

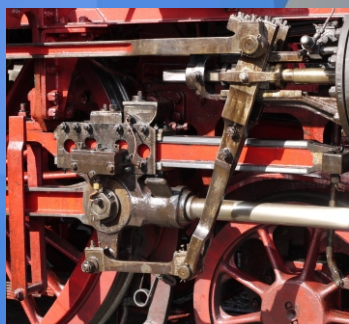
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Overview of Generative AI Models in the Software Industry

Andrii Holovko, Artur Dovbysh, Vladyslav Holdovanyi, Vladyslav Aliexsieiev

Lviv Polytechnic National University, Ukraine

andrii.i.holovko@lpnu.ua, <https://orcid.org/0009-0001-2380-5050>

artur.v.dovbysh@lpnu.ua,

vladyslav.a.holdovanskyi@lpnu.ua,

vladyslav.i.aliexsieiev@lpnu.ua, <https://orcid.org/0000-0003-0712-0120>

Abstract: Generative AI models have started to transform the software industry, driving innovation, and automating tasks previously deemed complex. This overview delves into the evolution, applications, and potential of these models, highlighting their capability to create novel content, enhance software development processes, and forecast industry trends. As these models continue to mature, the software industry stands on the cusp of a redefined future where human-machine collaboration will shape ground-breaking advancements.

Keywords: ARTIFICIAL INTELLIGENCE, GENERATIVE AI, LARGE LANGUAGE MODELS, SOFTWARE INDUSTRY INNOVATION, AI APPLICATIONS IN SOFTWARE INDUSTRY, SOFTWARE ENGINEERING, CHATGPT, GITHUB COPILOT

1. Introduction

AI is about to completely change how you use computers and upend the software industry

Bill Gates [1]

The arrival of Generative Artificial Intelligence (GenAI) has started a new phase in the software industry, changing the way technology is created and used. This type of AI, which can generate everything from code to digital art, does more than just automate simple tasks. It represents a major change in both the creative and analytical sides of software development.

Recent advances in GenAI have led to the creation of tools capable of devising innovative solutions to challenging problems, tasks traditionally handled by human intellect. These models, which learn and copy patterns from large datasets and open-source code repositories, can now do coding tasks, create complex algorithms, and more, greatly assisting developers in their day-to-day work.

This overview aims to provide an insight into GenAI's role in the software industry. We'll look at its development over time, its various uses in the software industry, and the major achievements it has brought to the field. In-depth case studies will provide examples of GenAI at work by evaluating the two most popular solutions nowadays: ChatGPT [2] and GitHub Copilot [3]. We'll also discuss the challenges and ethical issues it raises, along with predictions about its future impact.

This introduction is the beginning of a journey into GenAI, highlighting its significant influence on software development and the new paths it's paving for collaboration of developers and AI.

2. Evolution of Generative AI

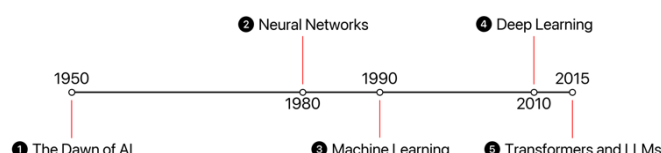


Fig. 1 Generative AI timeline

2.1. The Dawn of AI (1950-1980)

The history of GenAI can be traced back to the 1950s, with the development of Hidden Markov Models (HMMs) and Gaussian Mixture Models (GMMs). These early systems used rule-based reasoning to solve specific problems for generating sequential data like speech and time series. However, the lack of computing power needed by the algorithms and limited data sets available for training imposed significant constraints on their effectiveness and scope, slowing the progress in the field during its early years [4].

2.2. Neural Networks (1980-1990)

In this period, rule-based and expert systems got better, with advancements in how they represented knowledge and made inferences. At the same time, neural networks, modeled after the human brain, became popular in the 1980s. Key researchers like Geoffrey Hinton and Yann LeCun made important contributions to these networks, which are now a crucial part of GenAI [5].

2.3. Machine Learning (1990-2010)

Machine learning methods such as decision trees, support vector machines, and Bayesian networks gained prominence, forming the foundation for GenAI. These techniques enhanced abilities in pattern recognition and predictive analysis.

2.4. Deep Learning (2010-2015)

The emergence of deep learning marked a significant advancement in the field, leading to a paradigm shift towards deep neural networks. The creative power of GenAI is thanks to a specific type of neural network developed by Ian Goodfellow and his colleagues in 2014 and called a Generative Adversarial Network (GAN). GANs introduced a new paradigm for training models by using a two-network adversarial framework - a generator and a discriminator - which compete to improve the quality of the generated data.

2.5. Transformers and LLMs (2015-now)

Transformers, first presented in the influential 2017 paper "Attention Is All You Need" by Vaswani and colleagues [6], have evolved into a fundamental component for numerous advanced GenAI models. They changed how machines process text, making them understand and interpret it more accurately. Transformers use self-attention mechanisms to focus on important words in a sentence, improving context and meaning understanding. They're crucial in Large Language Models (LLMs) like GPT-4, handling huge datasets to produce text that's coherent and relevant.

ChatGPT, a renowned member of the GPT model family, achieved a remarkable milestone by reaching 100 million users in just two months, 4.5 times faster than TikTok [5].

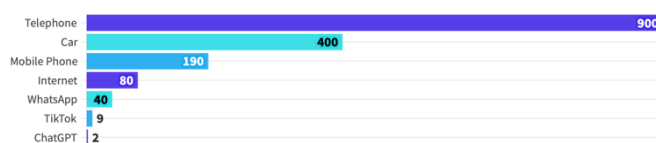


Fig. 2 Time to reach 100 million users for different technologies (in months)

The field of generative AI continues to evolve rapidly, with ongoing research and development leading to more sophisticated and diverse applications, including more ethically and socially aware AI instruments.

3. Applications of Generative AI in the Software Industry

GenAI has the potential to significantly improve software productivity by automating tasks, enhancing creativity, improving accuracy and efficiency, and streamlining development processes [7].

Developers no longer use big offline libraries like MSDN; instead, searching online on sites like StackOverflow or Google is now a part of their daily job. This approach has moved away from the old mindset of wanting to create everything from scratch. Nowadays, when developers are unsure about coding, they quickly look for answers on the internet.

ChatGPT and GitHub Copilot have taken this trend to new heights. Now, AI can assist you during coding sessions in a manner akin to real-life pair programming.

Empirical research involving over 40 McKinsey developers across the United States and Asia, engaging in tasks like code generation, refactoring, and documentation shows that software developers were able to complete tasks up to twice as fast when using AI-powered tools [8].

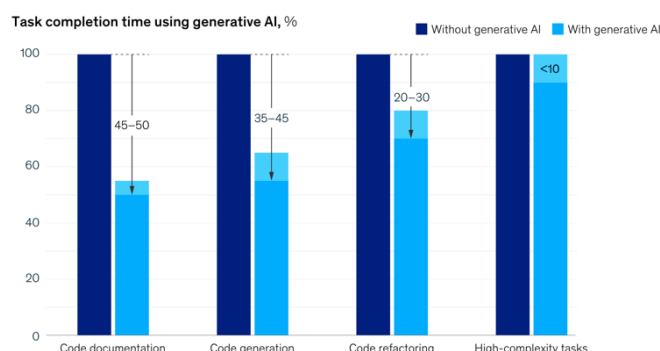


Fig. 3 Task completion time with and without GenAI

This research underscores the transformative potential of GenAI in software development while highlighting the need for a balanced approach that leverages both technological tools and human expertise.

4. In-Depth Case Studies

To understand how GenAI is changing software development, let's examine two key implementations: ChatGPT and GitHub Copilot. These tools show the power and potential of AI in helping developers write code, solve problems, and learn. By exploring ChatGPT and GitHub Copilot, we can see how AI is not just a futuristic concept but a practical tool in today's software engineering. Let's dive into each of these cases to see how they work and what they offer to the world of coding [9]–[12].

4.1. ChatGPT

Overview:

- **Developer:** OpenAI
- **Release Date:** November 2022
- **Purpose:** ChatGPT is designed as a conversational agent, utilizing advanced natural language processing and generation capabilities.

Technology:

- **Foundation:** Based on the GPT (Generative Pre-trained Transformer) architecture.
- **Working Principle:** It employs deep learning techniques, specifically transformer models, to understand and generate human-like text.

- **Key Features:** Autoregressive language model, meaning it generates text by predicting the next word in a sequence given all the previous words.

Applications in Software Development:

- **Code Writing and Assistance:** Provides suggestions and writes code snippets.
- **Debugging:** Helps in identifying and suggesting fixes for programming errors.
- **Documentation:** Assists in generating documentation for code.

Limitations:

- **Accuracy:** Sometimes generates incorrect or misleading information.
- **Context Understanding:** Limited in understanding complex software development contexts.

4.2. GitHub Copilot

Overview:

- **Developer:** GitHub in collaboration with OpenAI
- **Release Date:** June 2021
- **Purpose:** GitHub Copilot is an AI pair programming tool that helps in writing code and learns from the user's coding style.

Technology:

- **Foundation:** Built on the Codex model, a descendant of GPT-3, specifically trained on publicly available code.
- **Working Principle:** Analyzes existing code and comments to suggest individual lines or whole functions.
- **Key Features:** Ability to understand code in a broader context, supports multiple programming languages.

Applications in Software Development:

- **Automated Code Generation:** Suggests code completions and snippets.
- **Refactoring Assistance:** Helps in optimizing and restructuring existing code.
- **Learning Tool:** Adapts to user's coding style, providing personalized code suggestions.

Limitations:

- **Code Quality:** Suggestions may not always align with best practices or be the most efficient.
- **Dependency:** Can lead to over-reliance on automated tools, potentially reducing learning and problem-solving skills.

In comparison, **ChatGPT** focuses more on general language processing, including code, while **GitHub Copilot** is tailored specifically for coding tasks. Both are groundbreaking in their respective domains, pushing the boundaries of how AI can assist in software development. Nevertheless, it's crucial to view them as augmentative tools that enhance development processes, rather than substitution for the developer.

5. Challenges, Ethical Considerations, and Future Trends

Correctness: Relying on AI tools for tasks where you cannot determine the correct answer or how to verify it can lead to complications and pitfalls. For software development, it means that human supervision and intervention is necessary, such as reviews. Creativity and the capability to detect defects are the most important characteristics that distinguish you and your code from AI [7], [13].

Transparency and Explainability: GenAI models often work like a "black box" - it's not clear how they make decisions. This is a problem in situations where mistakes can be very costly, like in

healthcare or finance software. It's important to create AI models that are easier to understand, systems that can explain their decisions in a way that people can easily follow, ensuring they are reliable and trustworthy.

Copyright: GenAI presents challenges for intellectual property and copyright. The legal aspects of content created by GenAI, which is based on works from original creators, are not yet well-defined. This includes concerns about copyright violations, using unlicensed content in training data, and determining who owns the generated content. Since these issues are new, legislators are currently working on setting clear rules for how existing intellectual property laws apply to GenAI.

Economy: In a world of GenAI and low code, it's hard to imagine a future where software engineers are as highly paid as today. Jobs like programming will change. Developers will need to learn new things, like making AI-made software better, helping machines learn, and figuring out AI actions that don't make sense [14].

Dependency and Skill Degradation: Over-reliance on AI tools can lead to a degradation of human skills. As AI systems take over more tasks, there's a risk that human workers may lose the ability to perform these tasks themselves, which could be problematic in situations where AI assistance is unavailable or fails.

6. Conclusion and Research Directions

This paper provided an overview of GenAI models in the software industry, highlighting their evolution, capabilities, and the transformative impact they have had on various aspects of software development. From automating routine coding tasks to enhancing creative processes, models like ChatGPT and GitHub Copilot have demonstrated significant potential.

We also addressed the ethical considerations and challenges, such as correctness of generated code and the need for responsible AI practices, which are critical to ensure that these technologies contribute positively to the industry.

Future research directions:

- **Personalization:** Improve how AI models adapt to individual developer style and project needs.
- **Trustworthy and Reliability:** Focus on developing models that offer transparent and understandable explanations for their decisions, thereby boosting their reliability and trustworthiness for software developers.
- **Technology Integration:** Explore how GenAI can work with emerging technologies like quantum computing and blockchain.
- **Security Enhancements:** Focus on stronger security to prevent vulnerabilities in AI-generated code.
- **Economic and Organizational Impact:** Study how AI affects costs, workforce dynamics, and productivity in the software industry.
- **Sustainability:** Research the long-term environmental and resource implications of using GenAI.

By addressing these research directions, we can harness the full potential of GenAI models while mitigating risks and ensuring their beneficial integration into the software industry.

