z. Kozáková ,F. Krčma, Applied Sciences. **8(10)**, 1870 (2018)
9. M. Schön, H.-J. Bart ,J. Bartneck, Food and Bioprocess Processing. **117**, 84-94 (2019)
10. J. Lee, R.W. Durst ,R.E. Wrolstad, Journal of AOAC international. **88(5)**, 1269-1278 (2005)
11. J. Lee, C. Rennaker ,R.E. Wrolstad, Food chemistry. **110(3)**, 782-786 (2008)
12. A.T. Mustapha, C. Zhou, H. Wahia, R. Amanor-Atiemoh, P. Otu, A. Qudus, O.A. Fakayode ,H. Ma, Ultrasonics Sonochemistry, 105059 (2020)
13. J.H. Hong ,K.C. Gross, Postharvest Biology and Technology. **13(1)**, 51-58 (1998)
14. C. Wang, X. Li ,X. Meng. in *Resources, Environment and Engineering II: Proceedings of the 2nd Technical Congress on Resources, Environment and Engineering (CREE 2015, Hong Kong, 25-26 September 2015)*. 2015. CRC Press (Year)
15. A. Lacombe, B.A. Niemira, J.B. Gurtler, X. Fan, J. Sites, G. Boyd ,H. Chen, Food microbiology. **46**, 479-484 (2015)
16. C. Sarangapani, G. O'Toole, P. Cullen ,P. Bourke, Innovative Food Science & Emerging Technologies. **44**, 235-241 (2017)
17. Q.-Y. Nie, Z. Cao, C.-S. Ren, D.Z. Wang ,M.G. Kong, New Journal of Physics. **11(11)**, 115015 (2009)
18. M.J. Johnson, D.R. Boris, T.B. Petrova ,S.G. Walton, Plasma Sources Science and Technology. **29(1)**, 015006 (2020)
19. X. Li, J. Wu, B. Jia, K. Wu, P. Kang, F. Zhang, N. Zhao, P. Jia, L. Wang ,S. Li, Applied Physics Letters. **117(13)**, 134102 (2020)
20. H.-H. Kim, N. Takeuchi, Y. Teramoto, A. Ogata ,A.A. Abdelaziz, Int. J. Plasma Environ. Sci. Technol. **14(e01004)**, e01004 (2020)

Image segmentation of agricultural products using statistical indicators

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Abstract: Machine inspection is a mandatory technological process in industrial processing agriculture products. The camera detects color and shape based irregularities of the object resulting in a large number of parameters for decision-making and sorting product compliance. The goal was to discover a new criterion for decision-making using only the output signal of the RGB camera. Research employed the digital images of raspberries, blackberries, peas and yellow beans during real processing, obtained from a color sorter machine. The visual texture of the surface of the agricultural products was described via defined statistical indicators of color (color average value (Avg), standard deviation (Stdv), entropy (E), and lacunarity (L)) was used from the sphere of image fractal analysis as one of the criteria. By applying the non-parametric tests: Wilcoxon signed rank and Friedman test, statistically significant difference was established for the L and E criteria between compliant and non-compliant industrial products.

Keywords: COLOR, AGRICULTURE PRODUCTS, SORTING, MACHINE VISION.

1. Introduction

The need to introduce automatic sorting of fruits and vegetables is becoming more and more pronounced in the world. For this purpose, various non-destructive methods of inspection of agricultural products in technological lines have been developed. One of them is machine vision, which is a promising control tool [1, 2].

This type of inspection is based on the analysis and processing of images with multiple types of implementation in the agricultural industry. Inspection machines in industrial plants, color sorters, mainly rely on cameras, some on lasers, and some on a combination of cameras and lasers, as well as a combination of positions above or below the product being selected. The camera detects irregularities based on the color of the object, while the lasers are oriented to structural features and can detect insects, animal parts as well as stalks, stones, paper, plastic, metal and glass, even if they are the same color as the product of interest.

In general, the external quality of fruits and vegetables is assessed mainly through physical characteristics: color, texture, size, shape and visual defects [3-5]. Willingness to buy food mostly depends on the sensory characteristics of the product, ie. mainly from the color that represents the subjective feeling of each consumer [6]. Color can be considered an indicator of freshness and ripeness of the fruit [7], as well as the texture, smell and taste [8, 9]. Descriptive parameters can be created through color parameters, and statistical measures are in most cases mean and standard deviation. These characteristics (properties, attributes) of agricultural products can be represented by numerous values, while statistical methods represent the basis for predicting and classifying sets of these values - data. Texture is the most suitable physical characteristic that can be interpreted through various statistical measures.

Texture analysis can play an important role in identifying and segmenting defective objects when selecting agricultural products [9-11]. The main goal of this research was to find a new criterion by combining already used parameters in research conducted in this and other areas, based on which agricultural products could be distinguished, as well as to separate non-compliant products and foreign facilities from harmonized ones. One similar attempt at a general classification of agricultural and food products is presented in the paper [12]. At the microstructural level under the defined experimental conditions described in the paper, the authors were

able to make a division of certain food products based on fractal dimension (FD) values.

2. Materials and methods

The input data used in the research are digital images of agricultural products taken with the Optyx3000 color sorter during industrial processing. The color sorting and inspection system is part of an automatic line for inspection and packaging with a capacity of 3 t/h, in the ITN Eko Povlen factory in Kosjeric. The system captures images measuring 1024x1024 pixels in RGB format, and the scanning speed is 4000 Hz.

Based on the captured images, the machine recognizes compliant and detects non-compliant bio products. Non-compliant impurities include: wood, plastic, metal, glass, insects and animals or animal parts, plant products that have a similar color and shape (for example in peas - lat. *Solanum nigrum* which is toxic), as well as products that do not have the desired color (eg. yellow or dark overripe peas, etc.), stalks on a product of larger dimensions than allowed, moldy and infected products, etc.

After obtaining the first results based on images of raspberries that were published in the paper [13], the research was supplemented with images of peas, yellow beans and blackberries. The main goal was to describe the texture of organic products based on certain mathematical measures and to perform the recognition of harmonized fruits and classification according to defined categories.

The selected agricultural products for the purposes of this research are of different textures, colors and shapes.

The ranking of the evaluated samples is divided into three categories: harmonized, non-compliant and foreign impurities. Figure 1 shows a part of the analyzed images for the first two categories. An additional division of raspberry images into two subcategories has been introduced. The first refers to raspberries in which an opening can be observed at the place where the stalk was, and the second to raspberries in which this opening cannot be detected, in order to determine whether there is a statistically significant difference in the proposed criteria. A special category III is formed for foreign impurities that can be found during the inspection, such as stalks, earth, stone, plastic, paper, glass and the like.

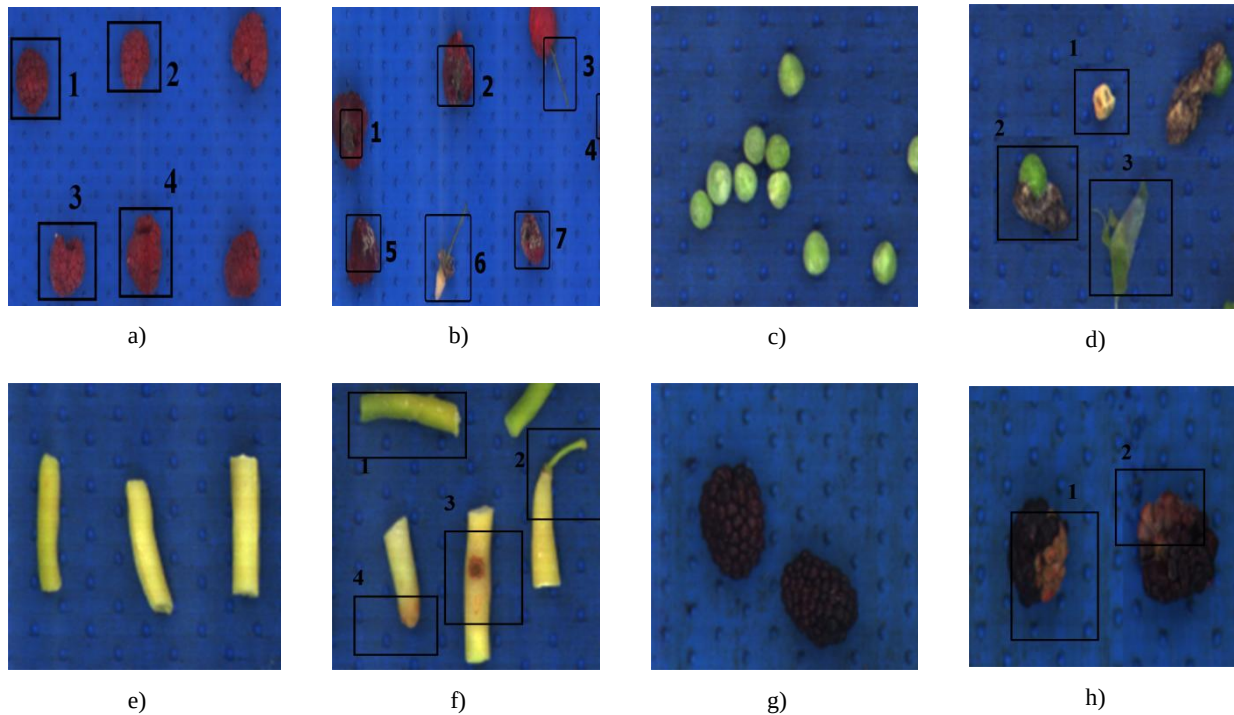


Fig. 1 Part of analysed images: a) acceptable raspberry (1,2- sample without a hole; 3,4-sample with a hole) b) unacceptable raspberry (1,2,4,5,7- example of mold and damage; 3,4- Example of stalk) c) acceptable peas d) unacceptable peas (1-wilted; 2-moldy; 3-pod part) e) acceptable yellow beans f)unacceptable yellow beans (1- immature; 2-stalk; 3,4-bruises) g) acceptable blackberry h) unacceptable blackberry (1,2-damaged)

In the Fig. 2 is presented schematic view of the proposed algorithm for analyzing digital images.

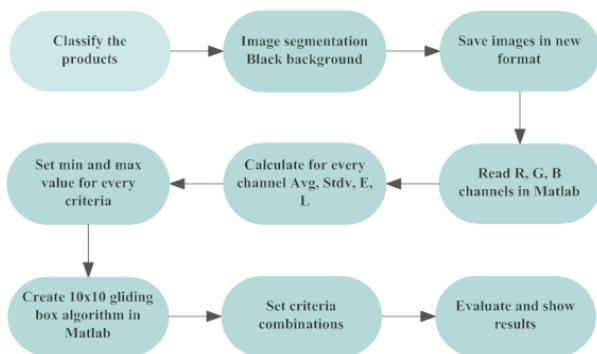


Fig. 2 Proposed algorithm

AdobePhotoshop® was used for the first iteration of image analysis, where regions of interest were extracted. Next step was to set up black background. Each raspberry and blackberry as well as all impurities that can be found on inspection, were separately saved images as 70x70 px in size, 8-bit in their original .bmp format. Peas images were saved as 30x30 px in size and yellow beans as 30x100 px digital images. The Matlab® program was used for further analysis, extracting individual values of colors r , g , b (red, green and blue). Since color can be extracted from each pixel of the region of interest, those variables emerge in order to express the degree of heterogeneity.

Most of the studies show the result of measurements as the average color and its standard deviation from all the pixels selected in the region of interest [14, 15], this standard deviation being mainly a consequence of the heterogeneity instead of the measuring error.

Entropy was calculated for all channels separately using Matlab® where has already built-in function. Entropy is a statistical measure of randomness [16] that can be used to characterize the

texture of the image. For the range of values of parameters r , g , b from 0-255, entropy is defined via the following equation (1):

$$E = - \sum_{i=0}^{255} p(i) \log_2 p(i) \quad (1)$$

where $p(i)$ is the part of the pixel that takes the value of i , and $\log_2$ is the base 2 of the logarithm.

Further, the calculation of the following statistical indicators was performed for each individual color: average value (Avg), standard deviation (Stdv) and entropy (E). The aim was to find a correlation between standard deviation and average value. Same formula for lacunarity, which are used on binary images in fractal geometry, was applied. The name lacunarity comes from the Latin name lacuna, which in translation means lack, gap or hole [17]. It can be defined as a measure of the heterogeneity of a structure or the degree of structural variation within an object. In this case, that criterion was marked as L and calculated separately for each r , g , b channel, refer to (2).

$$L = \left(\frac{\text{Stdv}}{\text{Avg}} \right)^2 \quad (2)$$

Also, statistical tests were performed for each criterion in order to confirm or deny normal distribution, based on which further use of statistical parametric or non-parametric tests is established. Because of smaller-size samples <50, the Shapiro-Wilk test was employed, which is more convenient. Then, descriptive analysis was carried out of all mentioned potential criteria. The significance of difference of the examined criteria among samples was checked using Wilcoxon sign rank test. Statistical analysis of the results was performed in the computer program IBM SPSS® 21.0 and MSeExcel® 2013. After obtained results were checked and analyzed, we made a hypothesis that appropriate image segmentation can be done according to the criteria L and E . Further, the range of values (min to max) was defined for the first category of acceptable products. Also, results were tested by combination of other proposed criteria.

The next step was to develop the algorithm in Matlab®, the so-called gliding box algorithm, because the texture can be considered in a region and not in individual pixels. For the calculation of defined image color parameters $I(x, y)$, to start with, a square was chosen 10x10px in size. The initial square is located at point (0, 0), in the upper left-hand corner. The algorithm records Avg , $Stdv$, E i L for every channel: r, g, b that are associated with the image underneath the moving window. If the parameters coincide with a specified range of values, the square is colored with a chosen color, in our case it was yellow to make the image better. The window is then translated by one pixel to the right and the underlying mentioned statistical measure is again recorded. When the moving window reaches the right-hand side of the image, it is moved back to its starting point at the left-hand side of the image and is translated by one pixel downward. The computation proceeds until the moving window reaches the lower right-hand edge of the image, at which point it has explored every one of its possible positions, i.e., to the endpoint (x_{m-9}, y_{n-9}) . Due to product's different dimensions, the best box size for each product and criterion were investigated. As above mentioned, the initial box surface amounted to 10x10 px and final 2x2 px.

Algorithm: Pseudo code for image analysis and application of 10x10 box

```

x1 = read the image
redChannel = extract red channel values x1
greenChannel = extract green channel values x1
blueChannel = extract blue channel values x1
cols = number of columns
rows = number of rows
for for each box 10x10 pixels in the image calculate
    redAvg, greenAvg, blueAvg = mean values of the current
    box 10x10
    redStd, greenStd, blueStd = standard deviation of the
    current box 10x10
    redE, greenE, blueE = entropy of the current box 10x10
    redL, greenL, blueL = (std/avg)2 of the current box 10x10
    if redL between min and max redL
        and greenL between min and max greenL
        and blueL between min and max blueL
        current box 10x10 color the pixels yellow
    end if
end for
replace the input image

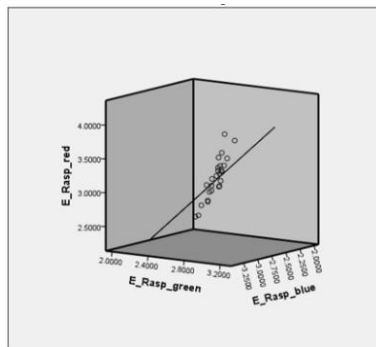
```

3. Results

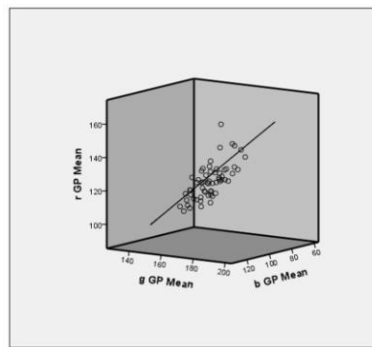
Based on descriptive analysis results for all categories and the Shapiro-Wilk test, the criteria L and E , for every r, g, b channel, were found to have normal distribution in category I products for blackberries, peas and yellow beans (Sig. > 0.05). In the case of raspberries, only for criterion E is the assumption of normality of distribution confirmed. Products of categories II and III do not have normal distribution. Based on Wilcoxon's test, a statistically significant difference was found between category I raspberries with and without opening according to the L parameter for all three channels (r channel: $Z = -3.553$, $p < 0.05$; g channel: $Z = -2.725$, $p < 0.05$; b channel: $Z = -2.788$, $p < 0.05$). The difference in the criterion of the mean value of Avg and entropy E was not statistically significant. In general, a low L value of the criterion suggests a homogeneous texture, while a high L value suggests a heterogeneous texture, but it should be noted that heterogeneous objects on larger scales may appear homogeneous and vice versa. Therefore, the value of criterion L can be considered as a measure of heterogeneity or scale-dependent texture.

Based on the previously presented result, it can be assumed that the parameter L , calculated in the already explained way, takes into account the variations in the figure, such as in this case the aperture. In the following statistical tests, raspberry data with and without holes will be considered together.

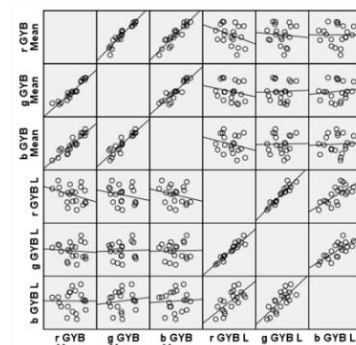
Further research addressed the question of whether there is a statistically significant difference between category I and category II products according to the defined criteria for all three r, g, b channels. Wilcoxon's rank test was also used for this question, where it showed a statistically significant difference (Sig. < 0.05; $p < 0.05$) when it comes to raspberries, blackberries and yellow beans for parameters L and E .



a)



b)



c)

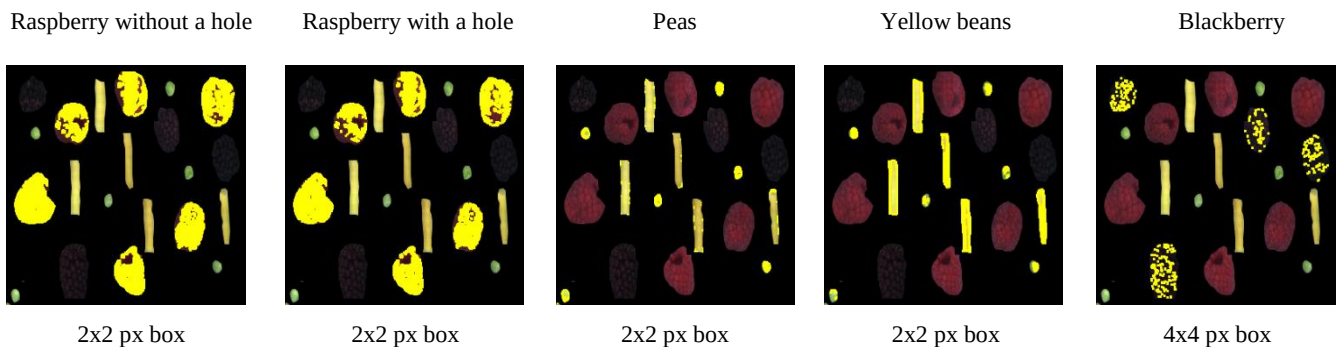
Fig. 3 a) 3D Scatter of entropy of raspberry; b) 3D Scatter of entropy of peas; c) Scatter plot matrix of Avg and L r, g, b channel of yellow beans.

Table 1: Proposed criteria and values

		Avg	E	L
Raspberry without a hole	R min	81	2,1346	0,0159
	R max	132	3,9744	0,0536
	G min	31	1,7569	0,0230
	G max	45	3,4214	0,0700
	Bmin	42	1,7980	0,0156
	B max	59	3,4094	0,0515
Raspberry with a hole	R min	82	2,3990	0,0228
	R max	136	4,0230	0,0809
	G min	31	2,0988	0,0207
	G max	46	3,5442	0,0752
	Bmin	42	2,1382	0,0182
	B max	60	3,655	0,0589
Peas	R min	99	1,2648	0,3514
	R max	167	2,4417	0,1624
	G min	132	1,2795	0,0260
	G max	193	2,4596	0,1300
	Bmin	66	1,2412	0,0166
	B max	129	2,376	0,1279

Yellow beans	R min	122	1,6603	0,0369
	R max	212	3,7743	0,0764
	G min	132	1,6411	0,0346
	G max	205	3,6752	0,0740
	Bmin	43	1,5022	0,0366
	B max	102	3,3803	0,0648
Blackberry	R min	18	1,6012	0,0504
	R max	45	3,3223	0,1668
	G min	17	1,4488	0,0230
	G max	25	3,0280	0,0700
	Bmin	21	1,4599	0,0323
	B max	32	3,1493	0,0969

Based on these conclusions, the following criteria are proposed: *min* and *max* values of *L*, *Avg* and *E* from *r*, *g*, *b* parameters obtained from images of fruits that belong to category I of acceptable products as well as their combinations. Each product was checked over seven combinations of these criteria. The application of independent *Avg*, *L*, *E* criteria, combinations: *L+E*, *Ag+E*, *Avg+L*, *Avg+L+E* for all three channels *r,g,b*. Also, for each combination the optimum box algorithm size was investigated to yield the best results, starting from 10x10 px to 2x2 px.

**Fig. 4** Representation of resulting images by applying the best combination of criteria and box size

According to the table of proposed ranges for criteria values, Tab.1, it can be concluded that there occur particular overlaps in two or more investigated products. For that reason, we have created several test images with all investigated good products, so as to reach an ideal combination of criteria that can be used to describe each product independently. An example of such image is given in Fig. 4. In investigating some combinations or an independent criterion for a single product, more than one product was recognized in the test image. Figure 5 shows images with criteria and box size that produced best results of recognition for each group of individually investigated product.

Good result means appropriate formation of the product shape when marking with yellow color. The application of the proposed algorithm allowed good recognition of raspberries and blackberries using a combination of criteria *Avg+E*. In raspberries the best result was produced by the box size 2x2px and in blackberry by 4x4px, and only these products were recognized with those box sizes and criteria. As for peas and yellow beans, none of the criteria combinations or box sizes gave satisfactory result. In the figures shown, the best result was yielded approximately by combination

Avg+E, and thereby both products were recognized nearly equally in the image.

**Fig. 5** Example of test picture

Next, separate test images were created for each agricultural product, which contains several products from each category that were randomly selected (Fig. 6 a and b).

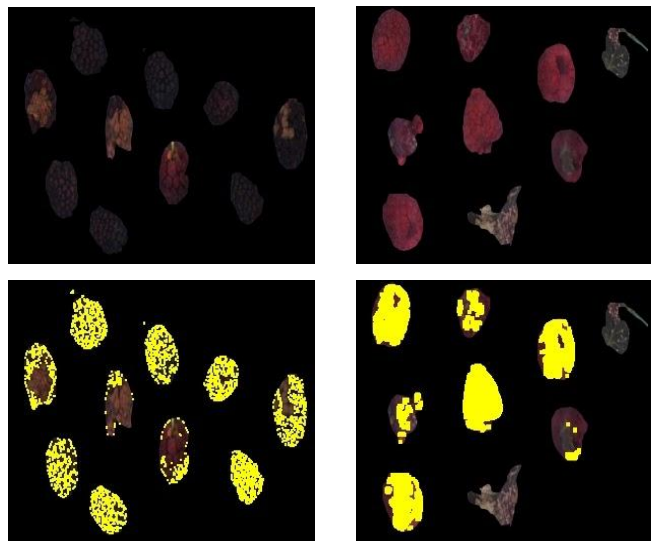


Fig. 6. a) blackberry image test, b) raspberry image test, c) application of Avg + E and 2x2 box, d) application of Avg + E and 4x4 box.

Based on the final results, several conclusions can be drawn. The values of L and E differ statistically significantly between the proposed categories of compliant, non-compliant product and foreign material in each tested agricultural product. By applying the proposed model, using the sliding square algorithm and selected input criteria, the combination of Avg+E criteria gave a satisfactory result in the detection of harmonized parts of raspberry and blackberry fruits. Conditionally satisfactory results were in the recognition of raspberries and blackberries in relation to the other two agricultural products, peas and yellow beans. The proposed model is not suitable for all products, primarily due to different product sizes.

The study [18] compared the performance of the system in classifying fifteen types of fruits and vegetables based on eight color and texture parameters. The combination of color and texture parameters proved to be the best, as in this paper, which confirms the conclusion that it is not possible to obtain a satisfactory result by using only morphological characteristics for identification. According to the results in the paper [19], a set of color and texture characteristics also gave a satisfactory outcome when it comes to recognition, but the texture parameters for each color channel were considered individually. The subject of the research was only one product, potato chips, and it was observed in certain experimental conditions. For each class, a different set of characteristics was influential. Finding a unique general combination of criteria ("fingerprint") for the classification of agricultural products requires much larger data sets.

4. Conclusion

The current situation, however, shows that classical methods for classifying fruits and vegetables have been developed for a limited number of fruit classes and small sets of products. Using only morphological features for identification, these varieties could not provide good enough results.

The proposed idea and algorithm have a range of advantages and disadvantages, which gives room for further research and improvement. The results showed that the color and morphological feature, as entropy, alone were not able to recognize different products with high accuracy. However, the combination with average values certainly can show acceptable results for particular

products, in our case raspberry and blackberry. It can be concluded that there is significant differences in the values of proposed criteria between good and bad product that can be used for further research. Problem with same recognition of pea and yellow beans can be attributed to a similar range of color values between yellow and green values in RGB color scale, which also reflected similar ratios of the proposed criteria L and E . The good side of the algorithm can be adequately recognized product boundaries by optimizing the box size and increasing the number of samples. For future research, it is necessary to carry out more experiments using a larger number of samples and different conditions to complete a study.

In addition, there is the idea of generalizing the recognition of different agricultural products based on the solution found, i.e. that the values of the obtained criterion or combination of criteria be the only solution for the general differentiation of agricultural products. Despite the variability of influential parameters in the paper, one of the conclusions is that statistical modelling of parameters by further research can lead to more significant results in the evaluation of agricultural products, confirmed statistically significant difference in the proposed criteria L and E , has the potential for further research.

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5. References

- [1] A.S.M. Shafi, M.M. Rahman Recognition and Classification of Fruit Diseases Based on the Decomposition of Color Wavelet and Higher-Order Statistical Texture Features. In: Uddin M., Bansal J. (eds) *Proceedings of International Joint Conference on Computational Intelligence. IJCCI 2019*. Alg. for Int. Sys. Springer, Singapore. (2020)
- [2] M. Khojastehnazhand, H. Ramezani. Machine vision system for classification of bulk raisins using texture features, *J. of Food Eng.* **271** (2020)
- [3] M. Teena, A. Manickavasagan, A. Mothershaw, S. El Hadi, D. S. Jayas, Potential of machine vision techniques for detecting fecal and microbial contamination of food products: A review, *Food and Biop. Tec.* **6** (2013)
- [4] D. Markovic, N. Mladenovic, V. Simonovic, I. Markovic, S. Stevanovic. Fruit flow calculation on the rotating sizing machines. *Tec. Gaz.* **21** (2014)
- [5] S. Khoje. Appearance and characterization of fruit image textures for quality sorting using wavelet transform and genetic algorithms, *J. of Tex. St.*, **49** (2017)
- [6] S. Shella, S. Meghashree, I. Monica, A. Prathima, K. Shriya. Automation for sorting of objects using raspberry pi3, *Int. J. of Adv. in Elec. and Com. Sci.*, Special Issue. (2016)
- [7] R. Valadez-Blanco, A.I.S. Virdi, S.T. Balke, L.L. Diosady. In-line colour monitoring during food extrusion: sensitivity and correlation with product colour. *Food Res. Int.*, **40** (2007)
- [8] R. Banerjee, B. Tudu, R. Bandyopadhyay. A review on combined odor and taste sensor systems. *J. of Food Eng.*, **190** (2016)
- [9] B. Zhang, W. Huang, J. Li, C. Zhao, S. Fan, J. Wu, C. Liu. Principles, developments and applications of computer vision for external quality inspection of fruits and vegetables: A review. *Food Res. Int.*, **62** (2014)
- [10] S.R. Dubey, A.S. Jalal. Apple disease classification using color, texture and shape features from images. *SIVIP* **10** (2016)

- [11] D. Singla, A. Singh, R. Gupta. Texture Analysis of Fruits for Its Deteriorated Classification. In: *Woungang I., Dhurandher S. (eds) International Conference on Wireless, Intelligent, and Distributed Environment for Communication. WIDECOM 2018*. Lecture Notes on Data Eng. and Comm. Techn.. **18**. Springer, Cham. (2018)
- [12] R. Quevedo, L.G. Carlos, J.M. Aguilera, L. Cadoche. Description of food surfaces and microstructural changes using fractal image texture analysis, *J. of Food Eng.* **53** (2002)
- [13] I. Markovic, D. Markovic, J. Ilic, V. Simonovic, E. Veg, G. Šiniković, N. Gubelj. Application of Statistical Indicators for Digital Image Analysis and Segmentation in Sorting of Agriculture Products, *Tech. Gaz.* **25** (2018)
- [14] V. Kumar, P. Gupta. Importance of Statistical Measures in Digital Image Processing, *Int. J. of Em. Tech. and Adv. Eng.* **2** (2012)
- [15] A. Girolami, F. Napolitano, D. Faraone, A. Braghieri. Measurement of meat color using a computer vision system, *Meat Sci.*, **93** (2013)
- [16] J. Steinbrener, K. Posch, R. Leitner. Hyperspectral fruit and vegetable classification using convolutional neural networks. *Com. and El. in Agr.* **169** (2019)
- [17] B.B. Mandelbrot. *The Fractal Geometry of Nature*. W.H. Freeman, New York, (1987)
- [18] S. Arivazhagan, S. Newlin, S. Nidhyandhan, L. Ganesan. Fruit Recognition using Color and Texture Features. *J. of Em. Tr. in Com. and Inf. Sci.*, **1** (2010)
- [19] F. Mendoza, P. Dejmek, J. Aguilera. Colour and image texture analysis in classification of commercial potato chips, *Food Res. Int.* **40** (2007)

Investigation of lipstick properties using statistical methods

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Abstract: The rheological non-destructive oscillation testing is conducted in order to predict and quantify the samples' properties of the commercial brand lipstick. The influence of the variation of the process parameters temperature, phase angle and strain are investigated. Regression models for the dependencies of the rheological and thermal properties (elastic modulus and shear stress) from the described process parameters are estimated, based on 681 experimental data in the temperature region from 26.9 °C to 74.7 °C.

Keywords: LIPSTICK, OSCILLATORY SHEAR RHEOLOGY, ELASTIC MODULUS, SHEAR STRESS, REGRESSION MODELS

1. Introduction

The aspiration to look physically attractive is a universal desire. All kinds of cosmetics including lipstick, although originally developed by the ancient Egyptians as ointments and ritual oils for the dead, eventually end up being used to soothe, adorn, accentuate and treat the skin of the modern, living humans. In recent time statistics show that these products are used by over 90 % of the female population. The face is the part of the human body that receives the most attention compared to the rest of it. Lipsticks play a significant role as a part of the cosmetic products created for facial use, regardless of gender and/or age. The common understanding that lipsticks or lip balms are created only for the female population is false [1 - 4].

All the lipsticks appearing on the market must meet specific standards, connected with their physical-mechanical properties. Some of them are: stability against temperature fluctuations (55 °C - 75 °C) and humidity; long shelf life; dermatological safety; pleasant taste and smell; softening at physiological lip temperature around 32 °C; good durability and no defects such as air bubbles; no cracks or sweating, should be free of physical changes, etc. [3, 4].

The viscosity of the lipstick should be high enough to keep its structure in the matrix. In addition, it should gradually decrease as the mechanical stress increases during physiological application [3, 4]. From a tribological point of view, lipsticks require varying degrees of friction to glide effortlessly on the skin [3, 5].

In this paper the rheological non-destructive oscillation testing was conducted in order to predict and quantify the properties (threshold flow stress, elastic modulus) of the lipstick samples. Regression models, describing the dependencies of the lipsticks characteristics: y_1 - elastic modulus [Pa] and y_2 - shear stress [Pa] on the variation of the process parameters: temperature, phase angle and strain are estimated, based on 681 experimental data in the temperature region from 26.9 °C to 74.7 °C.

2. Response surface methodology

Response surface methodology (RSM) is a group of mathematical and statistical procedures used in fitting an empirical model to the experimental data obtained in relation to an experimental design [6]. Regression models (polynomial models of some order), giving an adequate functional relationship between a response of interest y (performance characteristic) and a number of associated control (or input) variables (process parameters) $x_1, x_2, \dots, x_m$, are estimated:

$$(1) \quad \hat{y}(\vec{x}) = \sum_{i=1}^k \hat{\theta}_i f_i(\vec{x})$$

where $\hat{\theta}_i$ are the estimates of the coefficients in the regression model.

The natural values of the factors (z_i) in the regression models are coded in the region $[-1 \div 1]$ and the relation between the coded (x_i) and the natural values (z_i) is given by:

$$(2) \quad x_i = (2z_i - z_{i,\max} - z_{i,\min}) / (z_{i,\max} - z_{i,\min}),$$

where $z_{i,\min}$ and $z_{i,\max}$ are the corresponding values of the minimum and the maximum of the process parameters during the experiment.

3. Experimental conditions

The rheological method - oscillatory shear rheology to characterize the rheological behavior of the studied brand of lipstick was applied.

There are three different types of stresses (tension, pressure and shear) that can occur when a material is exposed to a load. If the material is stretched or compressed in one dimension, this leads to tension or pressure, respectively. However, if opposite forces are applied to opposite surfaces of the material, shear stresses are obtained. The modules that result from these stresses can provide information about the properties of the material.

Shear stresses can be obtained using rheological techniques which provide information on the elastic behavior of a material. Shear stress can be calculated when dividing the force required to cause deformation by the cross-sectional area of the material. The strain is the distance moved divided by the original length of the material.

For elastic solids, the energy generated (modulus of elasticity) during deformation of the material is stored, as a result of which the material returns to its original shape (is recovered) after removing the force causing deformation (Hooke's law) - an important feature for lipsticks.

The modulus of elasticity is a measure of the strain energy stored in the sample during shear, thus showing the elastic (solid-like) behavior.

An experiment was performed with samples of commercial brand lipstick to test its rheological and thermal properties like threshold flow stress, elastic modulus, etc. Minimum quantity (7 - 10 mg) of the lipstick is scratched on the surface of a closed aluminum capsule (diameter: 6 mm). The sample was heated at a constant rate of 5 °C for 1 min. The experiments were conducted during the cooling of the lipstick at an initial starting temperature 74.7 °C and the measurements were stopped when reaching 26.9 °C. As a result of the experiment 681 measurements were done.

The rheological behavior of the studied brand of lipstick characterized by the following performance parameters: y_1 [Pa] - elastic modulus and y_2 [Pa] - shear stress. The variation regions $[z_{min} - z_{max}]$ of the process parameters were: for temperature (z_1) - $[26.9 - 74.7 \text{ } ^\circ\text{C}]$; the phase angle (z_2) - $[0.0024 - 90 \text{ deg}]$ and the strain (z_3) - $[1.37 \times 10^{-5} - 1.483 \times 10^{-2}]$. The angular frequency for these experiments was constant and is 0.2 Hz.

4. Regression models estimation

The dependencies of the lipstick characteristics: y_1 - elastic modulus [Pa] and y_2 - shear stress [Pa] on the variation of the process parameters: z_1 - temperature $[^\circ\text{C}]$, z_2 - phase angle [deg] and z_3 - strain are estimated.

They are presented for coded in the region $[-1 \div 1]$ values of the process parameters in Table 1, together with the square of the multiple correlation coefficient R^2 and the square of the adjusted multiple correlation coefficient R^2_{adj} . The values of both coefficients are high (close to 1 or 100 %) and consequently the estimated models for the elastic modulus $\hat{y}_1(\vec{x})$ and shear stress $\hat{y}_2(\vec{x})$ can be considered as good enough for prediction and investigation.

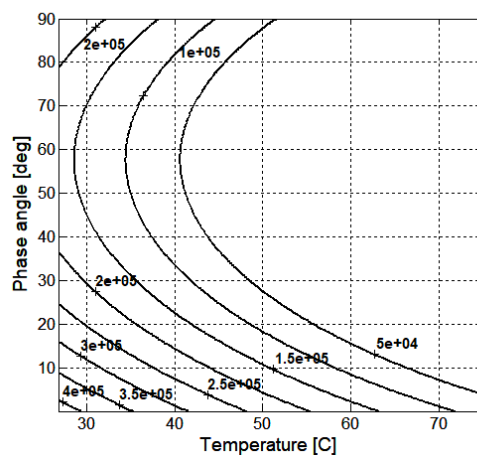
Table 1: Regression models for the lipstick characteristics

	Regression models	R^2 [%]	R^2_{adj} [%]
$\hat{y}_1(\vec{x})$	$106094 - 168532x_1 + 37062x_2 + 22270x_1^2 + 156319x_2^2 - 119409x_3^2 + 125116x_2x_3$	85.73	85.26
$\hat{y}_2(\vec{x})$	$795.8 - 992x_1 + 243.6x_2 + 266.8x_3 + 479.1x_1^2 + 368x_2^2 - 704.7x_3^2 - 1283.1x_1x_3 + 275.5x_2x_3$	82.72	82.52

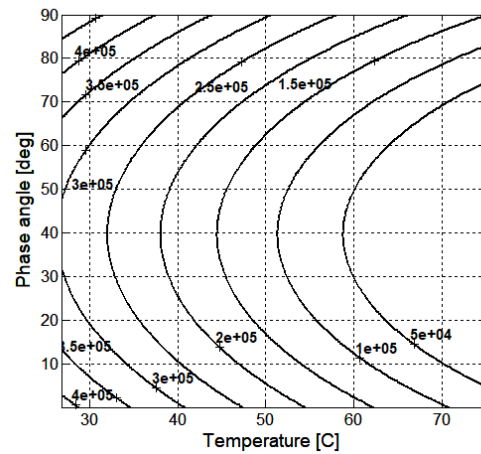
In Fig. 1 contour plots of the elastic modulus - y_1 , depending on the variation of temperature (z_1) and the phase angle (z_2) for different values for strain - z_3 are presented.

On Fig. 1a it can be seen that when the temperature (z_1) is around 32 $^\circ\text{C}$, which is the normal temperature for the human lips and phase angle (z_2) is minimum, the elastic modulus $\hat{y}_1(\vec{x})$ has high values. Fig 1b shows that in order to obtain a maximum of $\hat{y}_1(\vec{x})$, z_2 must have very large or small values within the experimental region, and in Fig. 1c it can be seen that maximum of the investigated lipstick characteristic is reached when the phase angle z_2 has smallest values (0.0024 deg).