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Application of Blockchain for Hydrogen-Related Data from Internet of Thing Devices Equipped with Hydrogen Sensors

Takeshi Tanaka^{1,*}, Satoru Tada¹, Masayuki Yamauchi¹, Koji Kakugawa¹, and Katia Vutova²
Hiroshima Institute of Technology, Hiroshima, Japan¹
Institute of electronics, Bulgarian Academy of Science, Sofia, Bulgaria²
tanaka@cc.it-hiroshima.ac.jp

Abstract: The Internet of Things (IoT) has seamlessly integrated more than a billion intelligent, interconnected devices into our world today, and is expected to accommodate soon hundreds of billions more such devices. This imminent proliferation heralds a profound transformation that stands to influence the electronics industry and many other sectors. Furthermore, integrating blockchain technology into IoT can impart genuine trust in the collected data. Hence, our research endeavors to harness this potential by applying it to hydrogen-related data, which are expected to be critical in realizing a carbon-neutral society. Specifically, our attention is directed toward utilizing an initial blockchain system to securely store data obtained from IoT devices equipped with hydrogen sensors that can communicate through Sigfox technology.

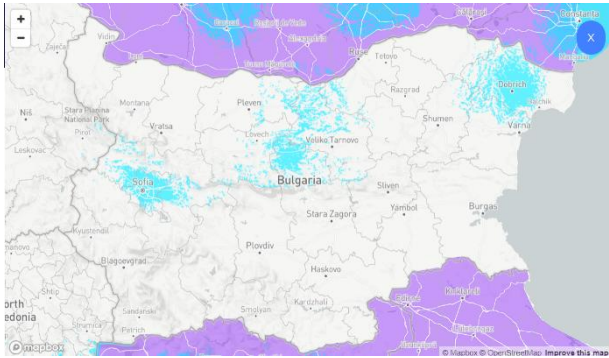
Keywords: HYDROGEN SENSOR, INTERNET OF THING, BLOCKCHAIN, SIGFOX, HASH FUNCTION

1. Introduction

Sigfox 0G technology is a Low-Power Wide-Area networking protocol owned by UnaBiz. It is designed to connect sensors and devices securely at low cost in the most energy-efficient way to enable Massive IoT (Fig. 1–3).

Since its inception in 2010, 0G technology has been adopted by 70+ national 0G network operators globally. The 0G operators own and commercialize the global 0G network in the respective countries that they operate in (Fig. 2).

Today, UnaBiz, the 0G operators, and over 800+ ecosystems of IoT players (chip manufacturers, device makers, solution providers, and system integrators) collaborate to provide the global 0G network as well as Massive IoT solutions and services to over 1,500+ B2B customers by connecting over 11 million devices.



(b)
Fig. 2 Europe (a) and Bulgaria (b) with 0G network coverage [2]

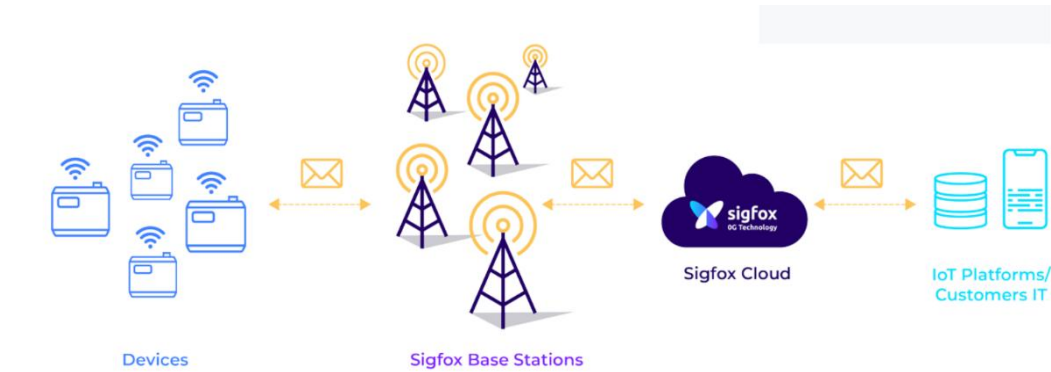
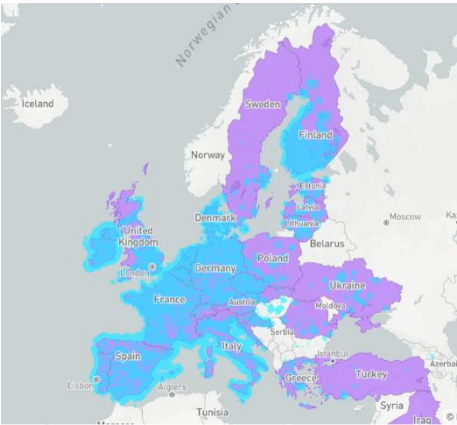


Fig. 1 Overview of Sigfox system [1]



(a)

THE 0G TECHNOLOGY



Autonomy

Extremely low-energy consumption, allowing years of battery life.



Simplicity

No configuration, connection request or signaling. Your device is up and running in minutes!



Cost efficiency

From the hardware to the network, every step is optimised to be as cost-effective as possible.



Small messages

No large assets or media allowed on the network, only small notifications: up to 12 bytes.



Complementarity

Sigfox oG technology can be used together with any other type of network, e.g.: Wi-Fi, Bluetooth, GPRS, NB-IoT, LoraWAN.

Fig. 3 Outline of the 0G technology [3]

The IoT has seamlessly woven together more than a billion intelligent, interconnected devices today, anticipating accommodating hundreds of billions more in the near future. This impending proliferation heralds a profound transformation that stands to influence not only the electronics industry but also a multitude of other sectors. Furthermore, the incorporation of blockchain technology into IoT has the potential to instill genuine trust in the data collected.

Hence, our research endeavors to harness this potential by applying it to hydrogen-related data, which are expected to be critical in realizing a carbon-neutral society.

In particular, we focus on using a preliminary blockchain system to securely store data derived from IoT devices equipped with hydrogen sensors capable of communicating via Sigfox technology.

2. Sigfox network

Sigfox provides an affordable, reliable, and energy-efficient solution for linking sensors and devices.

Through our dedicated radio-based network, we are committed to enable the efficient functioning of IoT. The Sigfox protocol emphasizes:

- **Energy Efficiency:** Minimal power consumption for extended battery life.
- **User-Friendly:** No complex setup or lengthy connection procedures—your device is operational within minutes.
- **Cost Optimization:** We streamline hardware and network operations for maximum cost-effectiveness.
- **Small Data:** Only small notifications, up to 12 bytes, are permitted on the network.
- **Versatility:** Sigfox can also serve as a complementary solution alongside other networks, such as Wi-Fi, Bluetooth, or GPRS, thanks to its affordability and ease of configuration.

3. Hydrogen gas sensor and measurement of its concentration

The MQ-8 gas sensor ((Fig. 4), which is manufactured by Zhengzhou Winsen Electronics Technology Co., Ltd, Zhengzhou, China utilizes SnO_2 as its sensitive material, exhibiting low conductivity in a clean-air environment. This sensor can measure hydrogen (H_2) gas in the concentration range of 100–1000 ppm. Users can transform the conductivity variations into a relevant output signal indicating gas concentration by employing a straightforward circuit. Our choice of the MQ-8 hydrogen sensor in this study is supported by these features.



Fig. 4 Photos of the hydrogen sensor (MQ-8) [4]

Basic Circuit

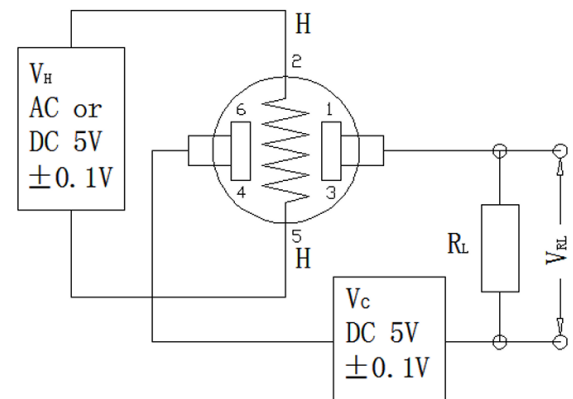


Fig. 5 MQ-8 test circuit [4]

Using the circuit in Fig. 5, we measured V_{RL} in the circuit to obtain the hydrogen concentration in the environment. The value of V_{RL} is used to calculate the sensor resistance. The graph's vertical axis represents the sensor's resistance ratio (R_s/R_0), whereas the horizontal axis indicates gas concentration. R_s denotes the resistance in various gas concentrations, and R_0 signifies the sensor's resistance in a clean-air environment. The resistance ratio of the sensor (R_s/R_0) can be corrected by considering concentration dependence (Fig. 6), temperature dependence (Fig. 7), and humidity dependence (Fig. 7). Therefore, it has been shown that the hydrogen concentration in the environment can be calculated using temperature, humidity, atmospheric pressure, voltage applied to the sensor, and hydrogen sensor voltage.

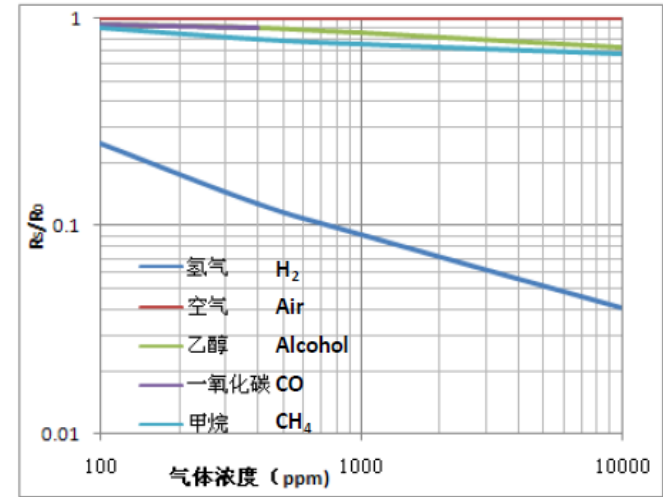


Fig. 6 Typical sensitive curve of MQ-8 [4]

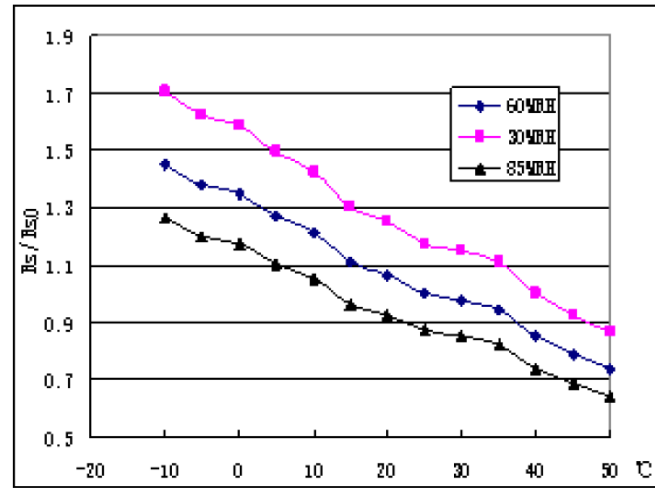


Fig. 7 Typical temperature humidity characteristics.

4. Data format and transfer method using Sigfox

Data from Sigfox IoT devices is a maximum of 12 bytes, and the data structure is as follows:

- Temperature integer: 2 bytes, four digits in hexadecimal
- Humidity integer: 2 bytes, four lines in hexadecimal
- Atmospheric pressure integer: 2 bytes, four digits in hexadecimal
- Sensor applied voltage: integer, 2 bytes, four digits in hexadecimal
- Hydrogen sensor voltage: integer, 2 bytes, four digits in hexadecimal.

In the remaining 2 bytes, the four digits of the hexadecimal hash SHA-256 are entered. These digits usually indicate the temperature, humidity, barometric pressure, sensor applied voltage, and hydrogen sensor voltage. Data on these same parameters are also transmitted in little-endian format. The sent data are displayed after decoding in Fig. 8.



Fig. 8 Message from the Sigfox device.

5. Data decoding and display

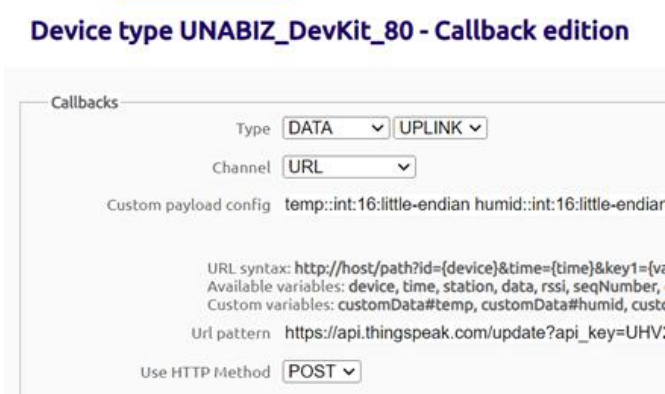


Fig. 9 Callback of the Sigfox device.

Using the Custom payload config of “temp::int:16: little-endian humid::int:16:little-endian press::int:16:little-endian x::int:16:little-endian y::int:16:little-endian z::int:16:little-endian” in the callback of the Sigfox device (Fig. 9), the parameters of temperature, humidity, atmospheric pressure, sensor applied voltage, and hydrogen sensor voltage were calculated. The H_2 concentration is estimated from the sensor resistance ratio (R_s/R_0) by considering concentration dependence (Fig. 6), temperature dependence (Fig. 7), and humidity dependence (Fig. 7). The results are shown in Fig. 10.