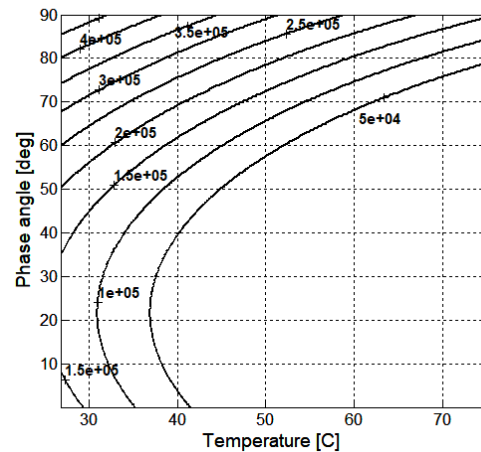
Contour plots of the shear stress - $\hat{y}_2(\vec{x})$ of the investigated commercial brand lipstick, depending on the variation of temperature (z_1) and the phase angle (z_2) for different values for strain - z_3 are shown in Fig. 2. In the first case (Fig. 2a) it can be seen that around the normal human lip's temperature (32 $^\circ\text{C}$) $\hat{y}_2(\vec{x})$ and phase angle is between 30 and 60 deg, the shear stress is less than 5 Pa. On other two contour plots graphics (Fig 2b and Fig 2c) $\hat{y}_2(\vec{x})$ has a maximal value, if the z_2 is maximum too.



a) $z_3 = 1.37 \times 10^{-5}$

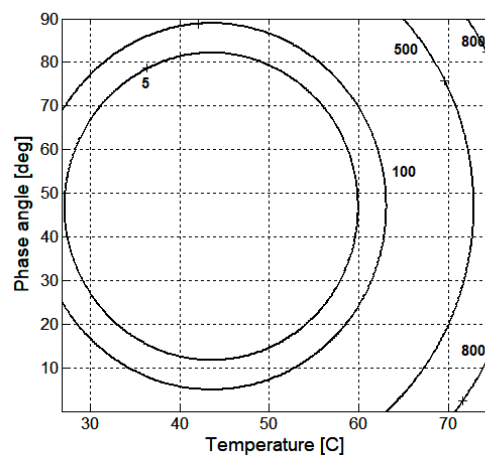


b) $z_3 = 7.42185 \times 10^{-3}$



c) $z_3 = 1.37 \times 10^{-5}$

Fig. 1 Contour plots of the elastic modulus - $\hat{y}_1(\vec{x})$, depending on the variation of Temperature (z_1) and the Phase angle (z_2) for different values for strain - z_3 : a) strain - $z_3 = 1.37 \times 10^{-5}$; b) strain - $z_3 = 7.42185 \times 10^{-3}$ and c) strain - $z_3 = 1.483 \times 10^{-2}$.



a) $z_3 = 1.37 \times 10^{-5}$

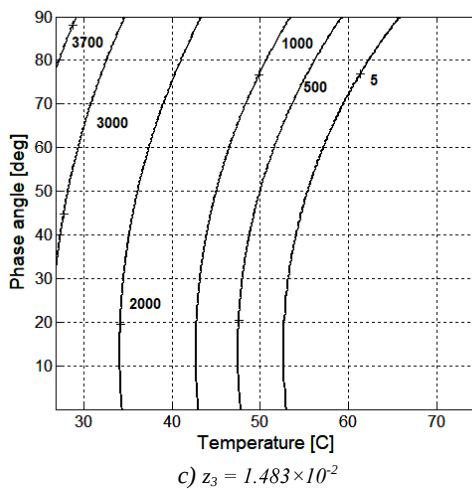
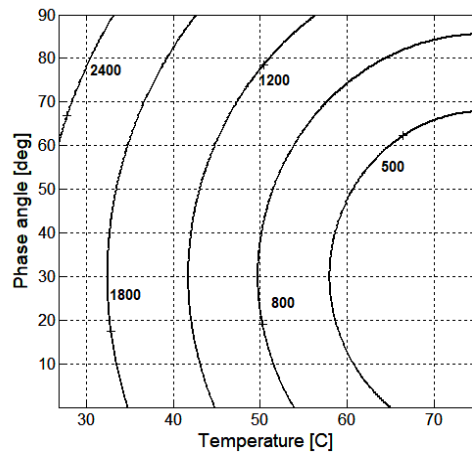


Fig. 2 Contour plots of the shear stress – y_2 , depending on the variation of Temperature (z_1) and the Phase angle (z_2) for different values for strain – z_3 : a) strain – $z_3 = 1.37 \times 10^{-5}$; b) strain – $z_3 = 7.42185 \times 10^{-3}$ and c) strain – $z_3 = 1.483 \times 10^{-2}$.

5. Conclusions

Investigation of the commercial brand lipstick using oscillatory shear rheology in order to tested its rheological and thermal properties is performed.

Regression models for the elastic modulus and the shear stress of the investigated product depending on the variations of the process parameters were estimated.

The obtained regression models can be used for future investigation and optimization of the rheological and thermal properties of the investigated commercial brand lipstick.

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References

1. P.G. Engasser, *Lip Cosmetics*, Dermatologic Clinics, **18**, 4, 641-649 (2000)
2. A.R. Fernandes, M.F. Dario, C.A. Pinto, T.M. Kaneko, A.R. Baby, M.V. Velasco, Braz. J. Pharm. Sci. 49, 293–299 (2013)
3. S. Pan, N. Germann, Thermochemica Acta, **679**, 178332 (2019)
4. M.S. Taylor, *Stabilisation of Water-in-oil Emulsions to Improve the Emollient Properties of Lipstick*, PhD Thesis, University of Birmingham (2011)
5. A. Beri, J.E. Norton, I.T. Norton, Int. J. of Cosmetic Sci., **35**, 613–621, (2013)
6. M.A. Bezerra, R.E. Santelli, E.P. Oliveira, L.S. Villar, L.A. Escaleira, Talanta, **76**, 965-977 (2008)

World mobile services market: economic aspect

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Annotation. The structural trends of the last ten years in terms of individual connections in the mobile market have been identified. The characteristics of the largest companies in the world that provide mobile services have been given. The sources of creating new value in the mobile business have been named. A comparative analysis of the provision of services by the leaders of the global mobile services market (like China Mobile, AT&T and Vodafone) has been conducted. The advantages and disadvantages of these mobile operators have been highlighted. A comparative portfolio of services of leaders-mobile operators has been compiled. It has been concluded that there are differences between the UK market, Chinese and US operators.

KEYWORDS: MOBILE COMMUNICATION, TELECOMMUNICATION SERVICES, WORLD MARKET, INCOMES, PRICING, INTERNET SERVICE

1. Introduction

The mobile market is developing at an unprecedented pace. It seems that almost every day the new devices appear. They are faster, more convenient and more powerful than the old ones. And almost every moment new types of mobile devices are created, and the number of applications running on them is estimated at millions. There is a huge need for new devices and applications that should generate huge amounts of mobile data [1].

The structural trends of the last ten years regarding individual connections in the mobile market reflected the general logic of global economic processes, according to which ten years ago the developed countries of Europe and the United States were the undisputed leaders of economic development. The last five years were characterized by a tendency to a certain stabilization and parity of the shares of these players [2].

According to the classification of the International Telecommunication Union, 52 countries are classified as developed, which is a fairly broad interpretation of modern ideas about development. The developed world includes Ukraine and five other countries from the post-Soviet space: Belarus, Estonia, Latvia, Moldova, and the Russian Federation. Most countries in Africa, Asia, and South America have traditionally been included in developing countries [3].

Mobile, telecommunications, Internet technologies are developing at a tremendous rate, and to constantly meet consumer demand, establish stable long-term relationships with customers, companies need to keep up with the times, monitor scientific and technological progress, adapt inventions and innovations to the needs of society, not forgetting the overall mission and goals of their business.

2. The state of the world market for mobile services

The current state of the world mobile market is best reflected in the selection of a group of leaders in this field. Among the many attributes of identifying leaders, the market value of the company is a determining factor for this list (Table 1). Thus, 10 global operators account for 35% of the total subscriber market. Let's analyze the ten largest telecommunications companies in the world.

1. AT&T Inc. is the largest telecommunications company in the United States, which occupied 32.5% of the mobile market in the country. It provides voice services in more than 200 countries and serves more than 34,000 Wi-Fi hotspots. Expanding its GigaPower - an ultra-fast Internet service, to 56 cities in the United States, it plans to continue diversification in the future. In May 2014, AT&T acquired DirecTV for \$ 48.5 billion, allowing the company to offer customers the ability to combine multiple services into one package.

2. China Mobile Ltd is the absolute leader in the number of subscribers to telecommunications services in China. It is the world's leading telecommunications company. Since April 2017, the market value of the company amounts to 215.3 billion dollars, from

January to December 2016 its customer base increased by 2.5%. China Mobile provides its subscribers with a full range of state-of-the-art telecommunications services, including high-speed mobile Internet access.

Table 1. The World's Largest Companies Providing Mobile Services, 2018

№	The company name (country)	Number of customers, mln	Market value, billion US dollars	Coverage countries
1	AT&T Inc. (USA)	355	245,58	200
2	China Mobile Ltd (China)	849	215,3	1
3	Verizon Communications Inc. (USA)	-	191,72	150
4	Nippon Telegraph & Telephone Corp. (Japan)	-	86,138	1
5	Softbank Group Corp. (Japan)	-	81,459	1
6	Deutsche Telekom AG (Germany)	100	76,11	50
7	Vodafone Group PLC (UK)	444	68,41	26
8	Telefonica S.A. (Spain)	180,8	52,84	21
9	America Movil (Mexico)	280,6	49,385	-
10	China Telecom (China)	62,36	37,309	1

Source: compiled on the basis of [4]

3. Verizon Communications Incorporation is the second largest telecommunications company in the United States. Its sales are 131.8 billion dollars (according to Forbes). Verizon, headquartered in New York, was established in 2000 by merging Bell Atlantic Corporation and GTE Corporation. In 2014-2015, Verizon acquired shares in AOL and Vodafone.

4. Nippon Telegraph & Telephone Corporation is a company known for its high-speed Internet. Japanese companies spend a lot of money to achieve the latest Internet technologies. Unlike other telecommunications companies, Nippon derives most of its revenue from fiber-optic Internet connections rather than product packages. To expand its customer base, the company is increasingly seeking to sell its virtual storage services.

5. Softbank Group Corporation is a company that began operations in 1981 as a software distributor. Since then, it has created an internal telecommunications segment that caters to Japan's mobile and broadband Internet needs. In addition to managing Yahoo! Japan, Softbank owns 80% of the shares of the American telephone service provider - Sprint. In 2015, Softbank acquired an IBM license for its human-readable Watson robot to create a Japanese Android called Pepper with plans to sell the robot to retail customers. The first 1,000 Pepper robots were sold in November 2015.

6. Deutsche Telekom AG is a German company with more than 218,000 employees. More than half of its income is earned outside Germany. In 2013, Telekom became the first telecommunications company to introduce a smartphone with Firefox. In 2015, the company launched a standardized European network that provides cross-border infrastructure in three out of ten countries.

7. Vodafone Group PLC (MTS) is one of the largest telecommunications companies headquartered in the UK. From 2012 to 2014, Vodafone acquired three companies: Cable & Wireless Worldwide, Kabel Deutschland and Ono. The mobile sales package accounts for 42% of the Vodafone service group's revenue, while 27% of revenue comes from sales of mobile devices outside the package. By acquiring Kabel Deutschland in 2013, Vodafone gained access to 8.5 million households of the cable company in Germany and was able to offer new services for telephone, television, broadband and wireless. Today MTS provides subscribers not only with cellular communication services, but also with access to the Internet from home and office via fixed lines, mobile and retail banking services (with the help of MTS Bank), access to mobile TV and much more. Vodafone is the most valuable brand in the United Kingdom, ranking in the top 100 most expensive brands in the world according to the BRANDZ™ rating.

8. Telefonica S.A. is a Spanish company that serves a customer base, mainly concentrated in Latin America. Its products and services include virtual cloud, mobility services, data centers, corporate, voice and security services. Telefonica sells its three main brands with different target audiences: Movistar serves Spain and Latin America; O2 serves the United Kingdom, Ireland, Germany, the Czech Republic and Slovakia; and VIVO serves Brazil.

9. America Movil is a Mexican company that serves 363.5 million access lines worldwide. It has a general coverage of mobile, fixed lines, broadband and television services.

10. China Telecom is a state-owned company headquartered in Beijing that provides fixed telephone services to 194 million customers. By the end of 2016, its broadband services had reached 113 million people. China Telecom's commercial brands include E-surfing, E-surfing Navigator, E-surfing E Home and E-surfing Flying Young.

The International Telecommunication Union (ITU) constantly monitors the development rate of fixed, mobile communications and Internet access in the world, individual regions and countries. According to union experts, in 2019, the number of mobile users was expected to increase to 7377 million people, and Internet users – to 3488 million people [5].

The dynamics of absolute indicators are largely determined by demographics and cannot reflect the basic trends in the global mobile market. The analysis of the annual growth rates of the mobile connection segments made it possible to determine the current state and forecast the development trends in the mobile communication market (Table 2).

Table 2. Annual Growth Rates of Mobile Connection Segments

Indicator	Annual growth rates, %				
	2015	2016	2017	2018	2019
Mobile telecommunications (developed countries)	103	102	104	103	101
Mobile telecommunications (developing countries)	107	108	105	103	102
Mobile telecommunications (World)	106	107	105	103	102

Source: compiled on the basis of [3]

The current period of the mobile market development is characterized by a saturation, in which overall growth in the last two years has slowed to 2-3%. There is a synchronization of growth rates of this segment relative to countries with different levels of development. Moreover, the declining share of India and China in mobile connections indicates a narrowing of the digital divide in the relevant segment among developing countries.

3. Trends in the development of mobile communications in the world

Analysis of the dynamics of mobile communications in the global market over the past ten years reveals the first trend - the annual increase in the number of mobile users. One of the reasons for the growth of mobile subscribers was the weakening of barriers to entry into telecommunications markets for foreign companies, which led to increased competition and lower prices for mobile services.

The second trend is the growth of the global market for mobile Internet access. Thus, the number of mobile Internet users increased from 9 per 100 inhabitants in 2009 to 69.3 in 2019. Such a significant growth in the segment of mobile Internet access was due to the development of high-speed data networks (3G / 4G), the active penetration of smartphones and tablets, due to the development of Android, sales of 3G-USB modems, the spread of Wi-Fi connection to a fixed network. As well as reducing the cost of unlimited mobile Internet, tariff packages [6].

Cisco, a world leader in network technologies, believes that operators have four areas in which they can create new value in their business (Figure 1) [7].

1. *Cost optimization.* Production costs in IT and network architectures typically account for one-third of an operator's typical operating costs. Experience working with large customers – service providers shows that you can increase the efficiency of operating costs of the service provider by at least 10%. The key factors are the virtualization of the production architecture, mobile access of the new generation, increasing the maneuverability of the business and new operational and business models.

2. *Pricing.* Pricing is the most powerful tool for making a profit, often managers do not give it due importance. Key factors for increasing profitability through pricing include: differentiated pricing and usage restrictions; pricing based on consumer perception of service value; general tariff plans prepared for the introduction of a comprehensive Internet; rationalization and simplification of tariff plans, package sales.

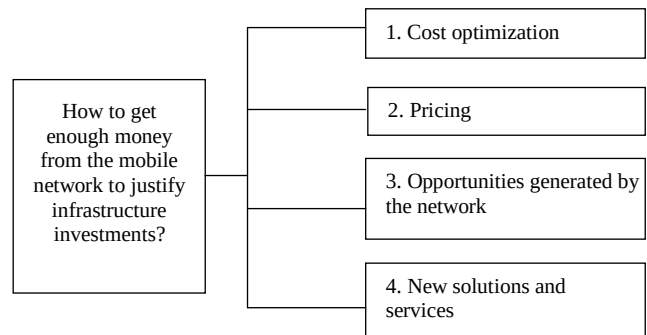


Figure 1. Sources of new value in the mobile business

3. *Opportunities generated by the network.* The key monetization opportunities generated by the network are the quality of business components such as: service (QoS), policies, application programming interfaces (API), data and analytics, information security.

4. *New solutions and services.* New solutions and services that could be provided by mobile operators include: virtual cloud; comprehensive Internet; inter-machine communications; connected rolling stock; solutions for corporate, medium and small businesses; joint services with independent providers; location-based services and analytical solutions.

A key factor in reaping the benefits of creating new, long-term business values will be the organization and successful operation of several levels of monetization above the network. At the level of solutions, services and functions, the internal technical value will be obtained from the mobile network and its transformation into final market products and services, which will be sold to interested final users through various channels.

Over the past few years, in order to double the core network and hoping to gain more market share, many of the largest transactions have been made by companies that buy competitors in the telecommunications industry.

4. Comparison of service provision by the leaders in the world mobile communication services market

To compare the provision of mobile services in the international market, we will choose three companies: China Mobile, AT&T and Vodafone. The market of mobile operators is characterized by a concentration of subscribers in the largest companies. Let's consider the dynamics of selected companies' incomes for 2015-2019 (Table 3).

Table 3. Incomes of Mobile Operators, 2015-2019

Company	Incomes, billion dollars				
	2015	2016	2017	2018	2019
China Mobile	70213	121231	127067	134563	152212
AT&T	63 055	118 928	124 028	123 018	124245
Vodafone	58 906	71 218	70 475	71 000	71 125

Source: compiled on the basis of [3]

According to the International Telecommunication Union ITU [5], the number of signed cellular contracts is increasing annually regardless of the crisis in the economy, but the number of fixed line contracts, by contrast, has been steadily declining over the past five years. Table 4 examines the dynamics of leading international companies' subscribers in 2015-2019. After all, the number of China Mobile subscribers in 2019 exceeded 800 million people, AT&T subscribers – more than 300 million people and Vodafone subscribers – more than 400 million people.

China Mobile uses its own and completely incompatible 3G version called TD-SCDMA. It also has the most advanced 4G / LTE network, but again uses Chinese TDD-LTE, which is just beginning to be used in some other countries. 4G uses 1900 MHz (band 39), 2300 MHz (band 40) and 2500 MHz (band 41 compatible with band 38) on TDD-LTE.

Table 4. Dynamics of Subscriber Connections for 2015-2019

Company	Number of subscribers, million people				
	2015	2016	2017	2018	2019
China Mobile	816	821	836	849	853
Vodafone	429	432	435	444	448
AT&T	345	348	350	355	357

Source: compiled on the basis of [3]

Let's analyze the international mobile operators according to the tariff packages they offer to their subscribers.

In most cities, China Mobile sold their prepaid cards not under its own brand, but under other names, such as Easy Own or MZone. Since 2015, China Mobile 4G SIM cards have been available in areas where LTE has been launched. Prices and plans vary slightly by region [9].

In most areas, such as Shanghai or Beijing, currently new subscribers are required to first choose a master plan, which is either MZone, EasyOwn, or a new global 4G plan. MZone's plans include data limits for mobile Internet and in some areas for Wi-Fi hotspots with SSID "CMCC-WEB" in China, as well as, as a rule, nationwide free incoming calls and vary between regions.

AT&T is built on GSM. Note that GSM in the US does not work in the usual 900/1800, but in the 850/1900 standard. A significant advantage in the US is the fact that you can save your number when switching to another operator. America is familiar with 4G/LTE, and the country is already moving towards 5G. Differentiation of tariff plans is mainly based on Internet traffic. Calls and SMS are almost unlimited everywhere. Most operators provide unlimited calls around the world for a specific monthly

price. For example, unlimited calls from the US to Ukraine at AT&T can be purchased at \$ 5 and called at \$ 0.32 [10].

Most begins when you need to choose a plan that suits your Internet traffic. The lower limit of the allocated traffic starts with 100 MB and ends, of course, unlimited. The main marketing feature is the connection in 4G / LTE networks. AT&T has the following tariff grid: 2 GB will cost \$ 30 and 5 GB will cost \$ 50. Calls and SMS across the country are unlimited. The cheapest AT&T tariff is \$ 30 (more details in Table 5).

Table 5. AT&T Tariff Plans

Price	Calls, SMS	Internet
\$ 30	unlimited in the USA	not included, \$ 2 for MB or \$ 250 for \$ 5
\$ 35	unlimited in the USA	1 GB is included, then the speed is reduced to 128 Kbps
\$ 45	unlimited (to Mexico and Canada inclusive)	included 6 GB, in Mexico and Canada, data with the possibility of transferring to the next month
\$ 65	unlimited (to Mexico and Canada inclusive)	"Unlimited" in Mexico and Canada; Policy of fair use: 22 GB, then the speed is reduced to 128 Kbps

Source: compiled on the basis of [10]

If you include automatic payment, all plans come at a discount of \$ 5 per month. Plans include unlimited domestic SMS and MMS and international SMS in more than 100 countries. You can increase the limits up to three times a month and the rest of the unused limits can be transferred to the next month. When the data limit is used, the data transfer rate will drop to 128 Kbps. The default data transfer rate outside of these packages is 1 cent per 5 KB, which is \$ 2 per MB. The \$ 30 plan contains no data at all. Therefore, it is necessary to purchase an additional data card at \$ 5, so you can use 250 MB of data [10].