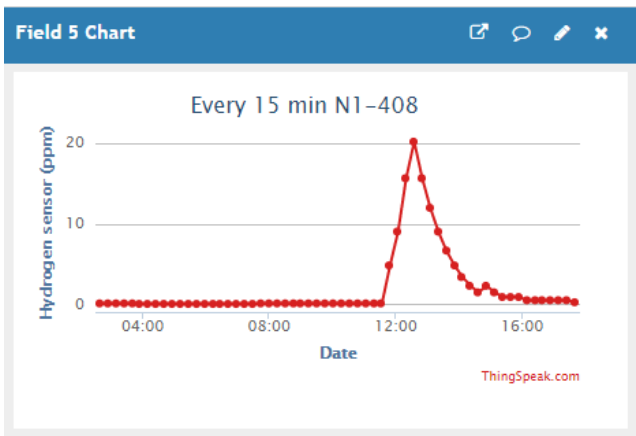


Fig. 10 Hydrogen concentration (ppm) estimated by the Sigfox device.

6. Blockchain

The Sigfox data comprised 10 bytes this time, and the maximum data size is 12 bytes, but there are still 2 bytes to spare.

Hence, when data are expressed in 24 hexadecimal digits, the parameters of temperature, humidity, atmospheric pressure, sensor voltage, and hydrogen voltage are properly indicated. Here, each set of 4-digit hexadecimal digits is used so that it can be used for other purposes. A hash of the transferred data was taken simultaneously with these four digits and appended to the end of the data (Fig. 11).

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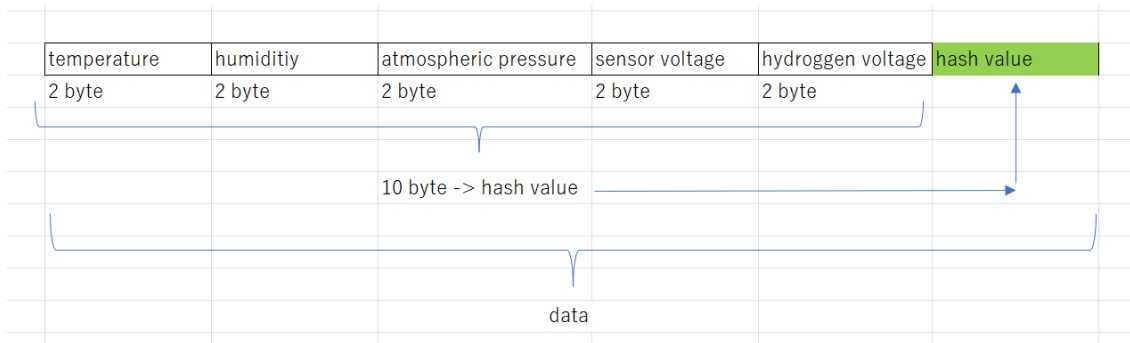


Fig. 11 Structure of data using Sigfox.

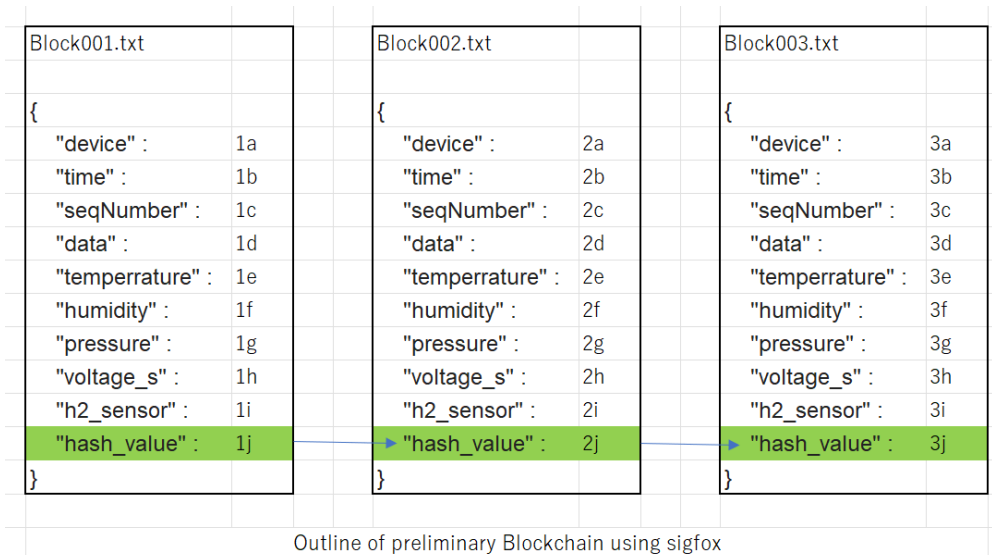


Fig. 12 Hashing performed using a general blockchain

Part of the transmitted data can now be hashed (Fig. 11). We performed hashing using a general blockchain (Fig. 12).

Thus, these values suggest that data reliability during data transmission could be significantly improved by using double hash values for data and files.

7. Summary

The IoT has seamlessly woven together more than a billion intelligent, interconnected devices today, anticipating accommodating hundreds of billions more in the near future. This imminent proliferation heralds a profound transformation that stands to influence the electronics industry and many other sectors.

Furthermore, integrating blockchain technology with IoT promises to instill genuine trust in the data collected. Hence, our research is dedicated to harnessing this potential, specifically in the context of hydrogen-related data, which play a pivotal role in realizing a carbon-neutral society. One suggestion for enhancing data reliability involves using double hash values for data and files during data transmission.

Nano-structured Electrode Materials with Reduced Amount of Platinum Aimed for Hydrogen Evolution. Part II: Effect of MWCNTs modification

Ana Tomova, Perica Paunović

Faculty of Technology and Metallurgy, University Ss Cyril and Methodius in Skopje, North Macedonia¹
pericap@tmf.ukim.edu.mk

Abstract: Direct Metal Laser Sintering (DMLS) is a revolutionary technology that allows a production of fully functional metal parts directly from a 3D CAD data, eliminating the investment to production tools and technologies which brings considerable cost and time savings. Metal parts made by DMLS technology are fully comparable with casted or machined parts. A range of application of DMLS technologies is very wide – from prototypes, through short-run production to final products. Advantages of DMLS technology are arising along with complexity of parts – more complex geometry of parts (in terms of shape and occurrence of the detail) make DMLS technology even more economically effective.

Keywords: HYDROGEN ECONOMY, CATALYST SUPPORT, MWCNTs MODIFICATION, COBALT, PLATINUM

1. Introduction

Living in the time of exhausted and limited reserves of fossil fuels [1], the “hydrogen economy” is emerging as a promising future energy supply system instead of the existing one based on fossil fuels [2]. The main focus of the hydrogen economy’s activities is directed to selection and development of the effective electrode materials for electrochemical devices for hydrogen production and its conversion to electricity. The modern electrodes materials are consisted of electrocatalytic phase (mainly metals, mixture of metals or mixture of metals and its compounds) and catalyst support (nano-dimensional carbon materials) [1]. The most used traditional electrode material contains platinum nanoparticles deposited on carbon blacks (Vulcan XC-72). In the first part of this paper series, the actual problems with platinum were explained, as well as the pathways for improvement of electrocatalytic activity of non-platinum metals [3]. Here we will explain the importance of the support materials and pathways for their improvement in order to enhance the electrocatalytic activity of the whole electrode material.

Metallic nanoparticles affinity to agglomerate in larger particles and show very poor dispersion, resulting in deterioration of the surface characteristics. This is a considerable limitation of their use as an electrocatalytic electrode material, in fact, they cannot be used as an electrocatalysts individually. To overcome this drawback, they must be applied to a support material. Therefore, the principal function of the support material is to provide a uniform dispersion of the metallic nanoparticles over the whole surface and to avoid their agglomeration. So, the support material should have superior surface characteristics. The other requirements that have to be assured for better performances of the electrode materials are [1]: *i*) high electrical conductivity. Because of the ratio between support material and metallic catalytic phase of 4–5:1, the support material should provide continuous exchange of electron with reacting ions; *ii*) good chemical and mechanical stability to provide long durability of the electrochemical devices and *iii*) to be “non-inert”, i.e. to provide interaction with metallic (catalytic) phase, which improve the electrochemical activity of the electrode material.

The most used support material in hydrogen economy is carbon black (Vulcan XC-72), as result of its appropriate properties, such as a high degree of ordering, surface characteristics and high electroconductivity [4]. The discovery of carbon nanostructures has attracted great attention to their application as a support material in the hydrogen economy. So, the newer carbonaceous materials such as carbon nanotubes (CNTs) and nanofibers were recognized as a very suitable for this purpose [5–7]. In comparison with Vulcan XC-72, CNTs show the following advantages: *i*) higher electroconductivity in range of 10^3 – 10^4 S·cm⁻¹ vs. 4 S·cm⁻¹ [8]; *ii*) higher specific surface area in range of 200–900 m²·g⁻¹ [8]; *iii*) Vulcan XC-72 possesses micropores smaller than 2 nm, which is not the case with CNTs [8]. This is important for the electrocatalytic purpose, because the fine nanostructured metallic particles can sink into the micropores, reducing the number of three-phase boundary reaction sites; *iv*) higher chemical stability, very important parameter for anodic reactions, where the electrochemical degradation of carbon

materials is shown by carbon graphitization [4]. This can be described by the fact that electrochemical corrosion takes place at the edge planes of graphite, whereas the basal planes are relatively inert. Therefore, a higher corrosion resistance was noticed in materials such as Pt/CNTs which are roll-ups of graphene sheets and possess a long-range order, as compared to Pt supported on carbon blacks which have a turbostratic structure and are composed of a mixture of graphite crystallites and amorphous carbon [9].

Because the manufactured MWCNTs always contain impurities such as amorphous carbon, alkali metal nanoparticles [10,11], a further treatment of carbon nanotubes is needed. The purification means remove of the impurities, while activation means making the surface more reactive as result of increased presence of functional groups. One of the most used purification/activation methods is treatment by nitric acid [6,12]. During purification process, shortening and opening of the MWCNTs occurs, implying more active surface.

The main goal of this research is to enhance the electrocatalytic activity of the Co-Pt based electrode materials through the purification/activation of the manufactured MWCNTs in concentrated nitric acid.

2. Materials and Methods

The first experimental step was a purification/activation of the manufactured MWCNTs (Guangzhou Yorkpoint Energy Company, China) in 28%wt. solution of HNO₃. Ultrapurified and deionized water was used for the preparation of the solution. The dispersed MWCNTs into the solution were stirred by magnetic stirrer (1000 rpm) for 4 h. The suspension full of MWCNTs was filtered by vacuum through a micro-filter. Final drying was performed at 95 °C for 12 h. The structural changes of treated MWCNTs related to the manufactured (non-treated), were studied using thermal analysis (TG/DTG), Raman spectroscopy and TEM microscopy. For thermal analysis a Perkin Elmer Pyris Diamond Thermogravimetric/Differential Thermal Analyzer was used. MWCNTs samples were heated in the temperature range of 25÷1000 °C with a heating rate of 20 °C·min⁻¹, in atmosphere of N₂. Scanning of the Raman spectra was performed using Micro-Raman multichannel spectrometer – Horiba JobinYvon LabRam Infinity (f x 10) using 532 nm YAG laser. Transmission electron Microscope JEOL JEM - 200 CX was used for TEM observation.

Surface changes were observed by cyclic voltammetry measuring the values of the double layer capacity [13,14]. The ratio of real versus geometric surface area S_R/S_G , of the electrodes was determined as a quotient of the catalyst’s double layer capacity C_{dl} versus the double layer capacity C_{dl0} of a pure oxide surface.

The preparation and composition of the studied electrode materials was identical as in the first part of this paper series [3]. The structural changes of the samples, was studied by infrared FTIR spectroscopy. The FTIR spectra were recorded using KBr pellets at

room temperature with a Perkin-Elmer System 2000 interferometer. Electrochemical characterization was performed using the same instrumentation line and methods as in the first part of this paper series [3].

3. Results and discussions

The electrocatalytic activity of the studied electrode materials expressed through polarization curves in the plot of current density-overpotential ($i-\eta$), are shown in Fig. 1. Corresponding values of Tafel slopes in the lower and higher current regions, as well as the overpotential at reference current density of $60 \text{ mA} \cdot \text{cm}^{-2}$ are listed in Table 1. The order of activity is the same as in the first part of this paper series: $\text{CoPt}(1:1) > \text{Pt} > \text{CoPt}(4:1): \text{Co}$, and the reason of this order was explained. But, if compare the electrocatalytic activity of each metallic phase with that of each metallic phase deposited on non-treated (manufactured) MWCNTs (presented in previous part), significant improvement can be observed. This comparison is shown in Figures 2 to 5.

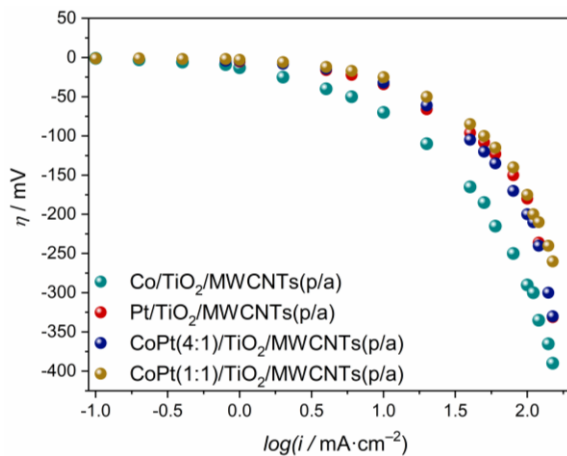


Fig. 1 Polarization curves in the plot $\log i-\eta$ for the studied electrode materials deposited on treated MWCNTs, in 3.5 M KOH

Table 1: Tafel slopes and overpotential at the reference current density of $60 \text{ mA} \cdot \text{cm}^{-2}$ for HE of the studied electrode materials in 3.5 M KOH.