Vodafone in the UK has good coverage at 2G (900 and 1800 MHz) and 3G (900 and 2100 MHz) and deploys 4G / LTE at 800, 2100 and 2600 MHz. Vodafone has the longest validity period among all network operators. They provide 180 days for any activity plus an additional grace period of 90 days before disconnecting the card [11].

Vodafone has adopted a "roaming at home" scheme and all limits can be used without additional roaming charges in the EU / EEA. Vodafone currently offers international roaming partners 4G / LTE in the UK. Some additional countries were included in the zone without additional fees: Albania, Bosnia and Herzegovina, the Faroe Islands, the Channel Islands, the Isle of Man, Switzerland and Turkey. Big Value Bundles from Vodafone are combined Internet, telephone calls and SMS plans. They are offered for 30 days, and all of them contain an unlimited number of SMS (Table 6).

Table 6. Big Value Bundles Tariffs from Vodafone

Price	Calls	Internet Traffic
10 pounds	150 minutes	500 MB
15 pounds	250 minutes	1 GB
20 pounds	500 minutes	4 GB
30 pounds	unlimited	12 GB

Source: compiled on the basis of [11]

The limits are valid in the UK and in all European countries in roaming. Internet usage in the UK is paid at £ 1 per day for 25 MB, up to a maximum of 125 MB per day, after which you are charged £ 4 per MB. Unused data is transferred to the next month. Freebee Data. Vodafone adds data limits for account replenishment. This means that a limit is issued as a bonus and is not deducted from the top-up amount.

In the fall of 2017, Vodafone launched a new £ 1 plan for casual users. Under this plan, you pay 20 pennies for 5 MB (both for text and minimum) to a daily cap of £ 1. When you reach £ 1 a day, you get unlimited calls and SMS, and up to 500 MB of data. The day is valid from midnight to midnight British time. The same assistance is provided for EU / EEA roaming, based on the time

zone associated with the roaming capital. For additional data, you can add 500 MB once a day for £ 1 to 2345. Thus, the maximum data consumption is 1 GB per day under this plan.

Table 7 highlights the advantages and disadvantages of each mobile operator.

Table 7. Advantages and Disadvantages of Mobile Leaders

Company	Advantages	Disadvantages
China Mobile	the largest player in the Chinese cellular market, providing the most complete portfolio of communication services for subscribers	prices for communication services are on average higher than those of competitors
Vodafone	the largest player in the Chinese cellular market, providing the most complete portfolio of communication services for subscribers	not the highest quality of one of the most relevant services today - mobile data transmission, prices are slightly higher than prices of competitors.
AT&T	high speed internet, unspent traffic moves to next month	if the subscriber did not have time to replenish the account in time, the operator threatens not only to disable services, but also nobody will call and no SMS will come.

The image of a modern telecommunications player consists of the following key components: the quality of products and services, their diversity in the operator's portfolio and compliance with the needs of the subscriber, and, finally, the cost of these services. A comparison of the services' portfolio of the international mobile market leaders is given in table. 8.

Communication services provided by telecom operators in China and the United States follow the global industry trends in communication services: the subscriber is offered with mobile Internet access services, broadband access from home, pay TV services, and of course a full package of traditional wired and wireless voice services.

Table 8. Comparative Portfolio of Leaders-Mobile Operators' Services

Service	China Mobile	Vodafone	AT&T
Voice mobile communication	+	+	+
Voice mobile communication	-	+	-
Messaging	+	+	+
Mobile Internet	+	+	+
Home Internet	-	+	-
Mobile TV	+	+	+
Home TV	-	+	-
Banking services	-	+	-
Navigation services	+	+	+

The difference from the UK market is that Chinese and US operators have not yet come to the need to change their strategy and look for business growth points outside the telecommunications sector, such as banking. The reason for this state of affairs is the maturity of the Chinese and American telecommunications markets and the available space for further penetration growth.

Thus, the Chinese and American markets, as well as the UK market, have access to the full range of wireless telecommunications services, including Internet access, but, unlike the UK market, modern fixed infrastructure and non-telecom businesses (such as banking services) provided by telecom operators are less developed.

5. Conclusions

The International Telecommunication Union (ITU) constantly monitors the rates of fixed and mobile communications' development, as well as development of Internet access in the world, individual regions and countries. According to the experts of the union in 2019, the number of mobile users should increase to

7377 million people, and Internet users – to 3488 million people. It should be mentioned that China Mobile – China (over 860 million people), AT&T – USA (over 245 million people) and Vodafone (over 720 million people) are the largest companies in the world and their regions, respectively.

Comparing the leaders of the international mobile market (China Mobile, AT&T, Vodafone), it was found that communication services provided by telecom operators in China and the United States, repeat the global industry trends in communication services: the subscriber is offered with mobile Internet access services, broadband network access from home, pay TV services, and of course a full package of traditional wired and wireless voice services. The difference from the UK market is that Chinese and US operators have not yet come to the need to change their strategy and look for business growth points outside the telecommunications sector, such as banking. The reason for this state of affairs is the maturity of the Chinese and American telecommunications markets and the available space for further penetration growth.

After analyzing the leaders of the international market for mobile services on such indicators as: availability of radio network and services, completeness of service, continuity, quality of customer service, we concluded that the international leader in mobile quality is China Mobile, but all mobile operators, which were analyzed, showed compliance with the established levels of mobile services' quality. Modern mobile operators provide their subscribers, in general, a similar set of services. This set includes products and services without which the full use of a mobile phone is impossible, such as voice communication, messaging services, Internet access. In addition to this basic set of services, each operator seeks to provide its subscribers with something special, such as access to the Internet at home on a fixed line, and on the street, via cellular communications, digital television, bank payments, etc. It is due to such "special" services that the operator is differentiated in the subscriber's imagining.

6. References

1. Zhavoronkova G., Zhavoronkov V., Klymenko V. Economic aspects of the development of information and communication technologies of Ukraine // Industry 4.0. 2/2018. P.97-100.
2. Ладиченко К.І., Тронько В.В. Сучасні тенденції розвитку світового ринку інформаційно-комунікаційних послуг, Дніпро: Дніпропетровський державний аграрно-економічний університет, 2019. С.145-152.
3. Country ICT data (until 2019) / ITU World Telecommunication. URL: <https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx>. (10.05.20).
4. Parietti M. The World's Top 10 Telecommunications Companies, 2020. URL: <https://www.investopedia.com/articles/markets/030216/worlds-top-10-telecommunications-companies.asp> (10.05.20).
5. ICT Facts and Figures 2019 // International Telecommunication Union. URL: <http://www.itu.int/en/Pages/default.aspx> (10.05.20).
6. Сардак С.Є., Ставицька А.В. Дослідження структури і тенденцій розвитку світового ринку інформаційних технологій // Технологический аудит и резервы производства, 2019. № 4/5 (24). С.96-100.
7. Cisco. URL: https://www.cisco.com/c/ru_ru/about/press/press-releases/2014/06-061814b.html (09.05.20).
8. Синица С.А. Анализ тенденций развития глобального рынка телекоммуникационных услуг // Вестник Евразийской науки, 2019. №1. Том 11. С. 9-18.
9. China Mobile URL: <https://simki.shop/internet-v-kitae/sim-karta-china-mobile-v-kitae> (10.05.20).
10. AT&T (Go Phone) CIIA URL: <https://simki.net/sim-karty-ssha/at-and-t-go-phone-ssha/> (10.05.20).
11. Vodafone GB URL: <https://simki.shop/internet-v-anglii/sim-karta-vodafone-v-anglii> (10.05.20).

Creation of a New Marketplace

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Abstract—Creating a new marketplace requires a different template of strategic thinking. Instead of searching within the accepted boundaries that define how we compete, managers can look systematically on them. In addition, they can find a free territory that represents a real breakthrough in value. This section will describe how companies can systematically follow the value of innovation by looking at the defined limits of competition - through alternative industries, through strategic groups, through customer groups, through complementary products and service offerings, through the functional - economic guidance of the industry, and even over time.

KEYWORDS—MARKET, CURVES OF VALUES, INDUSTRY, CUSTOMERS.

1. Introduction

Asystemic approach to innovation values can help companies get rid of competing groups.

Direct competition can be disastrous, especially when trades are poor or slow. Managers caught up in this kind of competition almost always say that they did not want them and would like to find a better alternative. They usually instinctively know that innovation is the only way in which they can get rid of competitive groups. But they just do not know how to start. Tips to improve more creative strategies or not to think limited are rarely followed by practical conclusions.

Companies that have created such a fundamentally new and superior value have searched for the way in which the companies make new trade and rebuild their existing ones. All came from a search in close-ups from a new perspective and none required any particular vision or prediction of the future.

A large number of companies focus on adaptation and winning of their rivals, and as a result of their strategy, they tend to lean towards the same basic dimensions of the competition. These companies share an understandable set of beliefs such as "how we compete in our industry or in our strategy group, R. Trill [1]. They share common wisdom about who their customers are and what they value, and about the way products and services their industry needs to offer. The more companies that share this common wisdom about how to compete, the greater is the co-competitiveness of congruence. As the rivals try to outperform each other, they only compete in the competition only on the basis of increased improvements in price or quality, or both.

2. Creation of the new value curves

Value curve - a graphic description of how a company or industry shapes its offer to its customers - is a powerful tool for creating a new market. Nartana by constructing an act of sacrificing relatives to other alternatives along successful factors that define competition in the industry or category, ICM [2].

To identify these alternatives, Intuit, for example, asked software within its industry to provide personal income, and also sought through alternative products to understand why customers opt for one rather than others. The main alternative to the software was a small pencil. The value curves for these two alternatives compile a map of the existing competitive space.

The schematic representation offered relatively high levels of speed and accuracy. But customers usually choose a pencil because of its price advantage and ease of use, and most customers have never used the arbitrary features of the software, adding value and complexity to the product.

We are looking at the Home Depot, a company that has rebounded self-service outlets in North America. For the past 20 years, the Home Depot has become worth 24 billion dollars, creating more than 130,000 new jobs in more than 1,100 businesses in America. Home Depot did not reach that level of growth by an erection of the division of the market away from other ironmen; more precisely, it created new self-service outlets from usual

domestic intermediaries.

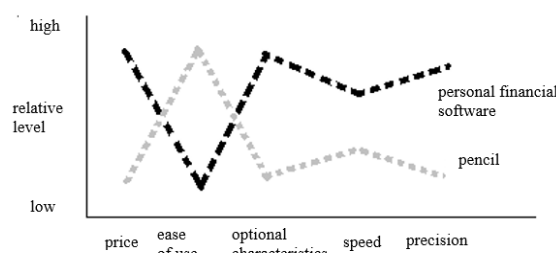


Fig. 1. Key elements of the product, service and delivery

There are many explanations for the success of Home Depot: its shape of the possibility, its relatively low-cost business locations; its well-informed service; its combinations of great offers and low prices cause great power and savings of large proportions. But such explanations miss the most futuristic question: Where did the Home Depot gain its original insight into how to rebel and expand its market?

The Home Depot has looked at existing industries that provide services for the needs of household progression. It has been seen that people have two choices: they can hire a vendor or can buy tools and materials from the ironman and do the job themselves. The key of the Home Depot original insight was the understanding of why the customers would choose one alternative rather than another.

Why do people rent a supplier? Surely not because they like to have tomorrow in their house who will fix them for the highest price. Certainly not because they enjoy taking time off the job while waiting for the supplier to appear. However, professional suppliers have only one decisive advantage specializing in "how to know", in which homeowners lack.

And knowledge in the executive departments of the Home Depot - succeeded in their mission to spur the possibility and trust of customers whose skills in the home are limited. They attract sellers with significant commercial experience, usually carpenters or painters. These assistants are exercised to lead customers throughout any installation of a kitchen cabinet project, on the occasion, or the construction of roof. Home Depot proposes an *in-store* counseling service that teaches customers about the skills such as electric wiring, wiretapping and plumber skills.

To understand the rest of the Home Depot formula, consider a quick overview: Why are people choosing actions instead of a professional supplier? The simplest response would be to save a new one. Most people can work without occurrences that complement one typical action. They do not need city locations, neighborhood services, or nicely exposed shelves, R. M. Stojanović [3].

And so Home Depot eliminated these expensive attractions, using a form of self service that constantly drops and maintains prices, creates savings on the level of supply, and minimizes exports.

Essentially, Home Depot offers the ability of professional home

vendors at remarkably low prices than in business. By releasing the decisive advantages of both alternative industries and eliminating or restricting everything else - the Home Depot has changed the great hidden need to progress the household to the real need.

3. Creating a new value curve

Intuit, a company that has changed the way in which individual and small businesses run their finances, also gained insights into value innovation by thinking customers are trading through alternatives. Its Quicken software allows individuals to organize, understand and manage their personal finances.

Every household goes through a monthly fatigue payment. Therefore, mainly, personal financial software can be a large and spacious market. But before Quicken, several people used software to automate this tedious and repetitive task.

At the giving up time of Quicken in 1984, 42 existing software packages for personal finance nevertheless broke the market, B. Đorđević i R. M. Stojanović [4].

Why? Just as Intuit's founder Scott Cook remembered: "The biggest competitor we had was not in the industry. It was a pencil. The pencil is a very solid and elastic replacement. Moreover, the entire industry anticipated it"

Examining why buyers are trading through an alternative has led Intuit to an important perception: the pencil has two decisive advantages over computerized solutions - incredibly low prices and ultimate ease of use.

Starting from about \$ 300, existing software packages were too expensive. They were also difficult to use, representing terrifying interfaces with full accounting terminology.

Intuit focuses on discovering both the decisive advantages that a computer has against the pencil; speed and reliability - and the decisive advantage that the pencil has against the computer; ease of use and low cost - and eliminated, or limited everything else.

Responding to four questions led the Institute to create a new value curve that connects the low cost and ease of using the pencil with the speed and accuracy of the traditional personal-financial

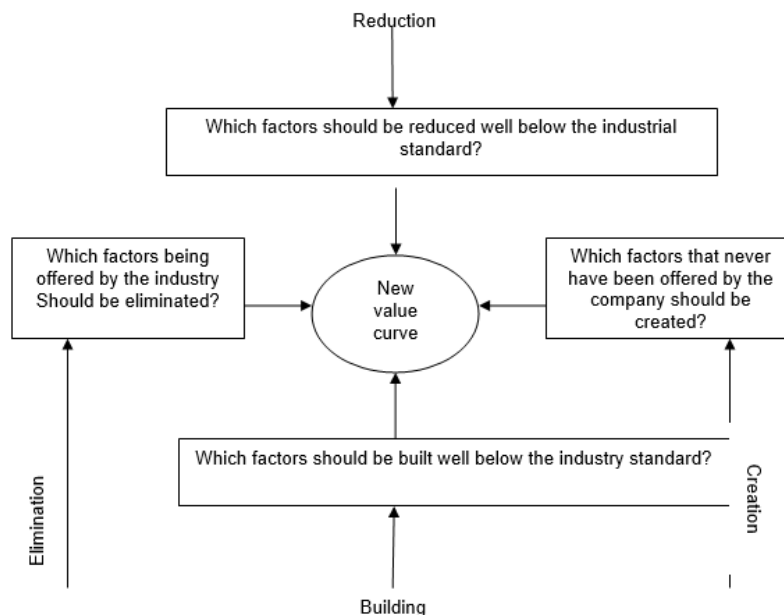
schematic view. It's far faster and more precise than a pencil, perhaps even simpler to use. Intuit eliminated the evaluated jargon and all the more sophisticated features that were part of the usual industrial wisdom about how to compete. It offers only a few basic functions that most customers use. Simplifying the project software costs, Quicken sells for about \$ 90, 70% lower price. Neither the pencil nor any other software packages can compete with divergent value curve of Quicken. Quicken created a breakthrough in value and recreated the industry, and developed the market somewhat over put together. (See "Creating a new value curve."), B. Đorđević [5].

There is a further lesson that talks about the way Intuit thought and glanced through alternatives. In observing other products or services that can fulfill the same function as its, Intuit can focus on private accountancy firms that submit individual finance. But when there is more than one alternative, it's wise to explore those with the highest strengths in the application as well as in the value of dollars. By establishing this, more Americans use pencils than accountants in managing their personal finances.

4. Viewing through strategic groups in the industry

Just as the new marketplace can be found by observing through alternative industries, it can also be found by observation through a strategic group. The term refers to a group of companies within an industry that follows a similar strategy. In most industries, all fundamental mental differences between industrial players are trapped by a small number of strategic groups.

Strategic groups can generally be classified into a rough hierarchical order built into two dimensions, cost, and achievement. Every jump in price strives to deliver a proper jump in some dimension of achievement. A large number of companies focus on proving their competitive business within a strategic group. The key to creating a new marketplace through the existing strategic groups is that the factors that determine the choices of customers to trade from one group to another.



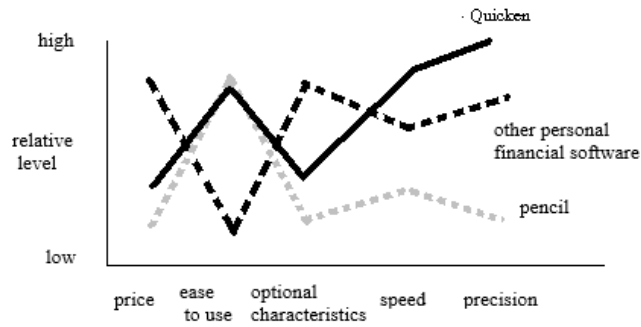


Fig. 2. Value curve of the Quicken

We are looking at Poll Ralf Lorena, who created a completely new and paradoxical market in wardrobe: high fashion without fashion. With worldwide well-known retail sales exceeding \$ 5 trillion, Ralf Loren is the first American to successfully spread his brand across the globe.

At the beginning of the career of Paul Ralf Lorraine, more than thirty years ago, experts of all the scale of the fashion industry criticized the company. Where are they, they asked, here's the fashion? A lack of creativity in design, so how can Ralf Loren reach such a high estimation? But the same people who criticized the company bought his clothes, as did a bunch of people around the world. Loren's lack of fashion was his greatest strength. Ralf Loren built on the decisive advantages of two strategic groups dominated by a large chain of clothing stores - designers of quality creation and the largest amount, but poorly paid, classical lines of Burberry, Brooks Brothers, Aquascutum and the like, J. Hayes [6].

What causes people to trade and choose between quality design and classic lines? Most buyers do not trade high-quality creations to reach an unoccupied, fast-paced fashion. They also do not enjoy paying funny prices that can sometimes reach up to \$ 500 per t-shirt. They buy clothes of quality design because of their sense of value because they wear the brand of an exclusive designer, the name that says, "I am different; I appreciate better things in life." They also love the beautiful luxurious feel of the material and the beautiful dressing of clothes.

Design trends of fashion houses work very hard to create and they are, ironically, the main disadvantage of quality design for most of the leading customers, from whom the couple has distortion or bodies for wearing such original clothes. Moreover, customers who opt for classical lines and not for high-quality design want to buy quality clothes that will last and justify their high price, L. J. Harold [7].

Ralf Loren built his brand in the space between these two strategic groups, but it did not succeed in taking the average group differences. Instead, Loren realized the superiority of the market. His designer name, the elegance of his business, and the luxury of his materials are what most of customers appreciate in a quality design; his contemporary classic came out and prices got the best of the classic line. By combining the most attractive factors of both of them, and eliminating or limiting everything else, Polo Ralf Loren

has not yet got a part from both segments, but he also dragged a large number of customers into every store.

5. Observation through a chain of customers

In most industries, more competitive clothing is about a simple definition: who is the target customer, when in reality there is a chain of "customers" that are directly or indirectly involved in the purchase decision. Customers who pay for a product or service may be different from actual users, and in some cases there are important influences.

When they succeed, they often have different definitions of value. A corporate sales agent, for example, may be more concerned about prices than a purchasing user, which is probably far more concerned about ease of use. Likewise, a trader can appreciate the manufacturer's right on time to the ultimate supply and the latest finances. But consumer buyers, even though they have a strong influence on them, do not appreciate these matters.

Individual companies often have different customers of large segments against small customers, for example. But the industry typically leans towards the group of customers. For example, the pharmaceutical industry focuses on influential doctors. The office equipment industry is hardly focusing on expensive - the corporate purchasing department and the clothing sales department mainly to its customers. Sometimes there is a strong economic reasoning for this focus. But it is often the result of industrial exercises that have never been tested.

Challenging the usual industrial wisdom about which target group of customers can lead to the discovery of a new marketplace. By observing through customer groups, companies can achieve a new insight into how to reconstruct their value curves in order to focus on the previous accompanying set of customers.

We're watching Bloomberg. For a bit more than a decade, Bloomberg has become one of the world's leading and best-selling business intelligence providers. Until the Bloomberg's debut of the early eighties, Reuters and Temperate were ruling on-line with the financial-informational industry, providing novelty in a real-time brokering and customer investment. The industry is focusing on customers of IT managers - who value standardized systems, which have made it easier for them to live their lives.

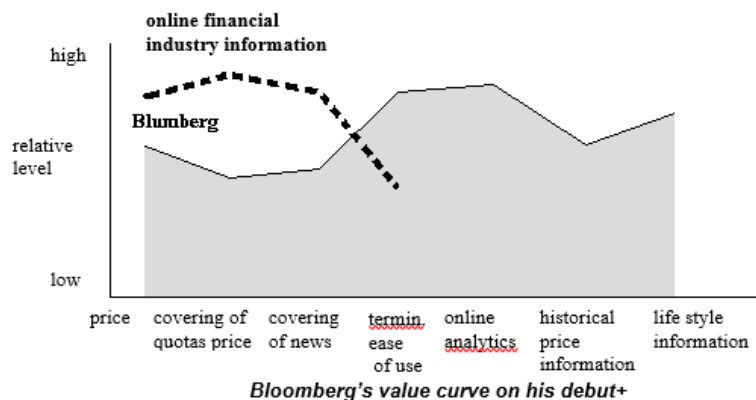


Fig. 3. Key elements of the products, services and deliveries

In order to prove his value curve, Bloomberg looked through a customer IT chain that traditionally offered financial information systems to the markets that used them. Its value innovation has been driven by a combination of the creation of new features - such as on-line analytical conveniences - which traders esteem more than IT managers and encourage ease of use under the influence of importance.

6. Conclusion

Many industries offer similar opportunities to create a new market space. Examining the common definitions of who can and who needs to be a customer, companies can often see fundamentally new ways to value. Most companies are additionally adapted, and somewhat passive, as they develop. Whether it is the emergence of new technologies or the main control changes, managers tend to project trends themselves. They wonder where the law will evolve, how it will be accepted, and whether it will become appraisal. They are raising their own actions to keep up with the development of the trends they follow.

By identifying a trend of this nature, managers can look back over time and ask themselves how the market would look like a trend is guided by its logical conclusion. Working back from this vision of a new value curve, they can then identify what has to be changed today to unlock superior value for customers.

It is no wonder that corporate leaders in the world see the creation of the market as the central strategic challenge of their organizations in the coming decade. They understood that in a crowded and outcast economy, profitable growth is not sustainable without creating, and recreating the market. This is what enables small companies to become big and big companies to regenerate.

References

- [1] R. Trill: Krankenhaus-Management, Luchterhand, Berlin, 1996.
- [2] ICM, The Inside Careers Guide to Management Consultants, London: Cambridge Market Intelligence Limited, 2003.
- [3] R. M. Stojanović: Strategija u ekonomiji. FIM Kruševac. 2007.
- [4] B. Đorđević i R. M. Stojanović: Strategijski menadžment. IP „Rad“ Beograd, 2013.
- [5] B. Đorđević: Izazovi menadžmenta, Ekonomski fakultet Priština - Blace, 2001.
- [6] J. Hayes: The theory and Practice of Change Management, Basingstoke, Hampshire: Palgrave, 2002.
- [7] L. J. Harold: "Managerial Psychology", University of Chicago Press, 1978. Mann Nany R, The Keys to Excellence, Prentice Hall, 1987.

Investigation of the degree of maturity of bio-enterprises in relation to the global sustainable development goals

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Abstract: Growing environmental problems and the uneven distribution of wealth around the world raised questions more than forty years ago about how to achieve sustainability. The United Nations Commission on the Environment and Development (WCED), formed in the autumn of 1983 and chaired by Gro Harlem Brundtland, draws accurate and concrete conclusions using full information from all over the world on the state of the planet and develops a report called "Our Common Future". Along with all the conclusions and recommendations, the Brundtland report introduces the concept of "sustainable development" which reads: Sustainable is a development that achieves the vital needs of the current generation without being deprived of it (ie without The leading aspect in this definition is the idea of reconciling the satisfaction of human needs with the limited resources, as well as the equality between the present and the future generations. The report demonstrates the need for a radical change in human activity to date and the need to establish sustainable development on a global scale. The conference in Rio de Janeiro (Brazil) in 1992 played a crucial role in affirming the concept of sustainable development in modern society, combining the harmonious interaction between economic prosperity, social justice and a preserved environment. The purpose of this report is to present the results of a study on the degree of maturity of management in bio-sector enterprises to adopt global sustainable development goals and link them to their business practices. The results of the present study confirm the thesis that the modification of the current socio-economic model of development there is no alternative. The main non-reproducible energy and raw materials sources are about to run out in the foreseeable future.

Keywords: BIOECONOMICS, BIO-ENTERPRISES, SUSTAINABLE DEVELOPMENT

1. Introduction

The conference in Rio de Janeiro (Brazil) in 1992 played a crucial role in affirming the concept of sustainable development in modern society [1], combining the harmonious interaction between economic prosperity, social justice and a preserved environment [2]. The concept of sustainable development has been expanded as "a process of change in which the exploitation of resources, investment orientation, technology orientation and institutional changes are in harmony with each other and increase the current and future potential to meet human needs and aspirations" [3]. This wording in practice links the environmental aspect with the economic and social side of the problem of sustainable development of society [4]. The most important document from the meeting is the previous Program for Global Sustainable Development called "Agenda 21" ("Agenda 21" - a document of 900 pages with 4 main sections) [5]. The program is (contains) a global action plan that outlines priorities for sustainable development in the XXI century. The UN General Assembly is taking special measures to turn Agenda 21 into a national policy and program for solving the world's environmental problems [6].

In Fig. 1 presents some important historical moments in the long road to the recognition of a common, international institutional framework for sustainable development.

1972	• Stockholm Conference, which initiates the cultural and political path to sustainable development
1992	• Conference in Rio de Janeiro, where "Program 21" related to the goals of humanity for the environment and the economy is launched
1999	• Davos. UN Secretary-General Kofi Annan launches global pact between UN and private sector and UN Global Compact is established
2000	• Millennium Summit. The Millennium Declaration is signed, which launches the Millennium Development Goals (2000-2015)
2012	• Conference for sustainable development Rio + 20. The support of all participants in the course of sustainable development as an opportunity for world development is confirmed.
2015	• The Third International Conference on Financing for Sustainable Development took place in July. The Addis Ababa Development Program has been published.
2015	• In September 2015, all UN member states (193) approved the 2030 Agenda with its Sustainable Development Goals.
2015	• United Nations Framework Convention on Climate Change. The signing of the Paris Climate Agreement in Paris took place in December 2015
2016	• The goals for sustainable development come into force in January 2016.

Fig. 1. Historical moments in the institutional framework for sustainable development

As early as the early 1990s, a broad international consensus was formed on a network of principles and goals for sustainable development, known as the paradigm for the effectiveness of development aid, set out in the Millennium Development Program. Historically, two periods are formed for the implementation of the Development Goals in 15-year time ranges (see Table 1). In the first period, in 2000, at the Millennium Summit, the Millennium Declaration was signed, which launched the Millennium Development Goals in the period 2000-2015.

	SDGs (2000 – 2015)	SDGs (2015-2030)
Goals	8	17
Tasks	18	169
Indicators	48	230

Source: UN

Table 1. Comparison of the Sustainable Development Goals (2000-2015) and (2015-2030)

Two years before this deadline, after intensified negotiations in order to set global development goals for the new period (2015-2030), the international community is preparing (with the widest possible representation of all stakeholders) a new, more ambitious a package of goals for the next 15 years, taking into account the experience gained and the state of the world [7]. The new Sustainable Development Goals are natural successors to the Millennium Development Goals (MDGs). They were adopted in August 2015 in New York, during the 70th UN General Assembly. At the event, the world leaders of 193 countries (193 UN member states, two observer countries and 11 other countries) agreed to achieve a better future for all and adopted a new global framework for sustainable development, the "2030 Agenda", called "Let's Transform the World" [8], [9]. It reflects the first international consensus reached that peace, security, justice and social inclusion for all should not be just separate goals, but mutually reinforcing" [10], [11]. The program is considered to be crucial for sustainable development worldwide. It sets 17 Global Goals with 169 specific sub-goals, balancing the integration of the three aspects of the concept of sustainable development - economic, social and environmental and outlining the path for sustainable development of the Planet for the period up to 2030" [12], [13]. They are universal, inclusive and relevant. for all countries in the world" [14], [15], [16].

2. Exploration

The European Union, together with its Member States, is playing a leading role in implementing the 2030 Agenda and achieving the Sustainable Development Goals. Although in the period up to 2020, Europe can point to good results on each of the set targets, it is planning additional targeted actions to meet each of the 17 global targets by 2030, and is preparing to achieve more long-term goals in the horizon until 2050 [17].

In this regard, on 20.01.2020 with Decision № 33 of the Council of Ministers the National Development Program "Bulgaria 2030" was approved, which covers the 17 global goals for sustainable development. This is the latest framework strategic document of the highest order in the hierarchy of national programming documents, determining the vision and general objectives of development policies in all sectors of government, including their territorial dimensions [18]. According to the document, the vision for Bulgaria is to become a country with a high standard of living and a competitive, low-carbon economy by 2030. The document provides predictability of the environment for generating innovative ideas and attraction for investment and human capital.

The Bulgaria 2030 Program defines three strategic development goals (see Fig 2).



Fig. 2. Strategic goals in the Bulgaria 30 program

The guidelines for the implementation of the set three goals are grouped in five strategic areas (axes) of development, as 13 national priorities are raised, presented in Fig.3.

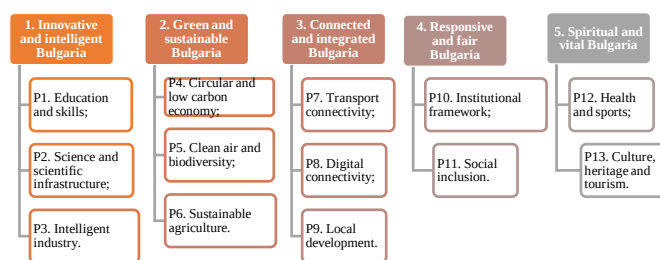


Fig. 3. Strategic areas and priority areas in "Bulgaria 2030"

The bio-enterprise sector is of strategic importance for achieving the goals of sustainable development. Data from the European Commission's research center show that the turnover of bio-sector enterprises by 2019 in the EU as a whole is over 2.3 trillion euros. The workforce employed in various sectors (mainly the agricultural and food sectors) accounts for 8.2% of the EU-28 workforce, which is over 18 million people. The industry estimates that by 2030, more than one million new jobs can be created in the bio-industry. A strong and fast-growing ecosystem of start-ups will play a leading role in realizing this potential. These indicators place the bioeconomy among the main elements for the successful realization of global goals.

Building a more sustainable bioeconomy contributes to building:

- a future that is carbon neutral, in line with the climate goals of the Paris Agreement;
- reduction of greenhouse gas emissions in the European energy sector. Bioenergy, the largest renewable energy source in the EU, is expected to remain a key component of the energy mix until 2030 and to contribute to meeting the EU's renewable energy targets.
- modernizing and strengthening the EU's industrial base by creating new value chains, as well as greener and more cost-effective industrial processes.

- Bioeconomy is the renewable segment of the circular economy. It can turn bio-waste and residues into valuable resources and create innovations and incentives to help producers and consumers reduce food waste by 50% by 2030.
- contributes to achieving neutrality with regard to land degradation and to realizing by 2020 the ambition to restore at least 15% of degraded ecosystems.

A survey of managers of bio-sector enterprises in Bulgaria shows the degree of knowledge and perception of the goals of sustainable development and how they intend to engage companies to achieve them.

- Engagement on the SDGs (Fig 4).

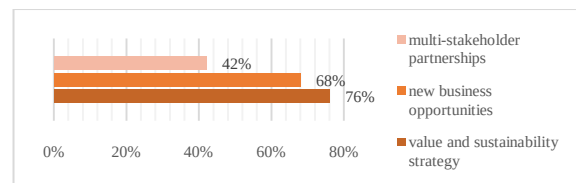


Fig. 4. Perception by business

The results show that:

- 76% believe, that it is important to address the SDGs as a part of their company's corporate values and sustainability strategy.
- 68% say that the SDGs offer new business opportunities=
- 42% report that the SDGs are important to improve multi-stakeholder partnerships.

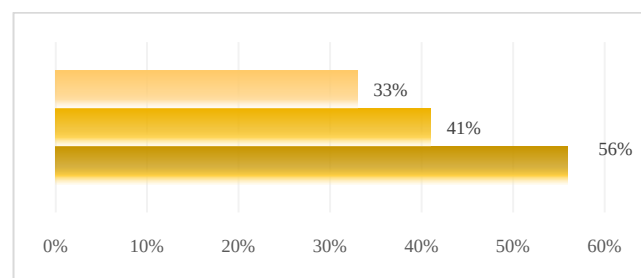


Fig. 5 Challenges for companies

Main Challenges that companies face in engaging with SDGs (Fig. 5). The results show that:

- 56 % say that limited/low social awareness and stakeholder demand on the SDGs are the primary challenges that their company faces
- 41 % indicate that there is no clear approach or direction for how they should implement the SDGs
- 33% cite that a lack of commitment and policy from Government is also a key challenge.

- Actions the Bulgarian government can take to encourage businesses to integrate SDGs. (Fig. 6)

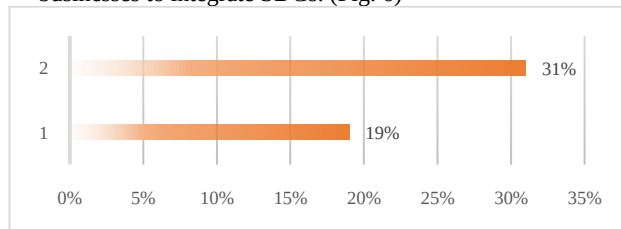


Fig. 6. The role of the state

The results show that:

- 19% suggest the development of a more supportive regulatory framework and policies that can guide businesses to integrate and implement the SDGs.
- 11% recommend greater support from Government in setting and achieving SDG goals.

An opportunity for more internal engagement. (Fig.7)

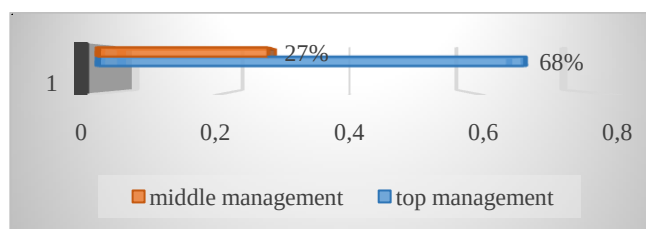


Fig. 7. Internal engagement at management levels

The results show that:

- 68%/ of top management report that the SDGs are well-known by top management
- 27 % of middle management believe the SDGs are well-known by middle management.

- Ranking of all SDGs based on priority areas for business to focus on. The results are summarized in fig. 8.



Fig. 8 Ranking of priority goals for business

Bio-enterprises have a crucial role to play in achieving each of the global goals and overcoming the challenges they pose to modern society:

- ❖ **Goal 1:** Eradicate poverty - Bio-enterprises can contribute to providing jobs for the poor. To this end, efforts need to be focused on the segments of the economy in which the largest numbers of the poor participate: micro and small enterprises.
- ❖ **Goal 2:** Zero hunger - can support local farmers by preferring foods produced in a sustainable way or participating in the fight against food loss.
- ❖ **Goal 3:** Good health and well-being - can educate people about the importance of good health and a healthy lifestyle and the right of people to receive quality health care.
- ❖ **Goal 4:** Quality education - in order to participate in solving this problem, bio-sector enterprises can invest in the development of material and methodological educational base.
- ❖ **Goal 5:** Gender equality - to invest in programs to introduce women to income-generating activities.
- ❖ **Goal 6:** Clean water and sewerage - through rational use of water resources, investment in research and development of water supply, promotion of hygiene.
- ❖ **Goal 7:** Affordable and clean energy - maintenance and protection of ecosystems for the use and further development of hydropower and bioenergy; encouraging the use of bicycles, public transport or walking to reduce carbon emissions.
- ❖ **Goal 8:** Decent work and economic growth - providing equal opportunities for people to find productive work, regardless of gender, income or socio-economic status.
- ❖ **Goal 9:** Industrialization, innovation and infrastructure - investments in transport, irrigation systems, energy supply, information and communication technologies.

They are needed to stimulate productivity and income growth, and this affects health and education.

- ❖ **Goal 10:** Reduce inequalities in countries - investment in transport, irrigation systems, energy supply, information and communication technologies is needed to stimulate productivity and income growth and improve health and education outcomes.
- ❖ **Goal 11:** Sustainable cities and towns - achieving universal access to adequate, safe and affordable housing and the renewal of slums.
- ❖ **Goal 12:** Responsible consumption and production - reducing waste production and seeking new solutions for the transition to sustainable consumption patterns by training people in this field.
- ❖ **Goal 13:** Combating climate change - innovation and long-term investment in energy efficiency and low-carbon development.
- ❖ **Goal 14:** Protection of marine ecosystems. Protecting the oceans, preventing the release of debris into the oceans, reducing the use of plastic products to the lowest possible level, organizing cleaning of coastal areas.
- ❖ **Goal 15:** Protection of terrestrial ecosystems - recycling, use of local sustainable foods, reduction of energy consumption through efficient heating and cooling systems.
- ❖ **Goal 16:** Peace, justice and strong institutions. Bio-business can raise awareness of violence and the importance of building a just society. It is necessary to promote social inclusion and respect for people of different backgrounds, ethnicities, religions, genders, sexual orientations and worldviews.
- ❖ **Goal 17:** Partnerships for Sustainable Development - work with governments, civil society, researchers and academics.

Bio-sector enterprises perceive the concept of sustainable development as a balance between the economic interests of business, the environment, employees, society and future generations. In this regard, their commitment to the concept is focused on the following areas:

- Products and packaging must be designed in such a way as to ensure their safety throughout their life cycle. It is necessary to increase the relative share of recyclable materials used in the production of products and packaging. In parallel, the energy used in the production process must be generated from renewable and environmentally friendly energy sources.
- Services to be organized and implemented in order to meet real human needs. They must be based on the principles of justice and equality.
- Waste and environmentally incompatible products must be reduced, destroyed or recycled.
- Chemical and physical substances, agents and conditions in the production and sale of products that pose a danger to human health must be eliminated. The products must not contain substances harmful or dangerous to human health or to the ecological balance.
- Achieving energy and resource efficiency.
- Workplaces and technological processes in enterprises must be designed in a way that minimizes or eliminates chemical, ergonomic, physical and other types of risk.
- The business organization should be oriented towards increasing the efficiency of the use of human capital.
- Safe, healthy and dignified working conditions must be provided in enterprises.
- Enterprise staff must be paid fairly for their work and supported through economic incentives, cultural diversity and social engagement.
- The long-term economic and financial stability of the production enterprises is ensured.

Conclusion

Sustainable development is “socially just and environmentally friendly”. Social justice is given priority criteria for the nature of the interaction between the four: ecology, economy, social sphere and institutional structure. This is new approach, compared to the prevailing understanding of the leading principle of environmental criteria, and the expression of this position in models for “eco-economy” and “natural capitalism”.

In addition, on its nature and end results environmentally friendly development is social fair. The level of environmental friendliness is a key indicator for standard of living. On the other hand, the institutional dimension is integrated into “social justice” and “Environmental friendliness”, because both are achievable only if they are created the relevant institutional structures and are adequately implemented regulatory mechanisms.