Sample N°	Met. phase (10%wt.)	b_1	b_2	η_{60}
1	Pt	23	373	-125
2	CoPt (1:1,wt.)	17	302	-115
3	CoPt (4:1,wt.)	20	365	-135
4	Co	43	383	-215

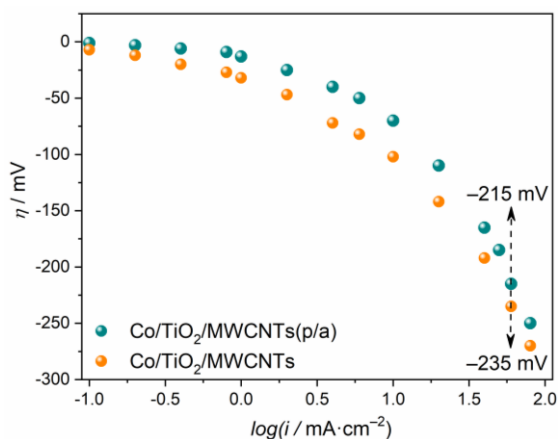


Fig. 2 Polarization curves in the plot $\log i-\eta$ for Co/TiO_2 system deposited on manufactured and treated MWCNTs, in 3.5 M KOH

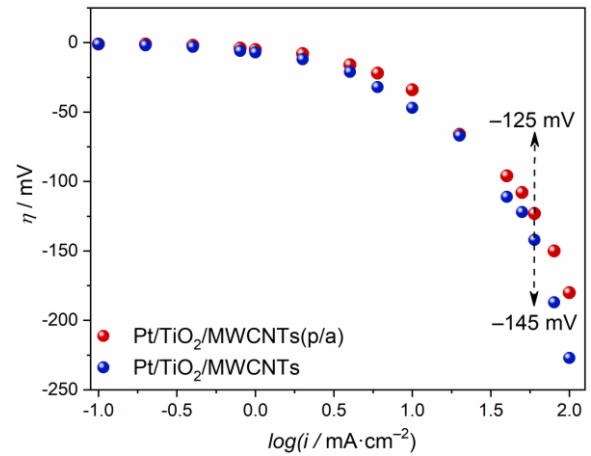


Fig. 3 Polarization curves in the plot $\log i-\eta$ for Pt/TiO_2 system deposited on manufactured and treated MWCNTs, in 3.5 M KOH

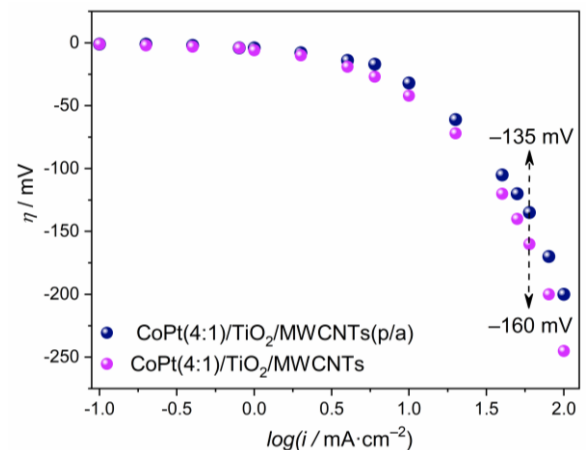


Fig. 4 Polarization curves in the plot $\log i-\eta$ for $\text{CoPt}(4:1)/\text{TiO}_2$ system deposited on manufactured and treated MWCNTs, in 3.5 M KOH

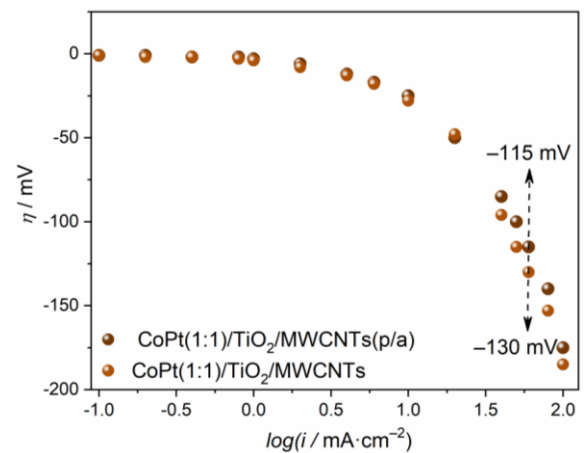


Fig. 5 Polarization curves in the plot $\log i-\eta$ for $\text{CoPt}(1:1)/\text{TiO}_2$ system deposited on manufactured and treated MWCNTs, in 3.5 M KOH

Confirmation of this improvement of electrocatalytic activities of the studied electrode materials are the values of Tafel slopes shown in Table 1 and in Table 2 in the first part of this paper series [3].

To check for some changes in the hypo-hyper d-interaction between the metallic phase and TiO_2 , as result of the MWCNTs treatment, FTIR spectra (Fig. 6) were recorded. All electrode systems show similar spectra and can be concluded that there is not additional hypo-hyper d-interaction as result of MWCNTs treatment. Therefore, the reason for improvement of the electrocatalytic activ-

ity should be sought in the structural or surface changes of MWCNTs as result of their treatment in nitric acid.

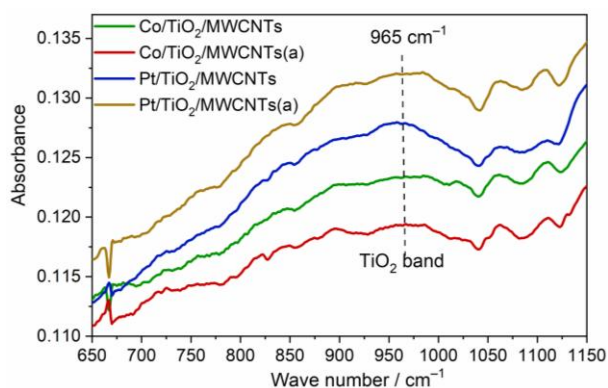


Fig. 6 FTIR spectra for electrode materials with pure metallic phase

Thermal analysis (TG/DTG) of the studied electrode materials has shown that the acid treatment caused higher thermal stability of the MWCNTs. In the DTG spectra shown in Fig. 7, one can see that all characteristic temperatures for the treated MWCNTs are shifted to the higher values. The DTG peak at 573 °C for non-treated MWCNTs is ascribed to the combustion temperature of amorphous carbon, while the peak at 757 °C corresponds to the combustion temperature of the MWCNTs. The corresponding combustion temperatures of amorphous carbon and MWCNTs for acid treated MWCNTs are 641 °C and 893 °C. According to the TG values of temperature shown in Table 2, weight loss of the non-treated MWCNTs starts at 523 °C, with complete oxidation at 617 °C. The corresponding temperatures for acid treated MWCNTs are higher – 585 °C and 847 °C respectively.

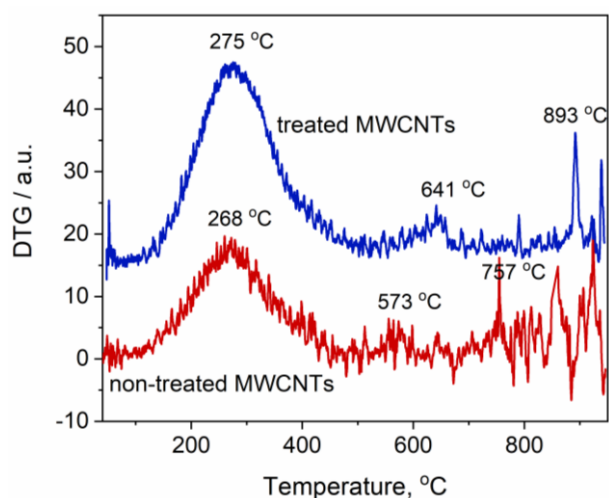


Fig. 7 DTG spectra of non-treated and treated MWCNTs

Table 2: Characteristic TG oxidation temperatures for the non-treated and treated MWCNTs.

Sample	TG ₁	TG ₂	TG ₃
Non-treated MWCNTs	173	523	617
Acid treated MWCNTs	180	585	847

The Raman spectra of the non-treated and purified/activated MWCNTs shown in Fig. 8 are consisted of two well pronounced peaks D and G. D peak at near 1350 cm⁻¹ expressing the presence of disordered carbon structure: defects such as pentagons or heptagons in graphite, vacancies from single to multiple, edges of the graphite crystal, amorphous carbon etc. [15]. G peak at 1585 cm⁻¹ is attributed to the highly oriented graphite [16]. A low pronounced and shouldered peak noted as D' can be observed at position of 1620 cm⁻¹. The presence of the D' peak points out that these carbon nanotubes are multiwalled [17]. The intensity ratio of the characteristic peaks (I_D/I_G) points out on the extent of disorder, i.e. the pro-

nounced presence of defects and impurities in the nanotubes. After the acid treatment of the MWCNTs the value of the I_D/I_G ratio from 1,32 decreases to 1,23. This indicates on the increase of crystallinity of the MWCNTs, i.e. removing of amorphous carbon and reducing the defects within its structure.

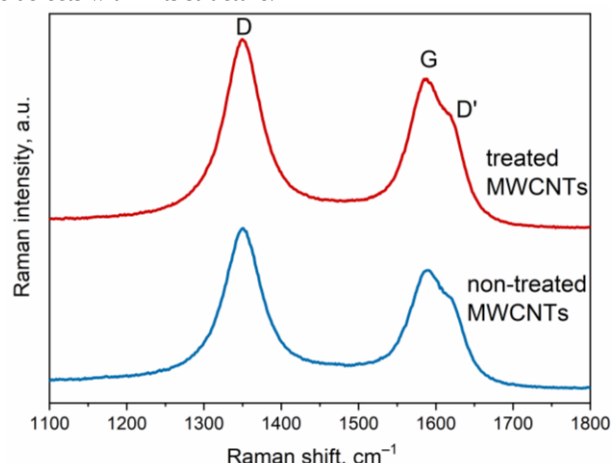


Fig. 8 Raman spectra of non-treated and treated MWCNTs

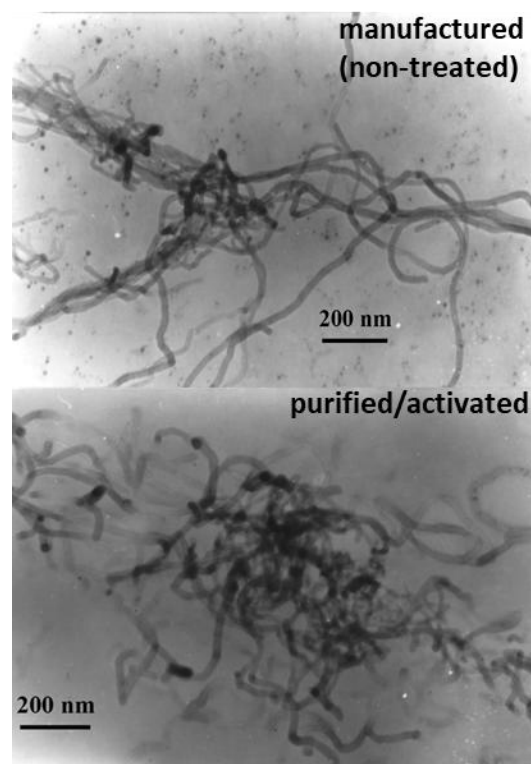


Fig. 9 TEM images of non-treated and treated MWCNTs

From the TEM images shown in Fig. 9, the shortening and opening of the MWCNTs can be clearly seen. This means increase of defects within the MWCNTs structure and increase of the I_D/I_G ratio is expected. But, the Raman results did not show that. The decrease of the I_D/I_G ratio can be explained by the high extent of the removal of amorphous carbon. The shortening and opening of the MWCNTs is an appropriate for electrocatalytic purpose, as result of increased MWCNTs reactivity, facilitating the process of applying the metallic phase over the MWCNTs surface. Also, a higher real surface area of MWCNTs could be expected.

This expectation was confirmed by the values of the double layer capacity for pure carbon phases and the ratio of real vs. geometric surface area (S_R/S_G). The measurements were performed in the region of potentials where only charging of double layer occurs with scanning rate from 1 to 10 mV·s⁻¹. The procedure for determination of C_{dl} for carbon blacks and carbon nanotubes, as well as electrocatalysts deposited on these carbon substrates, is presented elsewhere [18]. The results are shown in Table 3. The acid treated

carbon nanotubes have higher value for the double layer capacity than that of non-treated MWCNTs, i.e. they have more developed surface area expressed with higher ratio of real vs. geometric surface area (S_R/S_G). As was mentioned above, this is result of opening, shortening, and thinning of the nanotubes by HNO_3 treatment. Also, according to the C_{dl} and S_R/S_G values, MWCNTs show almost two times higher surface area than the traditionally used carbon substrate, Vulcan XC-72.

Table 3: Double layer capacity C_{dl} and ratio of real vs. geometrical surface area S_R/S_G for the studied carbon nanostructures.

Sample	C_{dl} , $\text{mF}\cdot\text{cm}^{-2}$	S_R/S_G
Non-treated MWCNTs	331	5520
Acid treated MWCNTs	355	5920
Vulcan XC-72	179	2980

4. Conclusions

According to the presented results, the following conclusions can be drawn:

- During the activation/purification of MWCNTs, two main processes occur: i) removing of other carbonaceous phases such as amorphous carbon and ii) shortening, thinning and opening of the MWCNTs.
- These phenomena favour the increase of the real surface area of the support material (MWCNTs) and consequently of the electrode material as a whole.
- All electrode materials deposited on the acid treated MWCNTs have shown improved electrocatalytic activity related to the corresponding systems deposited on non-treated MWCNTs.
- Compared with traditional electrode material (the same quantity of platinum, 10%wt. deposited on Vulcan XC-72), the best catalytic system 10%CoPt(1:1)/TiO₂/MWCNTs(p/a) has shown much higher electrocatalytic activity (−115 mV vs. −220 mV [19]) at reference current density of 60 $\text{mA}\cdot\text{cm}^{-2}$). Even the electrode material with pure Co phase (10%Co/TiO₂/MWCNTs(p/a)) exceeded the electrocatalytic activity of the traditional platinum electrocatalysts (−215 mV vs. −220 mV).

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Wetting coatings on TiO₂ based glasses for photovoltaic application and contact angle measurements

Stancho Yordanov¹, Mihail Georgiev², Silviya Simeonova³, Bojidar Jivov¹, Vladimir Petkov¹, Mihela Aleksandrova¹,

¹ Institute of Metal Science, Equipment, and Technologies "Acad. A. Balevski" with Center for Hydro- and Aerodynamics at the Bulgarian Academy of Sciences, 67 "Shipchenski prohod" str., 1574 Sofia, Bulgaria

² Faculty of Chemistry and Pharmacy, Department Chemical and Pharmaceutical Engineering, Sofia University, 1164 Sofia, Bulgaria;

³ Faculty of Chemistry and Pharmacy, Department Physical Chemistry, Sofia

University, 1164 Sofia, Bulgaria;

stanco14@abv.bg

Abstract: They have been conducted on ellipsometry and contact angles. The contact angles of a surface coating on glasses applied in photovoltaics were measured. This study used a DSA 100-Expert (Krüss GmbH, Germany) to measure contact angles on glass substrates. Contact angles were measured using the DSA 100-Expert tilt table accessory to identify both advancing and receding contact angles. A drop of deionized water is deposited on the glass substrate and then the table is tilted at a constant rate of 5 degrees per minute, to a tilt angle of 90 degrees.

Keywords: WETTING COATINGS, PHOTOVOLTAIC, GLASS, TIO₂

1. Introduction

The construction of solar systems with different power (for domestic and business customers) and large photovoltaic parks is a current energy alternative, in line with the trends for the use of ecological renewable energy sources [1-6]. At the same time, due to the drastic change in the geopolitical situation and the unsustainable prospects for access to conventional energy carriers, traditionally provided by large international suppliers, the role of the solar energetics is significantly increasing.

Regarding the final consumers of the generated electricity, photovoltaic plants are classified into three main categories [1,3,7]: stand-alone installations (providing power only to individual sites), solar systems connected to the National Electricity Distribution Network and combined (hybrid) installations combining the characteristics of the previous ones two.

The productivity of solar installations is determined by a variety of factors [3,7]: orientation of photovoltaic panels, impact of cyclic diurnal and seasonal weather changes, climatic specifics of the region, contamination of solar modules, etc. Main pollutants are heterogeneous local deposits, diverse fractions of dust particles [8,9] (of natural or industrial origin), products of the biological cycle of different populations, and others.

Different construction types of cleaning systems [7,8,9] (manual, automated and robotic) are used for the individual categories of photovoltaic systems. In this aspect, the use of a self-cleaning coating is considered as a promising and cost-effective approach for maintaining the solar panels in a highly efficient state [10]. Of significant interest is the development of innovative nano-sized, self-cleaning coatings [11-16], obtained by technological methods providing a long-lasting effect and high atmospheric resistance.

A self-cleaning mechanism has been discussed, which is defined as the capability to expel the contamination particles by the action of spherical water droplets [17-19]. It's proved that water contact angle is one of the significant factors to obtain self-cleaning coatings and strong anti pollution effect [20]. There are two main functional types of self-cleaning coatings: hydrophobic and hydrophilic. The main difference between hydrophobic and hydrophilic was based on the movement of water droplets. Self-cleaning hydrophobic coatings repels the present various contaminants by sliding away or rolling off the particles from its surface [21].

Hydrophobic coatings can be further classified as hydrophobic and superhydrophobic surfaces differentiated by the motion of droplets. Self-cleaning is expressed by the capability of a hydrophobic surface to wash out dust particles by the action of water droplets [17-19].

On the superhydrophobic coatings, the spherical droplets will be carrying the various contaminants away in a rolling motion, while on a hydrophobic surface, the half-spherical droplets carry the

contaminants away by sliding motion. It has been experimentally found that the rolling motion of droplets is significantly more effective to clean of the coatings than the sliding motion [11]. The hydrophobic coatings must be characterized a very high static wettability contact angle and a very low roll-off angle to obtain an effective self-cleaning mechanism [21].

Silicon dioxide SiO₂ is commonly used in the development of various hydrophobic self-cleaning functional coating for the cover glass materials. Research team [22] have obtained silica coating composed of base-catalyzed silica sol and acid-catalyzed silica sol by using dip-coating method and adequate laboratory regime of thermal treatment. The mixed silica coating exhibits suitable superhydrophobic and self-cleaning characteristics with the water contact angle of 162°. As the coating possess strong Si-OH bond, it gives strong adhesion to glass surface [21].

The existing micro and nanotextures on the hydrophobic coatings halt the expanding motion of liquid, substantially increasing the liquid droplet's contact angle [21]. Thus, the liquid droplet can immediately roll off at a higher speed for the superhydrophobic surface. Different from a hydrophilic coatings which holds back the contracting motion of the liquid and provokes the lowering in contact angle of the liquid droplet [21].

The self-cleaning mechanism of superhydrophilic coating can be initiated with or without UV light. At the same time, a self-cleaning hydrophilic coating is assisted by a photocatalysis mechanism to lowers the presence the various pollutants on the super hydrophilic surface under UV-light exposure [21]. The photocatalysis process is initiated by photocatalysts such as titanium dioxide TiO₂ (or other semiconductor materials) to generate electrons and holes and formed electron-hole pairs by absorption of UV-radiation in photocatalyst coating. In the further development of the process the electron-hole pairs then oxidize the adsorbed species on the photocatalyst [21,23,24].

The photocatalysis reaction of the obtained coating is based on the TiO₂ band where the bandgap is enough to generate more hydroxyl groups and superoxide anion for photocatalysis process [21]. The titanium dioxide is mostly applied as photocatalyst component, but its band gap energy is high which can absorb UV-radiation only. In relation to this, various modifiers such as silicon dioxide, iron, tungsten and nitrogen have been doped into the titanium dioxide materials to increase its photo-response to visible range of light.

Whereas self-cleaning mechanism without the influence of UV-light is denoted as non-photocatalyst. Superhydrophilic coating spreads the water droplet into thin-film layer of water and flow the contaminants down the water stream [25]. The superhydrophilic polymers consists of various polar functional groups such as hydroxyl, carboxyl, and carbonyl-chains. The different polar functional groups are characterized by significant attraction to water which provides the solid surface completely wetting [21].

In the present article, the results of the performed laboratory studies of experimental self-cleaning TiO_2 thin films, deposited by the sol-gel method on the glass plates are presented. Obtaining transparent self-cleaning coatings for solar panels is considered as a major possibility for potential application of the development.

2. Experimental

2.1. Materials

All compounds were supplied as analytical grades and were used without further modification. Thin film coatings are performed on glass slides from AGC Glass Europe. TiO_2 precursors and solvents were 99% titanium isopropoxide, also commonly referred to as **titanium** tetraisopropoxide or TTIP, is a chemical compound with the formula $\text{Ti}\{\text{OCH}(\text{CH}_3)_2\}_4$ /TTIP/ and 99.9% ethanol ($\text{C}_2\text{H}_5\text{OH}$), all purchased from Alfa Aesar Germany. The hydrolyzing agent is distilled water, and the stabilizer is nitric acid / HNO_3 /. Preparation of the glass substrate. Before being cleaned, the slides were cut to size (20 mm x 70 mm x 2 mm). Substrate cleaning is important prior to the deposition process, as this allows the cleaning and removal of submicron particles from the substrate surface. This is decisive for the quality of the bonding film on the substrate. The glass substrates were cleaned/washed/ in 99.9% ethyl alcohol for 15 minutes and acetone for 15 minutes and then dried for 30 minutes at 100°C . Cleaning the glass substrates improves the adhesion of the coating material to the substrate and prevents contamination on the formed coating.

Preparation of TiO_2 sol. The aim of the synthesis is to obtain coatings of TiO_2 on glass substrates applying sol-gel method. Mixture of precursor – 5 ml of 99 % TTIP and 5 ml of DEA / $\text{C}_4\text{H}_{11}\text{NO}_2$ /– was added dropwise to the acid solution, made of ethanol, water and nitric acid in a ratio of 1:1:0.5 for prevent gel formation. To ensure adequate hydrolysis, the mixture was continuously stirred at 500 rpm with a magnetic stirrer for 2 hours under air pressure to produce a pink translucent solution. Schematics of the process of obtaining a thin film of sol gel with TiO_2 . Depiction of the chemical synthesis of TiO_2 -based sol. A dip coating machine (Dip Coating technology) at a speed of 42.8 mm/min was used to deposit thin layers of TiO_2 on the substrates. A lower speed of the applied solution on the glass substrate helps the coating to be uniform, while a higher rate helps the solution to become thinner. The deposited films were then heated at a temperature of 500°C for 15 min /schema 1/.

Schema 1: Schematics of the process of obtaining a thin film of sol gel with TiO_2

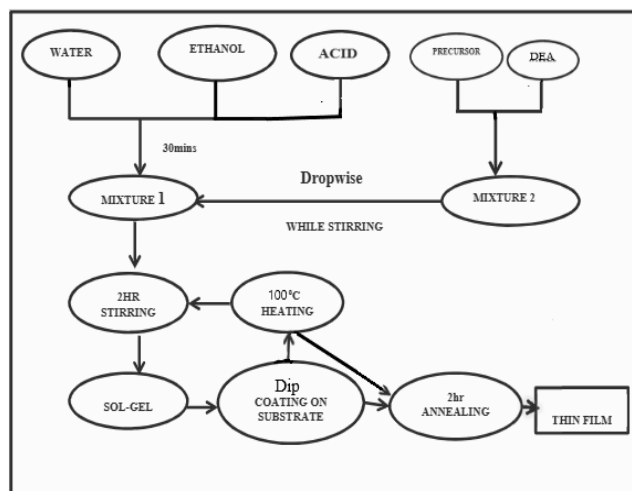


Table 1. Table for samples:

samples:	Main composition:	Drying time	T°C-treatment	Number of layers
GLS-11	TTIP	30 min	500°C- 15 min	1
GLS-12	TTIP	30 min	500°C-15 min	1

3. Result and Discussion

3.1 Contact Angle Measurements

This study utilised the DSA 100-Expert (Krüss GmbH, Germany) to measure contact angles on glass substrates. Contact angles were measured using the tilting table accessory of the DSA 100-Expert to identify both the advancing and receding contact angles. A droplet of deionised water was deposited onto the glass substrate, and the table was then tilted at a consistent rate of 5 degrees per minute, up to an angle of inclination of 90 degrees.

Each contact angle measurement was performed three times on each substrate to ensure the accuracy of the results. The advancing and receding contact angles were measured as the substrate tilted from 0 to 90 degrees. The images of the droplet at each degree of tilt were captured and subsequently processed using the DSA 100-Expert's built-in software.

Contact angle hysteresis, defined as the difference between the advancing and receding angles, was also evaluated in this study.

Sample Preparation

The glass substrates were cleaned before the experiments. The cleaning procedure involved wiping the substrates with a cloth soaked in 95% ethanol and rinse with deionised water. The substrates were then left to dry in a clean, dust-free environment. The cleanliness of the samples was confirmed through a preliminary contact angle measurement of a bare glass sample ($\theta < 10^\circ$).