By itself, a market economy does not provide sustainability of development. In many cases, it leads to the exact opposite results - the rich get richer and the poor get poorer. Environmental protection environment is in conflict with the desire to optimize the corporate profit. But the contradiction between some of the principles of market economy and sustainable development is surmountable. Moreover, their mutual is possible complementarity so that, under appropriate conditions, market incentives are used to achieve sustainable development. Environmental standards are difficult but consistently imposed the world market, in investment policy, in interstate economic and political relations. The analyzes show that developed and even some developing countries, rethink the directions of their economic policy, the structure of their holdings, the ranking of their strategic interests. For It would be extremely important for Bulgaria to achieve a gradual and well-balanced change in the structure of the national economy. The current structure, inertially following the development of industries and productions with high resource and energy consumption, low usability of raw materials, the heavy environmental heritage and continuing high pollution rates, technological backwardness and relatively low competitiveness, etc., show that we already are delayed in implementing sustainable development mechanisms. The Bulgarian economy could not withstand serious prices shocks due to the current structure of the economy, characterized by high energy and raw material dependence on imports, nor to compensate these price differences with a sufficiently competitive market product.

The results of the present study confirm the thesis that the modification of the current socio-economic model of development there is no alternative. The main non-reproducible energy and raw materials sources are about to run out in the foreseeable future.

The study shows that the bio-sector in Bulgaria knows the global goals for sustainable development and is ready to meet the challenges that these goals pose to its development.

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References:

- [1]. Gupta, Shr. (2012), Incentive-Based Approaches for Mitigating Greenhouse Gas Emissions: Issues and prospects for India, Working paper series, Julian Simon Centre for Policy Research, Liberty Institute, New Delhi, p.3.
- [2]. Sterner, Th. Policy instruments for a Sustainable Economy, in: Economic Policies for Sustainable development, Ed. By Thomas Sterner, Ch.1, p.12, The Netherlands: Kluwer Academic Publishers, 2014
- [3]. Wackernagel, M., Schulz, N., Galleias, L., Linares, A., Deumling, D., Martin, A., Jenkins, M., Kapos, V., Monfreda, C., Loh, J., Myers, N., Norgaard, R., and Randers, J., (2012). Academy of Sciences (PNAS), <http://www.eldis.org/static/DOC10649.htm>
- [4]. National Strategy in the Field of Energy (with Focus on Electric Power Engineering) BAS, Sofia, 2017.
- [5]. Meadows, D., Meadows, D. and Randers, J., (2014), Limits to Growth: The 30-Year Update, Chelsea Green Publishing Company
- [6]. Matthews, J., Munday, M., Roberts, A. & Williams, A. (2003). An Index of Sustainable Economic Welfare for Wales, the ERSC Centre for Business Relationships Accountability Sustainability and Society, Cardiff: Cardiff Business School, pp.3-4
- [7]. Mihova, T., Anguelov, K., (2018), Research on interactions among universities and high-technological enterprises at qualification of employees, IX National conference with international participation ELECTRONICA, Sofia
- [8]. Bioeconomy development in EU regions. Mapping of EU Member States' / regions' Research and Innovation plans & Strategies for Smart Specialisation (RIS3) on Bioeconomy. Final Report. February 2017. Framework Contract: 2014.CE.16.BAT Lot 2.
- [9]. Denmark as growth hub for a sustainable bioeconomy. Statement by the National Bioeconomy Panel. September 2014.
- [10]. European Commission. 2017. The role of waste-to-energy in the circular economy. Communication from The Commission to the European Parliament, The Council, The European Economic And Social Committee And The Committee Of The Regions Brussels, 26.1.2017 COM (2017) 34 final
- [11]. European Fat Processors and Renderers Association (EFPRA) Home Page. <http://efpra.eu/> (accessed July 25, 2018)
- [12]. Eurostat 2019 a: Structural business statistics (SBS), <http://ec.europa.eu/eurostat/web/structuralbusiness-statistics/data/database> (19-07-15).
- [13]. Monastiriotti, V and G. Petrakos (2009), Local Sustainable Development and Spatial Cohesion in Post – transition Balkans: in search in developmental model, GreeSE/GreeSE29
- [14]. Nikolova-Alexieva V., Valeva K., (2019), “Research on the development of bio entrepreneurship in Bulgaria economic-based entrepreneurship activity in the sectors of bioeconomy“ в XXIII rd International scientific conference; Knowledge in practice, Bansko, 13-15 December
- [15]. Nikolova-Alexieva V., Valeva K., (2019), Bioeconomics - a strategic sector in the circular economy, in 4TH International Scientific Conference – winter session - “Industry 4.0”, Mechanical Scientific and Technical Union - Industry 4.0, Borovets 11-14 December, 2019.
- [16]. Nikolova-Alexieva V., Valeva K.,(2019) Enhancing the competitiveness of bio-sector enterprises for stronger bio-economy“ , 4TH International Scientific Conference – winter session - “Industry 4.0”, Mechanical scientific and technical union - Industry 4.0, Borovets 11-14 December
- [17]. Peters, G. M.; Rowley, H. V.; Wiedemann, S.; Tucker, R.; Short, M. D.; Schulz, M. Red Meat Production in Australia: Life Cycle Assessment and Comparison with Overseas Studies. Environ. Sci.Technol. 2018,44 (4), 1327–1332.
- [18]. Nikolova-Alexieva V., Alexieva I., (2019), Analysis of the condition of Bulgarian bioeconomy and potential directions of its development, 22TH International scientific conference “The power of knowledge (11-13.10.2019), „Knowledge – International Journal Vol. 34.5 (doi:10.1088/issn.1757-899X) Kavala, Greece, pp. 1201-1209

Project of an experimental plant for the production of plates and granules of foam glass and composite material on this basis

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Abstract: A conceptual design of a technological line for the production on the one hand of a continuous flat strip and block and on the other hand granules and pieces of foam glass, including a ware house for raw materials, a workshop for preparation of materials, workshops for foamed granules and a continuous flat strip of foam glass, workshop for composite elements semi O, P and slabs, repair section and warehouse for finished products is presented. The necessary equipment and materials, building the technological line and functioning of the plant as a whole, are presented.

Keywords: TECHNOLOGY FOR FOAM GLASS PRODUCTION, FOAM GLASS PRODUCTION EQUIPMENT, FOAM GLASS BASE COMPOSITE MATERIAL

1. Introduction

The idea for an experimental plant, including a technological line for the production of foam glass (FG) and composite materials on this basis is very annual and is based on research experience, with the participation and implementation of several projects funded by BSMEPA at the Ministry of Economy and Research Fund at the Ministry education [1-4].

The processes of glass formation, the structure of the glassy state and the properties of different vitreous materials have been studied by a number of authors [5-12].

Foam glass as an insulating material has high chemical resistance, mechanical strength, sound and temperature resistance. It does not destroy under the influence of atmospheric conditions, does not burn and retains its mechanical and thermal insulation properties at temperatures up to 600°C. Foam glass is superior to similar known thermal insulation materials in terms of thermal conductivity, mechanical strength and moisture absorption in combination. The thermal insulation made of foam glass has a lower cost and higher operational resistance, does not require frequent repairs, which are typical for other materials. It has good sound insulation properties as it absorbs sound oscillations of different frequencies. Foam glass materials are easily machined and easily bonded to various building materials and elements, due to the uniform nature of its material - silicate compounds. The combination of the features and different properties of the foam glass allows its wide application in the form of blocks and plates such as solid foam glass and granules and pieces with a binder as a composite material for making structural elements from them and from solid foam glass, as well as independent use of granules and pieces as bulk material. All these types of materials are used to make thermal insulation in construction, shipbuilding, machinery, units, etc.

The resulting composite material consists of foam glass granules and a binder in the form of an aqueous dispersed colloidal system, including Portland cement in an amount of 92 ÷ 98% by weight and zeolite in an amount of 2 ÷ 8% by weight with a particle size similar to that of Portland cement and water in an amount half the mass of Portland cement and zeolite.

As a result of the developed projects many inventions have been created [13-17], many years of experience have been gained in their development and testing of operability, durability, determination of productivity, maintainability and other important parameters for the operation of a facility.

Currently, an application has been launched for the registration of two new technical solutions [18, 19] for patent protection, which overcome some of the weaknesses of previous solutions and create opportunities for greater productivity.

The envisaged factory price which includes a minimum profitability of 12% of production is from 60 to 100 EUR/ cubic meter, and the market price, which is offered for financial calculations is 130 EUR / cubic meter without VAT or 156 EUR /

cubic meter with VAT, as the international market price for Bulgaria, which is known to the company Pittsburgh Corning Europe in Brussels (for the ex-factory in Belgium) is 320-412 EUR/ cubic meter (March 2019).

2. Main units of the experimental plant. Conceptual plan scheme.

Level of specialization.

The experimental plant for the production of foam glass ware specializes in this production, concentrating the optimal technique of new machines created by inventions for the construction of a technological line with different branches to obtain various high quality products and products. The proposed plan scheme is designed for an ideal site.

Special requirements.

The production process of the foam glass (FG) is a normal production process for the silicate industry. The construction of the devices is safe, does not emit harmful gases and carcinogenic substances. The transport and storage of glass particles takes place in closed facilities, mainly closed bunkers. An aspiration system for dedusting is also provided.

Table 1: List of required areas in the factory.

Dimensions		A	B	H	Level
Type of room		M	M	M	
1. Warehouse of raw-materials		20	10	6	Shed
2. Preparatory section		20	15	6	I floor
3. Mill section (closed)		15	15	8	I floor
4. Workshop with shaft furnaces	I workshop	22,5	15	12	I floor
4a. Workshop composite elements	II workshop	22,5	15	12	I floor
5. Cut section (closed)		9	15	4	I floor
6. Warehouse of finished products		20	15	6	I floor
7. Repair workshop		10	6	4	I floor
8. Repair area		9	6	6	I floor
9. Substation		9	9	4	I floor
10. Laboratory		9	8	4	II floor
11. Area for additives and foaming agents		15	15	4	II floor
12. Management		7	15	4	II floor
13. Living quarters		9	7	4	II floor
14. Secretary's room and stairs		4	15	4	II floor
15. Pumping station (under the substation)		9	9	3	Basement

Schematic technological plan – drawings.

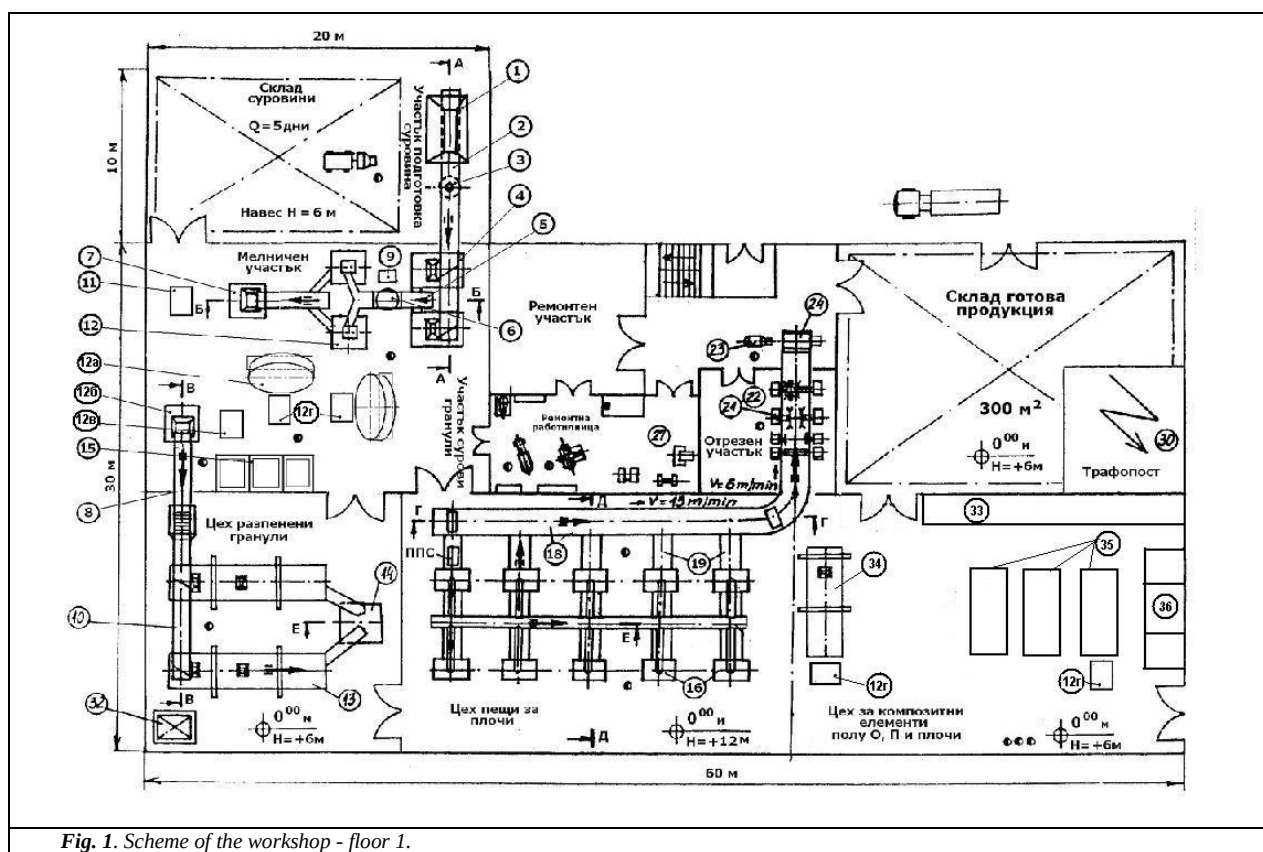


Fig. 1. Scheme of the workshop - floor 1.

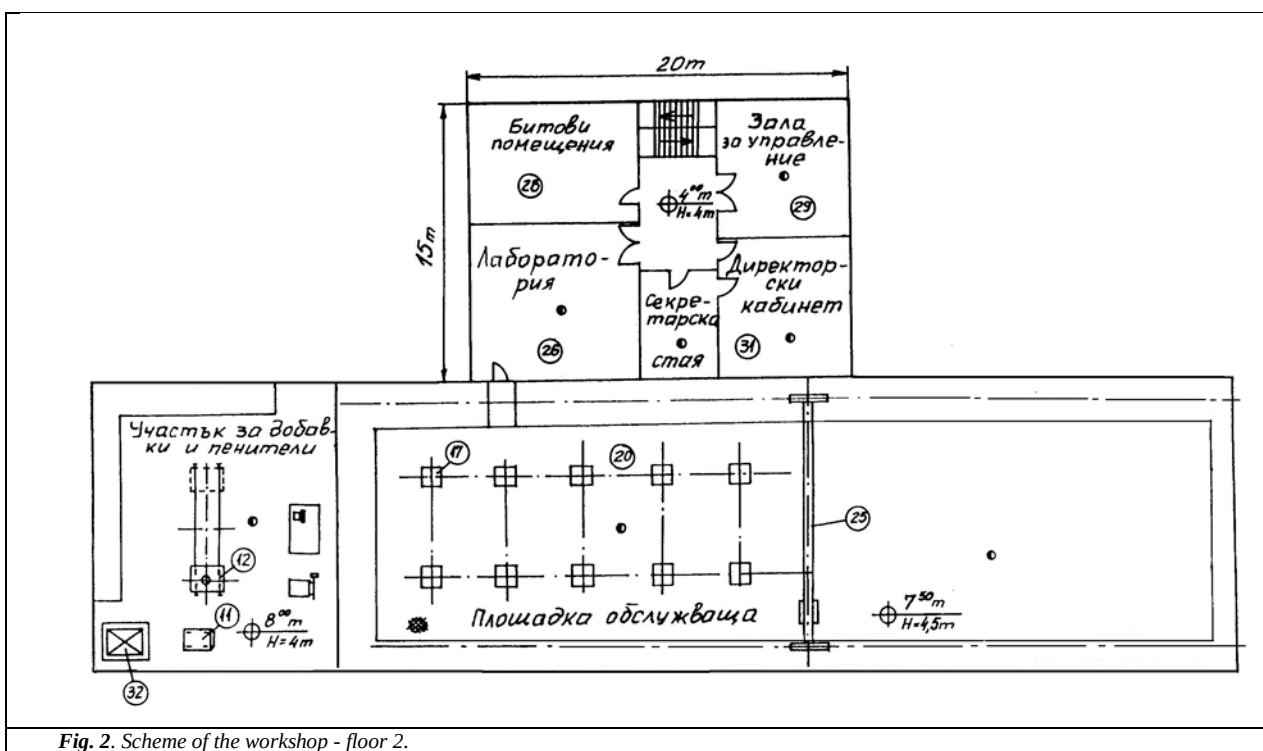


Fig. 2. Scheme of the workshop - floor 2.

Basic technological scheme-description**Warehouse of raw materials**

The raw material - crumbs (waste) arrives by truck and is stored outdoors in the warehouse.

Crushing compartment.

From the receiving hopper through a series of conveyors and crushing machines the raw material is fed to a mill. From the

second floor with a gravity conveyor are fed the additives - soot or glycerin (Bulgarian know how). The mill also acts as a mixing reactor - homogenizer of the charge of the future foam glass. The size of the ground glass particles is a powder with dimensions of 0.0063 mm. The next process is granulation with a device called a granulator. The dimensions of the raw granules are 5 to 10 mm, which are fed into the hopper above the furnace and foaming, stick together and form a homogeneous foamed structure, forming a foam glass plate or foamed independently in a rotating furnace.

Furnace compartment.

By gravity, the charge enters a vertical shaft furnace with a continuous process of operation. Passing through several technological zones in the furnace, the semi-factory comes out of the lower and shaped part. Using a circular saw, the length of the semi-factory is cut to a length of 1.2 m. The other two sizes of the FG plates are formed in the kiln - 0.6 m wide and 0.06 m thick. Through a gravity arc roller conveyor or a lowering device the PS plates enter a horizontal conveyor. The furnace is the result of several Bulgarian inventions and patents.

Cut section and warehouse of finished products (FP)

Through the horizontal roller conveyor the plates or block are moved to the warehouse for finished products.

Table 2: Preliminary title list of machines and equipment (all necessary facilities and equipment for the operation of the plant are laid).

No	Equipment
1	Feeding hopper
2	Conveyor
3	Shower for washing glass waste
4	Crusher type Vibromax VM - 20 vibrating
5	Conveyor
6	El. magnetic separator
7	Sieve vibrating flat closed
8	Scraper conveyor for raw granules
9	Non-glass waste hopper
10	Conveyor belt for carrying
11	Addition cart with scales
12	Mill on the special construction of Dipl. Eng. Toms Hrant
12a	Granulator
12b	Raw granule feed hopper
12b	Trays for drying raw granules
12r	Trolley with trays for ready raw granules
13	Rotary furnace for granules
14	Bunker with sieve for feeding foamed granules
15	Drying of raw granules
16	Vertical (shaft) system (without automation)
17	Container feeding system with charge
18	Rolling master
19	Rolling mill under the furnaces
20	Aspiration system around each furnace
21	Cut section with machines
22	Aspiration system around each machine in the cutting area
23	Transport internally at the factory
24	Packaging machine
25	Workshop crane
26	Quality assessment laboratory
27	Repair workshop
28	Living quarters
29	Control and computer control system
30	Substation
31	Telephone connections - system - Director's office
32	Freight elevator
33	Shelves for drying and hardening
34	Composite mixture homogenizer
35	Stretch table are products
36	Matrices for products

On the roller conveyor there is a cut section with longitudinal and transverse cutting of the massive slabs or block in order to produce slabs of other sizes (on request). At the end of the roller conveyor, the plates with dimensions of 1.2 x 0.6 x 0.06 m are lined up in europallets with dimensions of 1.2 x 0.18 x 0.15 m with a height of 1.8 m. machine for stacking and palletizing - a total of 39 pcs. in one pallet (30 lying and 9 vertical). Packed with or without polyethylene foil, the finished product (1 t) placed on pallets is transported by forklift to a storage room or a truck.

Repair workshop.