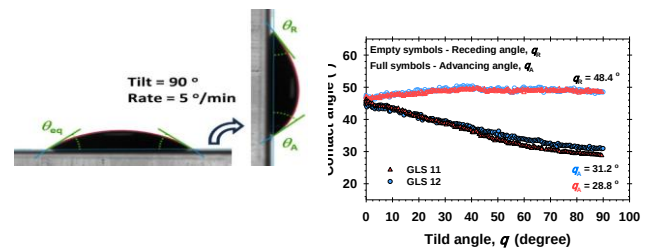


Fig. 1 . Contact angle measurements on modified glass surfaces: A) Represents the procedure of determining dynamic contact angles by tilting the optical table of the apparatus to 90 degrees. B) Illustrates the advancing and receding contact angles of a water droplet on samples GLS 11 and GLS 12. The values are calculated by taking the 2D profile of the droplet and applying the tangential method to both sides of the droplet concerning its midpoint

The receding angle of the droplet on both modifications is $\theta_R = 48.4^\circ$. The advancing angles, however, show slight differences: GLS 11 has $\theta_A = 31.2^\circ$, and GLS 12 has $\theta_A = 28.8^\circ$. Generally, differences within a 5% deviation are considered negligible in such experiments. However, the difference between the advancing angles of the modified glass surfaces approaches this value. Hence, in terms of hysteresis, it can be inferred that GLS 12 exhibits slightly higher resistance to droplet movement than GLS 11.

3.2. Ellipsometry Measurements

Ellipsometry measurements were employed in this study to determine the refractive index and thickness of the adsorbed layers on modified glass substrates. The Accurion EP4 Ellipsometer was utilised for these measurements due to its precision, accuracy, and non-destructive principle. The ellipsometer was operated in two distinct modes: Null-ellipsometry and Rotating Compensator Ellipsometry (RCE).

The measurements were made at an angle of incidence of 60 degrees, spanning a spectral range from 360 to 1000 nm. Initially, Null-ellipsometry was performed to determine the accurate refractive index of the substrate (glass) and the adsorbed layers. This mode measures the phase shift between *p*- and *s*-polarized light, providing high precision in refractive index determination.

Following the null-ellipsometry, the RCE mode was utilised to generate a thickness map of the adsorbed layers on the substrate. The rotating compensator technique allows for high-resolution measurements of amplitude and phase changes, making it particularly suitable for mapping the spatial variation in the thickness of thin films over large areas (500x500 μm).

All data obtained from these measurements were fitted using the Cauchy equation, a standard model for analysing transparent layers. The fitting process was performed using EP4's built-in software, which allows for the adjustment of multiple layers and substrates, thereby ensuring the precision and reliability of the thickness map.

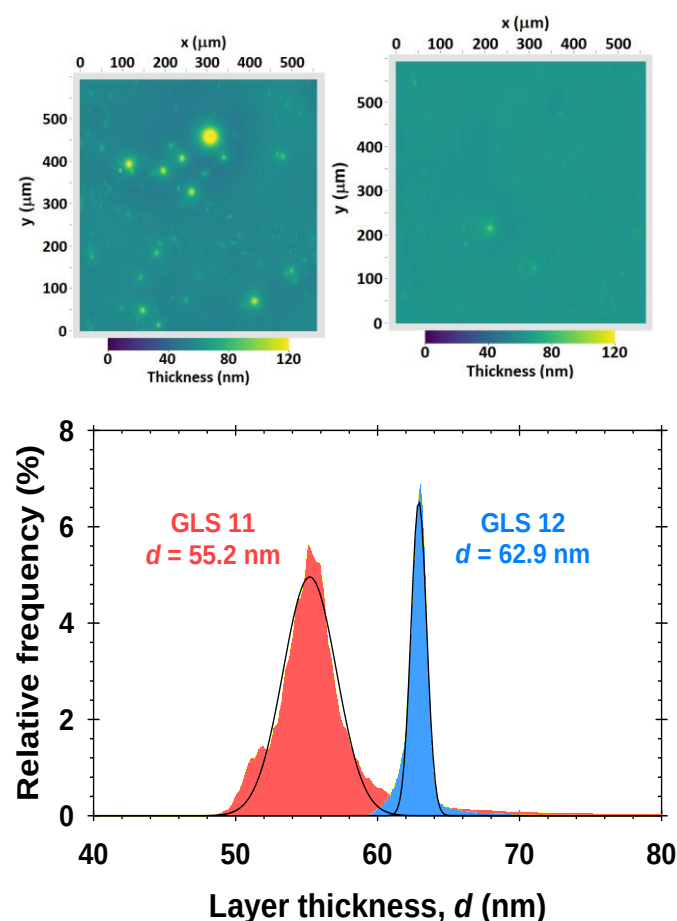


Fig. 2. Ellipsometry map images of samples: A) GLS 11 and B) GLS 12. The colour scale, ranging from 0 to 120 nm, visually represents the samples' thickness and is displayed below the images. The histogram presents the thickness distribution across the entirety of the observed area, modelled with a Gaussian fit (depicted as a solid line). The maximum point of this Gaussian fit is used to derive the thickness values displayed in the graph.

Figure 2. A displays an ellipsometry map image illustrating the thickness of the modified glass sample GLS 11. The image reveals that the procedure used to create GLS 11 results in a dense layer interspersed with hemispherical spots. The analysis of the accompanying histogram indicates a monomodal distribution of layer thickness, with a high-frequency value of 55.2 nm. The areas visible on the surface, represented in yellow, correspond to thicknesses around 100-120 nm, suggesting they are initial states for forming a double layer.

In contrast, the procedure used to produce the GLS 12 modified glass results in a uniformly dense layer with a thickness of 62.9 nm covering the entire surface (see Fig. 3B). The histogram shows that this layer displays a narrower distribution centred around the 62.9 nm mark. Additionally, the surface of GLS 12 has fewer spot inclusions than GLS 11.

Acknowledgments

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IoT related security issues and black-box testing experiences in a smart lighting system

Gábor Arányi^{1,*}, Veronika Szűcs¹University of Pannonia, Hungary¹

aranyi.gabor@mik.uni-pannon.hu, szucs.veronika@mik.uni-pannon.hu

Abstract: Automating and delegating daily tasks is a growing trend. Digital devices and the Internet of Things have boosted this development. This has transformed machine-to-machine (M2M) communication, industrial production, and control solutions as well as smart homes and consumer devices. IoT infrastructure and device networking require scalable, secure, efficient, resilient, and widely supported application layer communication protocols. It is vital to note that IoT infrastructure development prioritizes service implementation and functionality. However, IT security vulnerabilities and system reinforcement are typically neglected. Our present research focuses on a black-box vulnerability evaluation during smart street lighting system development. The goal is to raise awareness of the importance of safety-conscious growth.

Keywords: SMART LIGHTING SYSTEMS, IOT SECURITY ISSUES, BLACK-BOX TESTING, IT SECURITY VULNERABILITIES, HARDENING

1. Introduction

Nowadays, we are increasingly trying to automate many aspects of our lives and outsource more and more tasks. The IoT revolution and the rise of smart devices have contributed to this trend [7]. This has not only enabled the development of smart homes and consumer electronics, but has also significantly transformed industrial production, control solutions and M2M (Machine-to-Machine) communication, among other things. With the networking of IoT devices and infrastructures, it has become imperative to use efficient, robust, secure, scalable and widely supported application layer communication protocols [1-4]. These include, for example, MQTT, HTTP, AMQP, CoAP, DDS, LwM2M, or SSI, among others. These are typically deployed according to the type of devices, service platforms, or data being transferred. It is important to highlight that the development of IoT infrastructures focuses mainly on the implementation of services and the delivery of expected functionality, while the identification of IT security vulnerabilities and hardening are usually not sufficiently emphasized [5-6]. The focus of our current research is on a black-box vulnerability assessment performed during the development of a smart street lighting system. To summarize the results, the aim is to raise awareness of the importance of a safety-conscious approach to development. In the context of the smart street lighting project, a test infrastructure based on the MQTT protocol was investigated, which, thanks to its broad application, provides a good visualization of attack vectors, protection options and best practice solutions. The presented attack methods and countermeasures are intended to raise the awareness that in future developments, practitioners should already give priority to e.g. authentication, well-designed authorizations, encrypted communication, availability, automated protection mechanisms or redundancy in the conceptual design phase.

2. Reconnaissance, scanning

During the project, the investigation into the MQTT infrastructure's vulnerabilities was restricted to the pre-assigned scope; however, it is important to keep in mind that similar targets can be easily discovered by attackers (Fig. 1) using OSINT tools (see Fig. 1), Internet-scale port scanners (such as Masscan), and various scripts (such as Nmap mqtt-subscribe). The first step for MQTT is to inspect the port 1883, which is used for default unencrypted connections. This is because attackers typically try to discover the systems with the least amount of protection in addition to targeting specific systems. The search can be fine tuned further by specifying search parameters such as screening for susceptible MQTT broker versions or communications that do not require authentication. It was already proven during port scans that the tested MQTT server environment responded to ICMP echo (PING) messages, and service identification ran swiftly and seamlessly over the whole TCP and UDP range, since the tested MQTT server environment did not have a more significant firewall or IDS/IPS protection. Although the operating system could not be positively

identified, the Linux kernel version was almost certainly somewhere between 2.6.32 and 4.4 (potential kernel vulnerabilities). In light of the findings, the UDP-based service could not be identified with any acceptable degree of precision. SSH servers (TCP/22 OpenSSH 9.3 (protocol 2.0)) and MQTT brokers (TCP/1883 MQTT) were among the TCP-based services that were available.

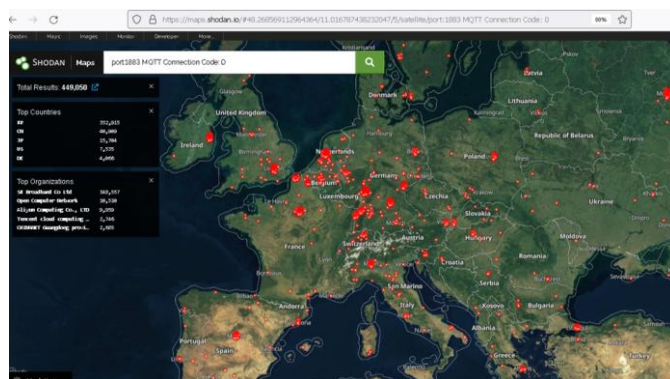


Fig. 1 Publicly available MQTT brokers with disabled authentication (source: Shodan.io).

3. Attacking strategies

3.1 DoS

There are essentially two process types available to choose from when the purpose is to deactivate a service. These process categories are flooding service and crashing service [1]. The purpose of the first method is to completely deplete the server's resources (Central Processing Unit, Random Access Memory, storage, bandwidth, network buffer, etc.) by inundating it with an excessive amount of work. When applying the second strategy, the service may be rendered inoperable by employing an appropriate exploit that takes advantage of a vulnerability. In order to accomplish this goal, it is obvious that we must either determine the type and version of the susceptible service or try each and every attack that is now accessible in the hope that one of them would be successful.

3.2 Common flood attacks (ICMP, UDP, SYN)

If the attack is of the non-distributed flood kind, there must be sufficient bandwidth between the perpetrator and the target IP endpoints (provider network segments). If this is not the case, this could represent a bottleneck during the attack. DoS attacks that are carried out during a SYN flood (also known as a half-open flood) and a UDP flood are carried out in the transport layer of the OSI model, whereas DoS attacks that are carried out during an ICMP flood (mainly a ping flood) are carried out on the network layer. The outcome of these attacks is largely determined by the

availability of services, protocols, intermediary network tools, service configurations, and network security measures.

Even though the ICMP flood attack (in our case PING flood attack) was partially successful in our case because there were no echo responses (as evidenced by the jump in icmp_seq fields 3 to 15 in Fig. 2), this did not significantly affect the accessibility of SSH and MQTT services (as displayed in the screenshot). The above method would be capable of simulating host unavailability only during ping-based monitoring (Fig. 2).

```
root@kali:~# ping 41.164
PING 41.164 (41.164) 56(84) bytes of data:
64 bytes from 41.164: icmp_seq=1 ttl=54 time=9.96 ms
64 bytes from 41.164: icmp_seq=2 ttl=54 time=9.91 ms
64 bytes from 41.164: icmp_seq=3 ttl=54 time=9.99 ms
64 bytes from 41.164: icmp_seq=15 ttl=54 time=10.1 ms
64 bytes from 41.164: icmp_seq=16 ttl=54 time=10.2 ms
64 bytes from 41.164: icmp_seq=17 ttl=54 time=18.5 ms
64 bytes from 41.164: icmp_seq=18 ttl=54 time=9.81 ms
64 bytes from 41.164: icmp_seq=19 ttl=54 time=38.4 ms
^C
root@kali:~# hping3 --flood --rand-source -i 41.164
HPING 41.164 (eth0 41.164): icmp mode set, 28 headers + 0 data bytes
hping in flood mode, no replies will be shown
^C
--- 41.164 hping statistic ---
403872 packets transmitted, 0 packets received, 100% packet loss
round-trip min/avg/max = 0.0/0.0/0.0 ms
root@kali:~#
```

Fig. 2 ICMP flood attack

During a SYN flood attack, the target is attacked with SYN packets that are sent in the first phase of the three-phase TCP handshake. These packets are transmitted as part of the TCP handshake. The two TCP-based services that had been discovered earlier became unreachable as a direct consequence of the successful execution of the attack, which led to complete constraints of service environment resources (Fig. 3 and Fig. 4).

```
root@kali:~# ssh root@41.164
Warning: Permanently added '41.164' (ssh) to the list of known hosts.
root@kali:~# hping3 -c 20000 -d 120 -S -w 64 -p 1883 --flood --rand-source 41.164
HPING 41.164 (eth0 41.164): S set, 40 headers + 120 data bytes
hping in flood mode, no replies will be shown
```

Fig. 3 SYN flood attack causing SSH service outage

```
root@kali:~# mosquitto_sub -t '#' -u admin -h 41.164
root@kali:~# hping3 -c 20000 -d 120 -S -w 64 -p 1883 --flood --rand-source 41.164
HPING 41.164 (eth0 41.164): S set, 40 headers + 120 data bytes
hping in flood mode, no replies will be shown
```

Fig. 4 SYN flood attack causing MQTT service outage

UDP flood attacks require at least one available UDP port that is running a service on the system where the attack is being launched. UDP-based flooding is rendered ineffectual since, in general, any intermediary network device is already outfitted with protection against the vast majority of these types of attacks, either in the form of a packet limiter or UDP flood protection.