Universal equipment is provided for the maintenance of the FG production line. There is also a grinding machine for sharpening circular saws. Cutting can also be done with a thread.

Filling compartment and storage for auxiliary materials.

Auxiliary materials, additives and foaming agents are stored by means of a pallet truck and a platform trolley in the auxiliary material warehouse. From it they are measured in weight ratio for use in the production line of raw granules in the section for preparation of the raw material. The powdered auxiliary materials from sacks are poured into the homogenizer placed after the mill or the mill itself plays the role of a homogenizer after grinding the specified dose of glass. Then they are lifted on the second floor above the mill, where a filling compartment is provided. With a freight elevator, the finished raw and dried granules are lifted above the respective kilns, and gravitationally enter the kilns on the lower floor.

Workshop composite elements.

It is planned to make 3 types of composite products - semi-O-shaped, U-shaped and flat elements from a homogeneous mixture of granules with different diameters and binder. The finished products also enter the warehouse for finished products.

Laboratory

All the necessary devices and apparatus for control of the technological process and the finished products are set.

Heating and ventilation

All workshop production rooms are heated in winter to + 5 ° C. All workers are placed in cabins 3 x 3 m, heated for winter and summer to +20°C. The cabins are isolated, with telephone connection and video surveillance.

Substation, subscriber station, auxiliary premises, etc.

All the necessary facilities, equipment for the operation of the above premises are set.

3. Conclusions

The conceptual design of an experimental plant for the production of foam glass ware is the basis for discussion, adjustments and development of a working design for the production of foamed glass granules and pieces, continuous tape or block of foam glass and various elements of composite material based on foam glass granules.

4. References

1. Project NF-00-92 / 05.05.2005 for a feasibility study on the topic: "Study for the development of technology and equipment for implementation in the production of energy-saving insulation (foam glass) from waste packaging glass" with a Subsidy Agreement № IF-02-19 /24.10.2005 for participation in the competition Financial

- scheme for support of Innovative Enterprises from the National Innovation Fund at BSMEPA. With the company KAM Ltd. Troyan.
2. Research project on the topic "Study of technological processes in the manufacture of thermal insulation material - foam glass, obtained in a model of the blowing section of a new vertical production system", with a contract with the Ministry of Education, Youth and Science № DTK-02/72 of 17.12.2009.
 3. Contract for financial assistance BG161PO003-1.1.06-0094-C001 / 07.12.2012 with beneficiary Promstroyproekt OOD and partner IMSTCHA-BAS, "Creation and research of a new technology and horizontal model for the production of composite thermal insulation materials in the form of pieces (large granules) of foam glass from glass waste", Project status - completed.
 4. Financial Assistance Agreement NP 03/14/04 of 04.04.2014, "Creation of structural documentation of modules to an existing tunnel kiln with a belt conveyor for construction of an experimental technological section and development of technology for production of foam glass granules based on recycling of household glass waste with a volume of 1500 to 2500 dm³/24 hours", INHOM Ltd. Beloslav, Project status - completed.
 5. N. Rivier, "Theory of Glass", Revista Brasileira de Física, Vd. **15**, No 4 (1985) 311-378.
 6. D. A. Keen, R. L. McGreevy, "Structural modelling of glasses using reverse Monte Carlo simulation", Nature, vol. **344**, (1990) 423-425.
 7. A. Shugar, T. Rehren, "Formation and composition of glass as a function of firing temperature", Proc. XIX Int. Congr. Glass, Edinburgh, 1-6 July 2001 Glass Technol., **43C** (2002) 145-50.
 8. R. P. Wool, "Twinkling fractal theory of the glass transition", J. Polym. Sci. Polym. Phys., **46** (2008) 2765-2778.
 9. L. O. Hedges, R. L. Jack, J. P. Garrahan, David Chandler, "Dynamic Order-Disorder in Atomistic Models of Structural Glass Formers", Science, vol. **323**, Issue 5919 (2009) 1309-1313.
 10. A. Bachvarova-Nedelcheva, R. Iordanova, St. Yordanov, Y. Dimitriev, "Optical Properties of Selenite Glasses", Journal of Non-Crystalline Solids, **355**/37-42 (2009) 2027-2030.
 11. I. M. Kalogeras, H. E. Hagg Lobland, "The nature of the glassy state: Structure and glass transitions", Journal of Materials Education, vol. **34**/3-4 (2012) 69-94.
 12. A. Takada, R. Conradt, P. Richet, "Residual entropy and structural disorder in glass: A review of history and an attempt to resolve two apparently conflicting views", J. Non-Cryst. Solids, **429** (2015) 33-44.
 13. I. G. Chorbov, K. A. Toncheva, L. I. Lakov and Y. B. Arsov, "Device for obtaining foam glass", Patent № 65718 / 24.11.2004, Status - Valid, Place of application Bulgaria.
 14. I. G. Chorbov, K. A. Toncheva, L. I. Lakov, Y. B. Arsov, L. N. Dosev, K. M. Lichev, "Device for obtaining foam glass", Patent №65745 /26.05.2006, Status - Valid, Place of application Bulgaria.
 15. I. Chorbov, K. Toncheva, L. Lakov, "Device for obtaining foam glass granules", Patent № 66666 / 06.06.2012. Status-Valid, Place of application Bulgaria.
 16. L. Lakov, K. Toncheva "Device for obtaining foam glass", Patent № 66903 B1, 2019, Status - Valid, Place of application Bulgaria.
 17. L. Lakov, L. Drenchev, D. Nazarski, "Composite thermal insulation material", Patent № 66960 B1, 2019, Status-Valid, Place of application Bulgaria.
 18. I. Chorbov, L. Lakov, K. Toncheva, L. Drenchev, N. Guo, H. Shi, "Device for obtaining foamed granules from composite material", Patent application № BG /P/2020/113247 dated 21.10.2020, Status - in examination, Place of application Bulgaria.
 19. I. Chorbov, L. Lakov, K. Toncheva, L. Drenchev, N. Guo, H. Shi, "Device for obtaining a continuous plane of foamed composite material", Patent application № BG/P/2020/113248 dated 21.10.2020, Status - in examination, Place of application Bulgaria.

State public relations in Serbia

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Abstract— *Public relations (PR) is a scientific discipline that deals with the creation and maintenance of mutual understanding between an organization or an individual. The term "public relations" appeared in 1987 in an annual US railroad. Since then, a large number of national and international associations, institutions and agencies have been established. Also, many universities in the world have formed faculties and faculties established special departments and chairs for public relations (PR). The paper presents an overview of the emergence of public relations (PR), a review of the international association and public relations institute and the state public relations (PR) in Serbia.*

KEYWORDS— *PUBLIC RELATIONS (PR), MEDIA, COMMUNICATION, ORGANIZATION, SOCIETY.*

1. Introduction

Public relations (PR) is a scientific discipline that deals with the creation and maintenance of mutual understanding between an organization or an individual and a targeted public and a constant job of creating and maintaining of the goodwill.

Significant application of public relations (PR) has been experienced by the development and application of digital media, information technologies (IT) and technologies in the field of communications.

Public relations (PR) is in direct connection with the following fields (Fig. 1) [1, 3-7, 21, 23-26]:

- News,
- Media,
- Social,
- Message,
- Communication,
- Organization,
- Advertising,
- Publicity,
- Audiences,
- Society and etc.



Fig. 1. Interdependence of public relations (PR) with other fields

As a birthplace of contemporary PR is considered the United States, and as the year of its creation is counted 1897, because particularly in that year the term "public relations" appeared in the annual of the U.S.' railroad. In the same year, the first internal public relations department was formed in the American company Westinghouse Electric, which was formed to realize important goals of the company, respectively, to suppress the impact of competition.

The first specialized agency "The Publicity Bureau" was founded in 1900 in the American city of Boston. Theodore Roosevelt formed the first media relations office in 1905 to promote national parks in America and from which journalists receive speeches by

the president in advance.

In 1906, Ivy Lee founded the first, conditionally speaking, Public Relations Office in New York, where he provided information to the media about the companies. His message to the companies was: "Let the public be informed".

The first public relations textbook was published in 1923 under the title "Crystallizing Public Opinion" published by Dr. Edward Bernays, a nephew of the famous psychologist and scientist Sigmund Freud, who is unofficially called the "father" of the PR.

In the United States, public relations courses at the Universities were organized in 1940, and already in 1947 specialized schools for PR were opened and PR was introduced as a special scientific discipline at economics and other faculties of social sciences.

The development of information technology has been conducive to an even stronger development of this area after the 1960s, and an increasing need for educational staff has led to the launch of a number of studies for the study of public relations. Associations set criteria, codes and conditions for accreditation of their members (Code of Professional Standards).

Today, about half a million people in the US are professionally dealing with the PR, and the world's PR capital is New York with over 700 specialized PR agencies.

In 1997, was established in New York and the first PR Museum in the world (URL: <http://www.prmuseum.com/>).

The long and chequered history of PR measurement and evaluation has been thoroughly summarized by Watson in 2012 [28] and Likely and Watson in 2013 [11], and discussed by many others, including Broom and Dozier in 1990 [2], Lindemann in 2003 [12], Mcnamara in 1999 [16] and 2014 [17], Michaelson and Stacks in 2011 [19], Stacks in 2010 [25] and Watson in 2008 [27]. Research in public relations is given in papers [2, 9, 16, 20, 22, 25, 27, 30]. So, the literature will not be reviewed here, except for noting the major theories of measurement and evaluation that were developed during this "flowering of research" (Likely and Watson in 2013 [11]. Macey & Schneider in 2008 [13], Watson & Noble in 2007 [29]) and in more recent scholarly research such as the Excellence study (Grunig & Hunt in 1984 [8]) and models for measurement and evaluation developed by Cutlip, Center & Broom in 1985 [3] and others. As the focus of this article is recent developments in standards and standardization [12, 14, 17, 19], these will be discussed first and then major theories and models of PR measurement and evaluation will be drawn upon as a framework for analysis during discussion and in drawing conclusions. Return on investment (ROI) of public relations is given in papers [10, 18].

Public relations have become a discipline that is concerned with reputation and whose ultimate goal is to achieve understanding and gain public support and influence public opinion and management. But it is also a professional concern for the reputation of the profession. In Fig. 2 is shown the process of public relations management [].



Fig. 2. Public relations process

2. International Association and Institute for Public Relations (PR)

The first association established in the Public Relation (PR) field is PRSA (Public Relations Society of America), founded in 1947. In the following year is formed the Institute for Public Relations (IPR). The first international association for Public Relation (PR) was formed in 1955 under the name IPRA (International Public Relations Association). The first European Association for Public Relations (PR) was founded in 1955 under the name CERP

(Confederation Europeenne des Relations Publique).

The first code of professional standards was adopted in USA in 1954 by the Public Relation Society of America (PRSA). The first international code of ethical conduct, called the "Athens Codex", was adopted in 1965 by the International Public Relation Association (IPRA) and CERP (Confederation Europeenne des Relations Publique).

In Table 1, are presented the most important international associations and institutions for Public Relation (PR).

Table 1. International Association and Institute for Public Relations (PR)

Abbreviations	Name of the association or institute	Established	Web site
AMEC	Association for Measurement and Evaluation of Communication	1996	http://www.amecorg.com/
CCPRF	Canadian Council of Public Relations Firms		http://www.ccprf.ca/
CERP	Confédération Européenne des Relations Publique (European Confederation of Public Relations)	1959	
CIPR	Chartered Institute of Public Relations	1948	http://www.cipr.co.uk/
CPRF	Council of Public Relations Firms		
CPRS	Canadian Public Relations Society	1948	https://www.cprs.ca/
EUPRERA	European Public Relations Education and Research Association	2000	http://www.euprera.org/
IABC	International Association of Business Communicators	1970	https://www.iabc.com/
IAMCR	International Association for Media and Communication Research	1956	http://www.iamcr.org/
IPR	Institute for Public Relations	1948	http://www.instituteforpr.org/
IPRA	International Public Relations Association	1955	https://www.ipra.org/
PRCA	Public Relations and Communications Association	1969	http://www.prca.org.uk/
PRSA	Public Relations Society of America	1947	http://www.prssa.org/
PRSSA	Public Relations Student Society of America	1967	http://prssa.prssa.org/
SNCR	Society for New Communications Research	2005	http://www.conference-board.org/SNCR/

3. Types of public relations

Types of public relations can be (Fig. 3):

- Media relations,
- Internal communication,
- Digital / new media,
- Reputation management,
- Community relations,
- Crisis communication,
- Event planning and etc.

In Table 2 are shown types of public relations with their description.



Fig. 3. Types of public relations

Table 2. Types of public relations

Types of public relations	Opis
Media relations	The media play an important role in the formation of public opinion, and particularly due to this, they make an attractive platform for public relations professionals as they can inform business partners, clients or voters through the media, and thus contribute to the creation of the image of the client in the public. There are a large number of tools that PR officers use when communicating with the media, so among them we find press releases (public announcements), news, statements, press conferences, briefings with journalists, events, advertisers, and the like. An important tool for effective media relations is a high-quality address, or newsletter, which includes the names and contacts of journalists who follow certain areas. It is also important to have a prepared news map with all the necessary information related to the client you represent. In relations with the media, the spokesperson of the organization is in charge of professionally communicating with journalists and editors.
Trade relations	The market is a public with whom you need to communicate carefully, because it is precisely the firm or client you are representing depending on the market, that is, those who buy your client's services or vote for him in the elections. It is necessary to listen to any markets and research to see consumer preferences and adapt to the results of these research in order to improve the service you provide. This reduces the various risks in business doing, you obtain better results leading to a lucrative goal - creating a long-term partnership with consumers. Among the tools that public relations professionals use the most important is direct written communication. Market communication is most often in the domain of marketing.
Authorities relations (Public affairs)	Communication relations with authorities are very important for every big companies, the public affairs department uses various instruments, such as direct and indirect lobbying. In addition to the market, each organization also depends on its public institutions that issue operating licenses, voting laws, adopting procedures, regulating market movements. In this aspect of public relations, it is necessary to monitor events on the political and social scene and to adjust the course of these events on time to the benefit of their client. More specifically, these activities relate to the monitoring of relevant political, legal and other key issues, and to the collection of information on the activities of public institutions, all at the top of the adjustment of communication to this public.
Internal communication	Internal communication encompasses all communication activities between members of the organization, in companies between management and employees, in parties between party leadership and membership, etc. An organization can have a genius product or service, but if the person in charge of selling this product leaves a negative impact on us, it is very likely that we will either not buy what we sell or we will give our trust next to the other manufacturer. In order to avoid such a scenario, it is in the interest of employers to have satisfied employees who will properly transfer the motto of the company to customers. It is therefore important to inform, educate and motivate employees so that they can represent the company publicly. This is achieved through working meetings, team building, professional seminars, briefings and intranets (internal Internet of the company).
Investor relations	Known as financial public relations, investor relations are a type of PR that seeks to increase the value of a company, consolidate the trust of shareholders and thus reduce the cost of capital and make the company or its shares attractive to investors, financial analysts, banks, funds, etc. A public relations specialist who is focused on communicating with the financial public must also have knowledge of the economy, the economy that is crucial to the implementation of this aspect of the PR. Their work includes the production of annual reports, tracking trends in the market, continuous information to the financial public, advising managers and providing financial information on demand.

4. State public relations in Serbia

In 1992, the first P.R.A. company was founded for Public Relations (PR) on the premises of Serbia, Croatia, Bosnia and Herzegovina, Macedonia and Montenegro.

In 1993 started working the Business School for Public Relations of Agencies (P.R.A.), the first institution of its kind in this part of Europe, with the goal of transferring the skills of successful communication between organizations and individuals in an optimal way. Business school for public relations works according to the standards of internationally recognized business schools.

In 1998, the Yugoslav Society for Public Relations (from the 2004 Serbian Society for Public Relations - DSOJ) announced the 1st competition for admission (Recognition for Professionals for the annual awards of the DSOJ Society for various fields of Public Relations (PR).

On May 17, 2004, it was founded the Serbian Society for Public Relations or Serbian Public Relations Society or Public Relations Society of Serbia (DSOJ - Serbian Association for Public Relations), continuing the tradition of PR of the Society of Yugoslavia - the oldest professional organizations in this area on the territory of the former SFRY. DSOJ Society is available on the Web site: <http://www.pr.org.rs/>.

The Serbian Public Relations Society, for the sixth time, will organize a national student competition in the field of communications and public relations within the annual conference OPPORTUNITY 2017.

In 2003, the Agency for Public Relations with the Ministry of Economy and Regional Development was established.

In 2005, the Public Relations Department of the Ministry of Defense was established.

In recent years, many private PR schools have been established in Serbia, such as the Balkan Media Team (URL: <http://www.balkanmt.com/>) and etc.

Also, many private faculties have formed special Departments and Chairs for Public Relations (PR).

5. Conclusion

Public relations (PR) is a scientific discipline whose roots in Serbia can be found in the early nineties. Ordering the development of this area begins with democratic changes in the beginning of 2000.

In recent years, many private PR schools have been established in Serbia.

Significant application of public relations (PR) has been experienced by the development and application of digital media, information technologies (IT) and technologies in the field of communications.

References

- [1] D. Baack, & K. Clow, "Integrated advertising, promotion, and marketing communications", 5th edition, Pearson Education Inc., Upper Saddle River, NY, USA, 2012.
- [2] G. Broom & D. Dozier, "Using research in public relations: Applications to program management", Prentice-Hall, Englewood Cliffs, NJ, USA, 1990.
- [3] M. Cutlip, A. Center & G. Broom, "Effective public relations", 6th edition, Prentice Hall, Englewood Cliffs, NJ, USA, 1985.
- [4] D. Dozier, "The innovation of research in public relations practice: Review of program studies", in: *Public Relations Research Annual*, vol. 2, Lawrence Erlbaum, Mahwah, New Jersey, USA, pp. 3-28. 1990.
- [5] W. Ehling, "Estimating the value of public relations and communication to an organization", in: *Excellence in Public Relations and Communication Management*, Lawrence Erlbaum Associates, Hillsdale, New Jersey, USA, pp. 617-638. 1992.
- [6] M. Fredriksson, & J. Pallas, "Much ado about media: Public relations in public agencies in the wake of managerialism", *Public Relations Review*, vol. 42, issue 4, pp. 600-606. 2016. doi: [10.1016/j.pubrev.2016.03.016](https://doi.org/10.1016/j.pubrev.2016.03.016).
- [7] J. Gehrt, & C. Moffitt, "Strategic public relations", Bookbyte Digital, Salem, OR, USA, 2009.
- [8] J. Grunig & T. Hunt, "Managing public relations", Rinehart & Winston, Orlando, Florida, USA 1984.
- [9] E.-J. Ki, & L. Ye, "An assessment of progress in research on global public relations from 2001 to 2014", *Public Relations Review*, vol. 43, issue 1, pp. 235-245, 2017. doi: [10.1016/j.pubrev.2016.12.005](https://doi.org/10.1016/j.pubrev.2016.12.005).
- [10] L. Lee & Y. Yoon, "Return on investment (ROI) of international public relations: A country-level analysis", *Public Relations Review*, vol. 36, issue 1, pp. 15-20. 2010.
- [11] F. Likely & T. Watson, "Measuring the edifice: Public relations measurement and evaluation practices over the course of 40 years", in: *Current Trends and Emerging Topics in Public Relations and Communication Management*, Routledge, New York, USA, pp. 143-162. 2013.
- [12] W. Lindenmann, "Guidelines and standards for measuring and evaluating PR effectiveness", Institute for Public Relations, Gainesville, Florida, USA, 2003.
- [13] W. Macey & B. Schneider, "The meaning of employee engagement", *Industrial and Organizational Psychology*, vol. 1, pp. 3-30. 2008.
- [14] J. Macnamara, "Emerging international standards for measurement and evaluation of public relations: A critical analysis", *Public Relations Inquiry*, vol 3, issue 1, pp. 7-29, 2014.
- [15] J. Macnamara, "Public relations theories, practices critiques", Pearson, Sydney, NSW, Australia, 2012.
- [16] J. Macnamara, "Research in public relations: A review of the use of evaluation and formative research", *Asia Pacific Public Relations Review*, vol. 1, issue 2, pp. 107-133. 1999.
- [17] J. Macnamara, "The development international standards for measurement and evaluation of public relations and corporate communication: A review", Technical Report, University of Technology Sydney (UTS), Australian Centre for Public Communication, Broadway, NSW, Australia, 2014.
- [18] J. Meng & B. Berger, "Measuring return on investment (ROI) organizations' internal communication effort", *Journal of Communication Management*, vol. 16, Issue 4, pp. 332-354. 2012.
- [19] D. Michaelson & D. Stacks, "Standardization in public relations measurement and evaluation", *Public Relations Journal*, vol. 2, pp. 1-22, 2011.
- [20] K. Mogenssen, "From public relations to corporate public diplomacy", *Public Relations Review*, vol. 43. pp. 605-614. 2017. doi: [10.1016/j.pubrev.2017.03.011](https://doi.org/10.1016/j.pubrev.2017.03.011).
- [21] A. Okay & A. Okay, "The place of theory in public relations practice", in: *Public Relations: From Theory to Practice*, Pearson, Boston, MA, USA, 301-342. 2008.
- [22] N. Rodríguez-Salcedo, & T. Watson, "The development of public relations in dictatorships - Southern and Eastern European perspectives from 1945 to 1990", *Public Relations Review*, vol. 43, pp. 375-381. 2017. doi: [10.1016/j.pubrev.2017.01.001](https://doi.org/10.1016/j.pubrev.2017.01.001).
- [23] F.P. Seitel, "The practice of public relations", 10th edition, Pearson Prentice Hall, Upper Saddle River, NJ, USA, 2007.
- [24] D.M. Scott, "The new rules of marketing and PR", John Wiley & Sons, Hoboken, NJ, USA, 2013.
- [25] D. Stacks, "Primer of public relations research", 2nd edition, The Guildford Press, New York, USA, 2011.
- [26] D. Stacks & S. Bowen (editors), "Dictionary of public relations measurement and research", Institute for Public Relations (IPR), Gainesville, Florida, USA, 2013.
- [27] T. Watson, "Public relations research priorities: A Delphi study", *Journal of Communication Management*, vol. 12, issue 2, pp. 104-123, 2008.
- [28] T. Watson, "The evolution of public relations measurement and evaluation", *Public Relations Review*, vol. 38, issue 3, pp. 390-398, 2012.
- [29] T. Watson & P. Noble, "Evaluating public relations: A best practice guide to public relations planning, research and evaluation", 2nd edition. Kogan Page, London, UK and Philadelphia, PA, USA 2007.
- [30] D. Wright & M. Hinson, "Examining how social and emerging media have been used in public relations between 2006 and 2012: A longitudinal analysis", *Public Relations Journal*, vol. 6, issue 4, pp. 1-40, 2012.