3.3 Service overload

The MQTT broker under test operated an OpenSSH service that was accessible to the public and utilized password-based authentication. The utilization of the appropriate instrument to reserve all the available SSH sessions can render the service inaccessible to system administrators (Fig. 5).

```
root@kali:/tools# ssb -w ./pass_top10k.txt -v root@ 41.164
v0.1.0
Secure Shell Bruteforcer
infosec@kitabisa.com

:: Username: root
:: Hostname: 41.164
:: Port : 22
:: Wordlist: ./pass_top10k.txt
:: Threads : 100
:: Timeout : 30s

[ERR] Failed '111111': ssh: handshake failed: read tcp 11.49:44704-> 41.164:22: read: connection reset by peer.
[ERR] Failed 'baseball': ssh: handshake failed: read tcp 11.49:44738-> 41.164:22: read: connection reset by peer.
```

Fig. 5 SSH dictionary attack causing DoS

4. MQTT specific attacks (query overload, big messages etc.)

The initial attack aims to overwhelm the capacity of the MQTT broker by transmitting numerous high-volume messages to various topics, with or without a group of subscribed customers. The reason for this occurrence can be attributed to the broker's practice of retaining all messages (within a specified queue limit) for every subscribing client. Consequently, the service is at risk due to the broker's vulnerability as a single point of failure. The attack is deemed successful if the utilization of queues, which are linked to subscribing customers, exerts a detrimental effect on the resources of the broker, including disk space, random access memory (RAM), and central processing unit (CPU). Additionally, the attack is considered successful if the machine hosting the broker reaches maximum utilization of its CPU or network bandwidth.

The second approach, which can be characterized as an amplification attack within the MQTT environment, involves the periodic transmission of large messages in order to launch a Denial of Service (DoS) attack against the resource-limited clients that are connected to the broker. The success of the attack is contingent upon the prevention of clients from getting additional messages, as well as their utilization of CPU resources in persistent attempts to receive resource-intensive communications. It is noteworthy to add that in the event of clients with a persistent session being forcefully disconnected, the broker would store all incoming messages (up to the specified limit) in a queue and make another effort to transmit them upon reconnection. This includes the transmission of resource-intensive messages that may impact the clients' CPU.

The RAM use of all brokers is impacted by the act of publishing messages.

The outcomes of the amplification attack are as follows.

The utilization of Transport Layer Security (TLS) significantly impacts both the maximum payload size and the processing time. For instance, a message containing a payload of 255MB, which is the maximum supported size, could only be received when employing the plaintext configuration. Moreover, the processing time is approximately ten times longer when TLS is employed (Fig. 6).

```
root@kali:/tools# ls ./Scharpass -lah
-rw-r--r-- 1 root root 354M Sep 30 16:49 ./Scharpass
root@kali:/tools# mosquitto_pub -t 'tasmota/discovery/AC08FBDAF69A/sensors/verx' -f Scharpass -h 41.164
```

Fig. 6 Publishing of big amount of data

4.1 Eavesdropping

MQTT clients can have three types of permission: publish, subscribe, and both. If we can subscribe to any (or all) of the broker's topics, we can intercept, collect, and analyze the published messages (Fig. 7).

- The maximum size of a packet, including both headers and payload, should be restricted.
- It is recommended to impose a restriction on the maximum payload size within PUBLISH messages.
- The message rate should be restricted.
- The active connections should be limited.
- The maximum number of queued messages should be restricted.
- One effective approach to minimizing disk input/output (I/O) is to optimize the configuration of an in-memory database and log settings.
- The concept of a hard limit on memory refers to a specific threshold or boundary beyond which the storage capacity of a system or device cannot be exceeded.
- In order to mitigate the impact of slow Denial-of-Service (DoS) attacks, it is recommended to establish a limit on the number of keepalive connections.
- Bandwidth throttling refers to the deliberate limitation or restriction of the available bandwidth for data transmission in a network.
- The appropriate configuration of preserved messages
- The utilization of load balancers is employed to evenly distribute network traffic across numerous MQTT brokers.
- Implementation and fine-tuning of firewall rules
- The utilization of demilitarized zones (DMZs)
- To verify your configurations, you can utilize the tools `mqttsa` and `mqtt-pwn`.

6. Conclusions

The current societal phenomenon entails the increasing automation of many facets of everyday existence and the outsourcing of tasks to external entities. The emergence of the Internet of Things (IoT) and the increasing adoption of intelligent gadgets are the main driving forces behind this phenomena.

The aforementioned phenomenon has resulted in substantial transformations across various sectors, including smart homes, consumer electronics, industrial manufacturing, control systems, and Machine-to-Machine (M2M) communication.

The importance of communication protocols cannot be overemphasized.

The effective functioning of IoT devices and infrastructures heavily relies on the presence of application layer communication protocols that are efficient, durable, secure, scalable, and widely supported. This category encompasses several protocols, including MQTT, HTTP, AMQP, CoAP, DDS, LwM2M, and SSI.

This study investigated the security concerns that arise during the development of Internet of Things (IoT) platforms. The prioritization of functionality in the development of the Internet of Things (IoT) often overlooks the importance of identifying and addressing information technology (IT) security concerns.

This study highlights the significance of implementing a safety-focused approach to development, specifically within the framework of a smart street lighting system.

This paper focuses on the evaluation of vulnerabilities inside the MQTT system. The research was around the execution of a black-box vulnerability assessment on a smart street lighting system that employs the MQTT protocol. The examination comprises the operations of reconnaissance and vulnerability scanning within the

Message Queuing Telemetry Transport (MQTT) architecture. This study presents a comprehensive examination of many types of attacks that specifically target the MQTT protocol. These attacks include query overload, huge message attacks, eavesdropping, message manipulation, and dictionary attacks.

A number of actions are suggested in order to address vulnerabilities and strengthen security against attacks. The tactics encompassed in this list consist of often updating the system, deactivating unnecessary services, employing higher port numbers, implementing endpoint protection measures, and deploying anti-brute force solutions. It is recommended to implement security precautions for both the MQTT broker and the messages transmitted. The procedures encompassed in this context are authentication, unique client identifiers, Transport Layer Security (TLS), authorization, message size limitations, rate control, and the deployment of load balancers.

The last section concludes by offering a set of safety recommendations that emphasize the importance of including authentication, TLS, authorization, message size restrictions, and other techniques to enhance the security of the MQTT broker and communications inside an Internet of Things (IoT) environment.

In conclusion, the essay underscores the crucial necessity of an Internet of Things (IoT) development strategy that places utmost importance on security, particularly in the context of a smart street lighting system that employs the MQTT protocol. Furthermore, the work provides insightful viewpoints regarding potential vulnerabilities and the necessary measures to mitigate them.

Acknowledgement

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Engineered nanomaterials based on graphene oxide and their potentials for combined cancer therapies

Kamelia Hristova-Panusheva¹, Trayana Kamenska¹, Zlatina Gospodinova^{1,2}, Natalia Krasteva^{1*}

Bulgarian Academy of Science, Institute of Biophysics and Biomedical Engineering, Sofia, Bulgaria¹

Bulgarian Academy of Science, Institute of Plant Physiology and Genetics, Sofia, Bulgaria²

kamelia.t.hristova@gmail.com, trayanakamenska@abv.bg, zlatina.go@abv.bg, *natalia.krasteva@yahoo.com

Abstract: Graphene oxide, owing to its unique physicochemical properties, has established itself as a versatile platform with applications ranging from drug delivery to medical imaging. The modification of graphene oxide has the potential to enhance crucial properties such as near-infrared (NIR) adsorption capacity, water dispersity, and cytotoxicity. This paper aims to discuss the potential of unmodified graphene oxide and polyethylene glycol (PEG)-modified graphene oxide nanoparticles as responsive systems to NIR in the context of combined photothermal and chemotherapy. The focus is on their application for treating colorectal and hepatocellular cancer cells, highlighting their promise in integrated cancer therapies.

Keywords: MODIFIED GRAPHENE OXIDE, PEGYLATED GRAPHENE OXIDE, PHOTOTHERAPIES, CHEMOTHERAPY, COLON 26 CELLS, HEPG2 CELLS

1. Introduction

Engineered nanomaterials (ENMs) have recently garnered significant attention for many applications, ranging from optoelectronic, electronic, cosmetic, dental bonding, and imaging to drug delivery systems [1-3]. The central focus is on certain nanomaterials like graphene oxide (GO), an oxidized form of graphene, known for its cost-effectiveness, abundance, and ease of processing [4-6]. The interest in GO is immense and comes from its unique one-atom thin sheet structure [7, 8], which ensures a high specific surface area with de-localized electrons, facilitating efficient drug loading. The heightened interest in GO is further attributed to its high content of oxygen-containing functional groups. These groups located on the edge or basal planes of the GO sheets offer high reactivity and can be easily modified for biomolecule attachment. The modifications improve the physicochemical properties of GO, such as NIR adsorption capacity, water dispersity, and drug loading/delivery capacity [9, 10]. Current literature supports that PEGylation is pivotal in mitigating the cytotoxicity of various graphene oxide derivatives while enhancing their physiological stability and pharmacokinetic properties [11-13]. Notably, GO-PEG serves a dual purpose as a photosensitizer (photothermal absorbent) in photothermal therapy (PTT) and as a drug carrier. This dual functionality positions GO-PEG as a promising candidate for the development of intelligent nanoplateforms, offering synergistic anti-cancer therapies [14].

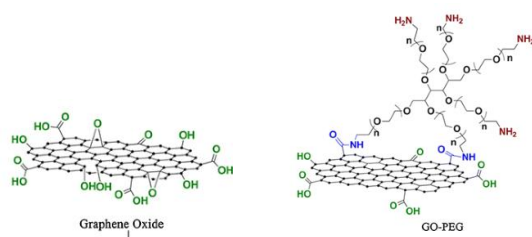


Fig. 1. Schematic illustration of graphene oxide(GO)and PEGylated graphene oxide (GO-PEG)

Consequently, we have subjected graphene oxide (GO) nanoparticles to modification using polyethylene glycol (PEG) and evaluated their biological efficacy against two different cancer cell lines: HepG2, representing hepatocellular cancer, and Colon26, representative of colorectal cancer. This evaluation was conducted following near-infrared (NIR) irradiation.

2. Experimentals

2.1 Synthesis of GOs nanoparticles

The synthesis of nano-graphene oxide (nGO) and nGO-PEG nanoparticles (NPs) followed a well-established protocol, as detailed previously [14-16]. In brief, a water solution containing GO (Graphenea, Spain) at a concentration of 1 mg/ml underwent sonication for 2 hrs at 500 W (VCX 500, Sonics and Materials, Inc., Newtown, CT, USA) in order to achieve nanosized GO.

For the preparation of nGO-PEG NPs, mPEG-NH₂ (Abbexa Ltd., Cambridge, UK) was added to nGO solution. The resulting mixture was sonicated at the same conditions for 5 min and was subsequently incubated for 22 hrs in a water bath at 70⁰ C. The resultant nGO-PEG was centrifuged to remove unbounded PEG and was then stored at 4⁰ C.

2.2. Physico-chemical characterization of GOs Nanoparticles

The average size, size distribution and zeta potential of the nanoparticles were characterized by Zetasizer, following a previously described methodology [14].

2.3. Cell culture

The mouse colorectal cancer cell line, Colon 26 and HepG2, a hepatocellular cancer cell line, were purchased from American Tissue Culture Collection (ATCC) and was maintained in DMEM medium supplemented with 10% foetal calf serum and antibiotic/antimycotic solution at 37°C in a fully humidified atmosphere at 5% CO₂.

2.4 Assessment of biological activity of GOs nanoparticles

The cells were seeded at a density of 1x10⁴ cell in 96-well plates for cell viability assessment, 1x10⁴ cell in 24-well plate for overall cell morphology evaluation, and 1x10⁵ cell in 6-well plates for cell motility assessment. The cells were allowed to incubated for 24 hrs before exposure to nanoparticles with a concentration of 100 µg/ml. At the next day the cells underwent irradiation for 5 or 15 minutes at 808 nm depending on the cell culture plate, and were subsequently stained with fluorescein diacetate (FDA) to evaluate the alteration in cell morphology as previously described [15].

Cell viability after 24 hours of incubation with nanoparticles was assessed using the WST-1 kit from Takara, following the manufacturers' instructions. For the evaluation of cell motility, a wound healing assay was conducted at the 24-hour of incubation of cells with NPs coupled with a 5 minute laser irradiation at 808 nm.