Development of remote-control smart home system

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Abstract: The Smart Homes come rapidly into our everyday lives bringing comfort, security, help and many other benefits. The development of Information and Communication Technology and the advances in the applications based on Internet of Things emerged the appearing of more and more Smart Home solutions. The Smart Home System should implement default or custom integrated functions and intelligent self-adaptive methodology, based on the analysis of the habits, requirements and preferences of its inhabitants.

In this paper the authors consider the development of Android and Wi-Fi based remote control Smart Home System, which integrates the analysis of the survey of the everyday habits of the people. An analysis of habits of 64 surveyed people was made. The results can be taken into account during the process of defining the default integrated functions at the stage of designing a Smart Home. The presence, absence or approaching certain location by the people are included as elements of the Smart Home System.

Keywords: SMART HOME, REMOTE CONTROL, IOT, INDOOR OUTDOOR CONTROL, SELF-ADAPTIVE SYSTEM, DEFAULT INTEGRATED FUNCTIONS, ANDROID, WI-FI

1. Introduction

There are plenty proposed projects and applications for Smart Home (SH) automated systems' design and development [1 - 4]. Although, they consider different functionalities, application of different elements, operations and networking, undoubtedly, they all are connected with the increase of the comfort and security, saving energy, efforts and troubles. One of the problems is that many SH devices work with different interface applications, use different communication protocols and standards [5, 6]. One of the big challenges is integrating different varieties of applications in one environment. Another challenge is the defining of pre-set default functions and to develop a learning technique for intelligent self-adaptation of the functions of the SH [7], depending on the observation and analysis of the behavior of the people living in the SH [8].

The aim of the current SH automation project is to bring the necessary comfort and security in each home depending on the habits and lifestyle of its inhabitants. The proposed system includes

waking up the home with the owners at a pre-set time or with the home inhabitants, turning on the lights with a pre-set brightness and color, starting the background music, turning on in advance the coffee machine or water heater, as well as the boiler and heating, opening the blinds or curtains at reaching a set level of outdoor illumination, turning on the TV on a pre-set channel. The developed remote-control SH system is based on default and custom integrated functions, taking into account the habits, desires and needs of its inhabitants. The system includes the presence, absence or approaching certain area as elements of the Smart Home System by GPS location signal of the mobile phone and data acquisition from other sensors. In this paper the authors consider the development of remote-control SH system, which integrates the analysis of the survey of 64 people of their everyday habits, needs and preferences. The results are taken into account during the process of defining the default integrated functions at the stage of the design development of the SH automated system.

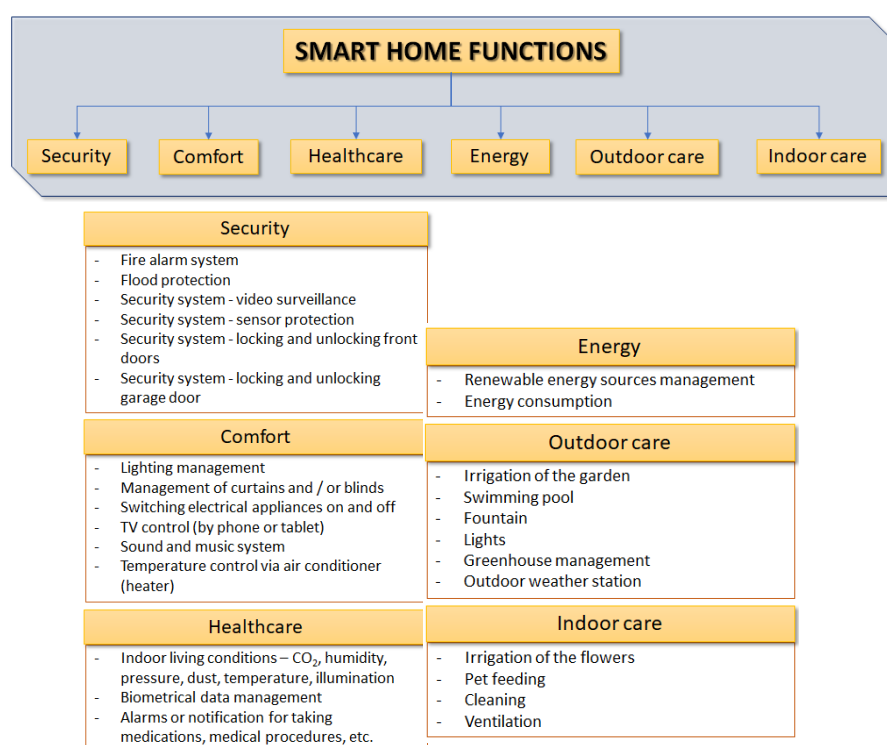


Fig. 1 Functional description of the Smart Home.

2. Smart Home System Design

The functional and operational design (Fig. 1 and Fig. 2) of a Smart Home (SH) Automated System includes several stages: the choice of its elements (sensors, actuators, controllers, network connection elements, electric devices, software solutions and interfaces, etc.), defining its layout and structure, modelling the SH subsystems, developing the user interface, estimation of its cost, testing and validation of the SH system, optimization of the system, etc.

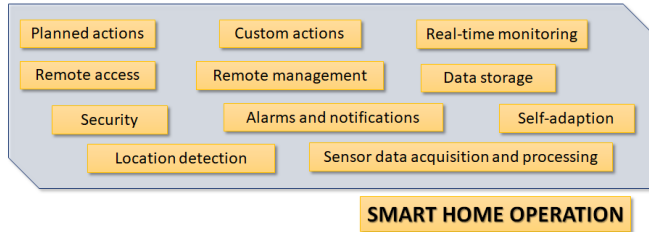


Fig. 2 Operational description of the Smart Home.

The chosen remote SH system elements are: Android and Wi-Fi connection, NodeMCU and Raspberry PI controllers, smoke-optical and thermo-differential sensors, humidity, temperature, pressure, light sensors, CO₂ sensors, gas sensors, IP video cameras, motion sensors, sound sensors (from breaking a window or breaking a door) and/or for opening them - magnetic sensors, relays, GPS in a mobile device, automated locking system, RGB led lighting, standard lighting, stepper motors, rails with belt (for the curtains and tents), electric devices (air conditioner, TV, boiler, coffee machine, etc.), infrared receiver, infrared transmitter, etc.

The user requirements for every SH are individual, but still the SH system functions can be classified as default and custom, depending on the everyday habits of the people, their needs and preferences, the architecture of the building, the apartment or the house, with its adjoining facilities and garden.

Table 1: Study, concerning some aspects of security and comfort

No.	Question
Q1	Do you get up at the same time during the work week?
Q2	Do you go to bed at the same time during the work week?
Q3	Do you use a boiler?
Q4	Do you have coffee or tea in the morning before going out?
Q5	Do you turn on the TV while preparing for work?
Q6	Would you use your TV as an alarm clock?
Q7	Do you park in a garage?
Q8	Would you use an automatic garage door opening when approaching it?
Q9	What device would you prefer for opening/closing a garage door?
Q10	Would you monitor your home while you are outside, if you have video surveillance?
Q11	In case of an accident in your home, what action would you prefer?
Q12	Would you like to receive a notification when your child arrives or leaves school / home?
Q13	Would you use your mobile phone instead of a TV remote control?
Q14	Would you like to turn on the lights when you enter your home?
Q15	Do you play music from your mobile phone at home?
Q16	Would you like the music to be synchronized in all rooms?
Q17	Would you change the color of your background light?
Q18	Do you get up at the same time on your weekends?

3. Inquiry for Individual Habits

For the development of remote-control SH system in order to investigate and summarize the individual everyday habits, needs and preferences of people, a study, concerning some aspects of security and comfort of living is performed. The results are directed toward the definition of default and custom functions of the SH system. Such research can be continued by adding more functions

of the smart home or such questionnaire can be applied during the development of an individual project for SH system. The survey included 64 people. The questions are presented in Table 1.

In order to evaluate the results of the inquiry scores are assigned to the answers as follows: No (0 points), yes (1 point) and neutral answer or irrelevant (0.5 points), answers in favor of the function implementation – rather yes (0.75 points), answers in favor of not applying the function – rather not (0.25 points). The obtained results are presented in Table 2.

Table 2: Study, concerning some aspects of security and comfort

Questions	Points					Sum	Score, %
	1	0.75	0.5	0.25	0		
Q1	14	22.5	0	2	0	38.5	60.15625
Q2	3	18.75	0	4	0	25.75	40.23438
Q3	34	0	0	0	0	34	53.125
Q4	37	0	6	0	0	43	67.1875
Q5	24	0	3.5	0	0	27.5	42.96875
Q6	7	0	0	1.75	0	8.75	13.67188
Q7	13	0	0	0	0	13	20.3125
Q8	48	8.25	0	0.5	0	56.75	88.67188
Q9	20	0	7.5	0	0	27.5	42.96875
Q10	39	9.75	0	1.5	0	50.25	78.51563
Q11	33	11.25	6	0	0	50.25	78.51563
Q12	15	0	23.5	0	0	38.5	60.15625
Q13	17	7.5	0	3.5	0	28	43.75
Q14	40	3	0	0	0	43	67.1875
Q15	41	0	9.5	0	0	50.5	78.90625
Q16	30	0	0	0	0	30	46.875
Q17	47	0	0	0	0	47	73.4375
Q18	1	0	9	0	0	10	15.625

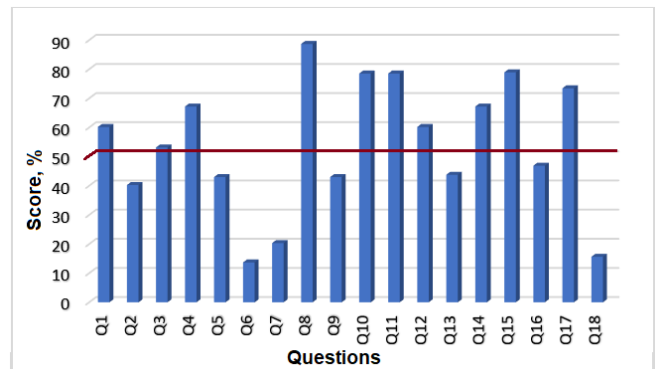


Fig. 3 Inquiry scores in % for each question.

The analysis of the habits of the people and their preferences can be summarized for determination of default functions for setting or intelligent self-adaptation. From Fig. 3 it is seen that the candidates for default actions or functions of the system can be connected with:

- Planned actions, connected with the morning activities during the work days – turning on the boiler for a pre-set time before the people wake up, preparing or turning on the coffee or tea maker machine, set music playing in the morning;
- Planned actions, concerning security – home monitoring with video surveillance, receiving information about accidents in your home, receive a notification when your child arrives or leaves school/home;
- Planned actions, increasing the people comfort of life – automatic garage door opening when approaching it, turning on the lights when you enter your home, change the color of your background light.

The custom activities that should be set by logic or by user include the end of evening activities, the use of TV in the morning while preparing for work, or as an alarm, or the weekend waking up. Some activities are not recognized due to the lack of experience for their use – use of the mobile phone (tablet) instead of a TV remote control, music to be synchronized in all rooms, operating the garage door (or outdoor) without a device for opening.

4. Remote control Smart Home system

The developed remote-control SH system has several important features:

- *Planned actions:*

The planned actions are created individually for each of the controllers, and are planned in advance. For example, the lights, background music and TV are set to turn on at 8.00 in the morning due to the fact that home users then get up for work, and the TV via infrared transmitter switches to a pre-set channel, the blinds open (if outdoor light is enough) and half an hour earlier the boiler is switched on and 5 minutes earlier - the coffee machine. All this is realized through the mobile application shown in Fig. 4.

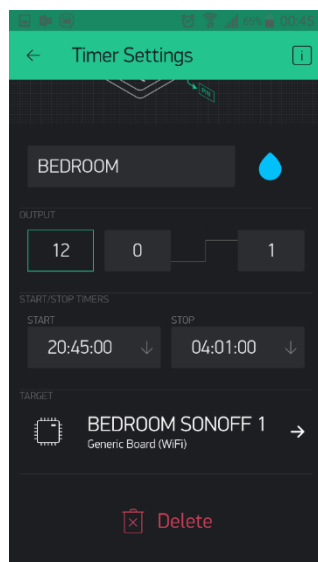


Fig. 4 Implementation of planned actions function.

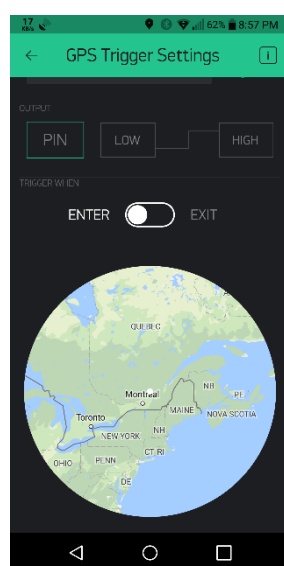


Fig. 5 Definition of location by GPS.

- *Actions according the location of the user*

The developed mobile application gives the possibility for building actions according to the location of each of the devices (users) on which the mobile application is installed via the GPS system of the phone (Fig. 5). The logical algorithm can include the entry or exit of the phone from a given radius around a defined destination as a condition. This is done through the mobile application, which sets a radius of, for example, 20 meters around the house, and when entering this radius, the front door/garage door will open, and at entering it will close. This function can be implemented also for sending notifications for arrival or departure of the child at school/home, etc.

- *Communication and system connectivity*

The SH system allows the communication of all elements in the system with each other, as well as the remote programming of each of the controllers through the server and the mobile application. This remote access allows also the system to be reconfigured by an operator without having to visit the users. The SH system allows the management of the users and the delegation of rights for each of them.

- *Controlling users in the system*

Each of the users of the mobile application is visualized in the server. They create an individual profile associated with the SH via scanning a QR code. This allows to see what actions have been undertaken, at what time and by which user. Only an administrator can determine the functions to which the user will have an access.

- *Management of devices in the system*

The control of the devices in the system through the server allows their remote reprogramming and adjustment, all controllers in the system are visualized, their type, what libraries they use, whether they are connected wired or wireless, whether they are turned on or off and for how long they are used. This allows the calculation of the electricity consumption and the evaluation of the costs. Information is also collected from all sensors and stored for a predetermined period of time, which is unlimited and allows the making statistics and diagrams for different parameters.

The functions and actions described above are realized on a working prototype, as well as all functionalities of the mobile application (Fig. 6).

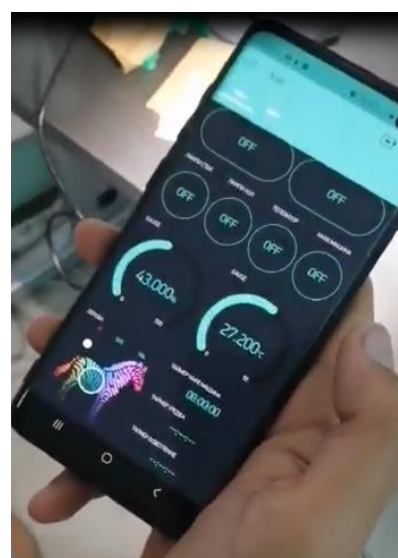


Fig. 6 Mobile application – example functions.

5. Conclusions

The developed remote-control SH automation system allows the management of each of the home appliances, monitoring the parameters of the indoor environment such as temperature, humidity, lighting, CO₂, the presence of smoke, fire or water, etc. All this is integrated in one Android mobile application. The mobile device also plays a role in the home automation, becoming its active element through its location (GPS function). All this is achieved with the use of NodeMCU and Raspberry PI controllers, as well as the construction of a web server that allows the management of all components in the system.

The SH reduces electricity costs by using appliances only when needed, increases home comfort by controlling lighting and media devices, reduces cables by using an existing Wi-Fi network, and as it applies the overall technology advances, it shortens the distance between the user and the products. Security and care for the home are realized, even when the users are not in it, and the specific needs and habits of its occupants are taken into account through the planned actions and the default functions. It has never been easier for the home and the appliances to work properly for the benefit of their users.

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References

1. H.M. Marhoon, M.I. Mahdi, E. Dh. Hussein, A.R. Ibrahim, *Modern Appl. Sci.* **12**, 12, 8-17 (2018)
2. P. Sethi, S.R. Sarangi. *Hind. J. of Electr. and Comp. Eng.*, **2017**, 9324035 (2017)
3. T.S. Gunawan, I.R.H. Yaldi, M. Kartiwi, N. Ismail, N.F. Za'bah, H. Mansor, A.N. Nordin, *Indo. J. of Electr. Eng. and Comp. Sci.*, *Indonesian Journal of Electrical Engineering and Computer Science*, **1**, 2, 107 – 115 (2017)
4. P.J. Clarkson, S. Keates, *A practical inclusive design approach*, Proc. of INCLUE 2001, London (2001)
5. L. Gao, Z.X. Wang, J.L. Zhou, C. Zhang, *Energy and Power Eng.*, **8**, 13-22 (2016)
6. Sh. Kumar, *IJCNC* **6**, 1, 33-43 (2014)
7. B.M.H. Alhafidh, W. Allen, *Int. J. of Eng. Res. and App.*, **6**, 8(1), 64-90 (2016)
8. G. Dewsbury, Br. Taylor, M. Edge, *The Process of Designing Appropriate Smart Homes: Including the User in the Design*, (1st Equator IRC Workshop on Ubiquitous Computing in Domestic Environments, 13-14th September 2001) 131-146 (2001)