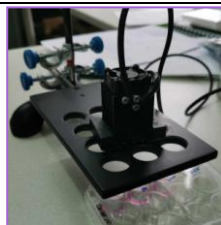


Fig. 2. A single 808 nm near-infrared light (NIR) laser system used for irradiation of cancer cells

2.5. Statistical analysis

The data presented in this article are expressed as means $\pm$ standard deviation (SD). Statistical differences between groups were determined using analysis of variance (ANOVA), and probability levels of 0.05 and 0.01 were considered to indicate statistical significance.

3. Results and Discussion

3.1. Physico-chemical properties of GOs nanoparticles

Zetasizer measurements revealed that the unmodified graphene oxide (GO) NPs exhibited a negative charge, characterized by a zeta potential value of -32.9 mV, and an average particle size of 252.7 nm (as shown in Table 1). Conversely, upon PEGylation GO NPs displayed increased dimensions of 324.6 nm, accompanied by a reduced negative charge of -21.6 mV. The observed size variations in both types of GO nanoparticles are attributed to the introduction of a larger PEG moiety (0.35 kDa). Additionally, the substitution of the negatively charged -COOH group in GO molecules with neutral PEG molecules probably contributed to the decrease in negative zeta potential

Table 1. Zeta potential and average particle size of GO and GO-PEG NPs in water solution

Type of NPs	Surface charge [mV]	Average particle size [nm]
nGO	-32.9	252.7
nGO-PEG	-21.6	324

The particle size distribution analysis indicated an increase after PEGylation, with the size distribution of nanographene oxide (nGO) particles ranging from 43.82 nm to 458.7 nm. In contrast, nGO-PEG particles exhibited a broader size range from 164.2 nm to 615.1 nm. This observation suggests that the PEGylation process led to a dispersion of sizes in the graphene oxide nanoparticles, contributing to a broader range in the distribution of particle sizes.

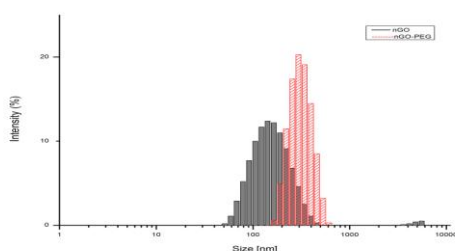


Fig. 3. Particle size distribution of nGO and nGO-PEG NPs

3.2. Biological activity of GOs Nanoparticles

The FDA staining and WST-1 assay results (see Fig.3 and Fig.4) illustrated a distinct impact of both nanoparticles, alone and in conjunction with near-infrared (NIR) irradiation, on both cell lines. In Colon 26 cells, NIR irradiation suppressed the viability of untreated and graphene oxide (GO)-treated Colon 26 cells but stimulates viability in cells treated with GO-PEG. Conversely, a slight stimulation of cell viability was observed after irradiation of control and GO-treated HepG2 cells while no noticeable effect was observed in GO-PEG-treated cells. These findings highlight the differential responses of Colon 26 and HepG2 cells to the combined influence of NPs and NIR irradiation.

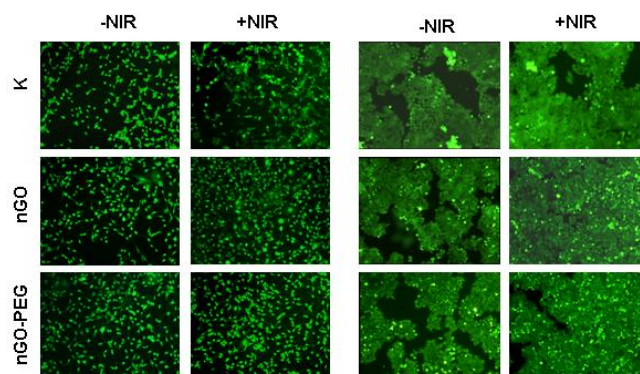


Fig. 4. FDA micrographs of Colon 26 cells (left panel) and HepG2 cells (right panel) incubated for 24 hrs with nGO and nGO-PEG NPs, and irradiated for 5 min at 808 nm; magnification 10x

An intriguing observation is that in Colon 26 cells the synergic effect of both types of GO nanoparticles and NIR irradiation closely resembles the impact observed in irradiated controls. In contrast, in HepG2 cells, the most significant inhibitory effect on cell viability was observed in non-irradiated GO-treated cells. This suggests cell-type-specific responses, indicating that the combined influence of GO and NIR irradiation may vary in its effectiveness across different cancer cell lines. Understanding these distinct responses is crucial for tailoring nanoparticle-based therapies for specific cancer types.

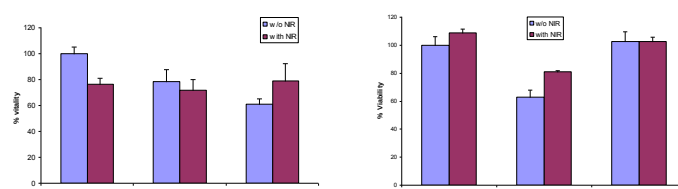


Fig. 5. Viability of Colon 26 cells (left) and HepG2 cells (right) after 24 hrs incubation with nGO and nGO-PEG NPs, followed by 5 min irradiation with 808 nm

Recognizing the crucial role of cellular migration in tumor invasion and metastasis [16], our objective was to investigate the impact of nGO and nGO-PEG, with and without near-infrared irradiation, on cell migration using the *in vitro* wound-healing assay. Both cell lines were exposed to 100 μ g/mL of nGO and nGO-PEG, incubated for 24 hrs and then subjected to 15 minutes of NIR irradiation with 808 nm. The results depicted in Fig. 5. showed the effects on cancer cell migratory capacity resulting from nanoparticle treatment alone and in combination with NIR irradiation, with evaluations conducted 24 hours after cellular incubation.

Upon assessing the combined effects of nanoparticles (NPs) and near-infrared (NIR) irradiation on Colon26 motility, the most pronounced inhibitory effect was observed in cells treated with nGO-PEG and subjected to NIR irradiation. In the case of HepG2

cells, the analysis of wound healing results unveiled a more robust inhibitory effect of both NPs compared to the untreated control.

These findings underscore the differential impact of NPs and NIR irradiation on the motility of Colon26 and HepG2 cells, emphasizing the importance of considering cell-type-specific responses in therapeutic applications.

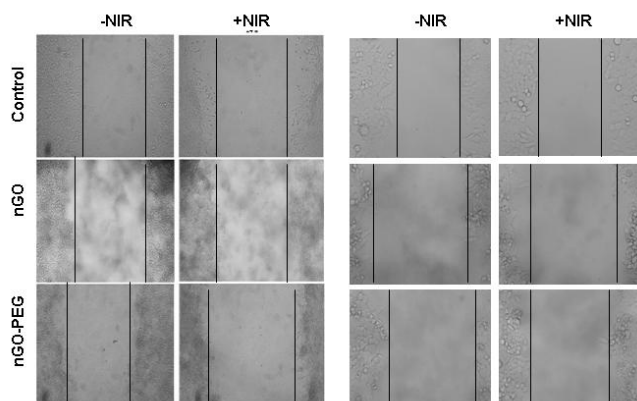


Fig. 5. Wound closure of Colon 26 cells (left panel) and HepG2 cells (right panel), after 24 hrs incubation with nGO and nGO-PEG NPs, followed by 15 min irradiation with 808 nm, magnification 10x

4. Conclusions

In summary, our findings indicate that unmodified (nGO) and PEGylated nano-graphene oxide (nGO-PEG) nanoparticles exhibit varying potential for cancer treatment, depending on the specific type of cancer cells under consideration. The differential responses observed underscore the importance of tailoring nanoparticle-based therapies according to different cancer cell types' distinct characteristics and behaviors. This insight contributes to a nuanced understanding of the applicability and effectiveness of nGO nanoparticles in the context of cancer treatment strategies.

5. Acknowledgements

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Design, production, and evaluation of product quality for electric vehicle parts

Ilo Bodi^{1,*}, Erald Piperi¹, Antonio Qyrsaqi², Llukan Apostoli²
Polytechnic University of Tirana, Albania¹
Everest Shpk, Tirana, Albania²
ibodi@fim.edu.al

Abstract: The final products that emerge from innovative production processes for different electric vehicle parts are Aluminum profiles of all designs for applications such as doors, structural and semi-structural parts, etc. The production line of these products is automated, where every work process, is controlled by CNC panels in which they are implemented and programmed with different software. The automation of the production processes tends to improve the quality of the product and tends to optimize the production process to minimize and decrease production waste. This paper presents the production process of different electric vehicle parts and how their quality is evaluated by using PFMEA analysis according to the quality standards. The implementation of quality standards resulted in product quality and enterprise quality management system improvement.

Keywords: ALUMINUM PROFILES, AUTOMATED PRODUCTION PROCESS, PRODUCT QUALITY, PFMEA ANALYSIS

1. Introduction

The process of materials selection in the product development process is always referred to as a complex step by industrial manufacturers. Different industrial manufacturers attempt to develop a systematic method to select the best material that suits their products. A few factors determine the best material and the complexity level rises. There are two main reasons why the material selection is required [1]:

1. To design an existing product with better performance, lower cost, increased reliability, and reduced weight.
2. The selection of materials is the primary consideration of product design because overall product performance is directly influenced and determined by the materials selection process.

The automotive industry uses light alloy materials, reinforced plastics, and polymers to produce different vehicle parts. These materials offer improved properties such as strength impact, easy moldability, improved aesthetics, and reduced weight compared to conventional automotive components [2]. Their potential for maximum mass reduction and the potential to reduce carbon emissions from lightweight vehicles are the main advantages that offer opportunities in the automotive industry [2]. Until now the factors restraining the market are high material costs and large investments in materials research activities by companies [3].

According to [4] the typical weight distribution in cars is Steel 71% (of vehicle body panels), Cast Iron 15% (of body parts engine, gearbox, axle), tires (tires, tubes), and others including Zinc, Copper, Aluminum, Polymers, etc. The use of aluminum in automotive applications has increased by more than 80% in recent years [5]. Aluminum castings have been applied to various automotive parts for a long time. As a major trend, the material for the engine blocks, which is one of the heaviest parts, switches from cast iron to aluminum, resulting in significant weight reduction.

2. Materials to produce automobile parts.

Everest Shpk Company was established in 1997 and is one of the leading companies in Albania that produces aluminum profiles for different applications such as doors, windows, and accessories. According to the company [6] the production process of aluminum ingots consists of a propane gas furnace with a capacity of 25 – 27 tons as shown in Figure 1 (but the furnace is filled depending on the number of ingots to be produced). The melting temperature of aluminum is 713 °C inside the furnace. Aluminum casting is done in the interval of temperatures 740 – 750 °C. To remove impurities in the oven, flusses are thrown so that the latter remains on the surface of the molten material and is manually removed from the furnace. In the furnace, aluminum scraps, different aluminum waste materials to be recycled from different production sectors, are thrown for the aluminum ingots production cycle.



Fig. 1 The furnace of aluminum ingots production [6]

In the furnace, ingots of the 6060 series are produced because they are more suitable for production, they are corrosion resistant, weldable, etc. Aluminum 6060 is part of the aluminum-silicon magnesium family. The chemical composition of the aluminum 6060 produced for automotive parts is shown in Table 1 and the mechanical properties are shown in Table 2.

Table 1: AL 6060 chemical composition [6]

Element	Al	Si	Cu	Mn	Mg	Cr	Zn	Ti	Fe
Percentage %	97.9-99.3	0.3-0.6	0.1	0.1	0.35-0.5	0.05	0.15	0.1	0.1-0.3

Table 2: AL 6060 properties [6]

Properties Type	Properties	Symbol	Units	Value
Physical	Density	P	g/cm ³	2.71
Mechanical	Young's modulus	E	GPa	70
	Poisson coeff.	V	na	0.34
	Linear expansion	ΔL	μm/m-K	23.4
Thermal	Melting temperature	Tm	°C	660

After the production process of aluminum ingots, the material is subject to thermal treatment. The thermal treatment processes are

Recrystallization, Aging, Heat Treatment, and normalization. All these processes are done to improve the mechanical properties of the material as shown in Figure 2.

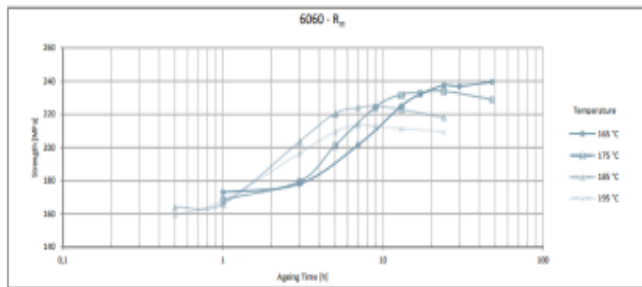


Fig. 2 Relation between the time of heat treatment according to mechanical strain [6]

3. Design and production of electric vehicle parts.

The design phase begins in the design department of Everest Shpk company according to the client's 3D models designed in SolidWorks software. In this phase, all the elements of the design are exploded and identified according to the design standards as shown in Figure 3.

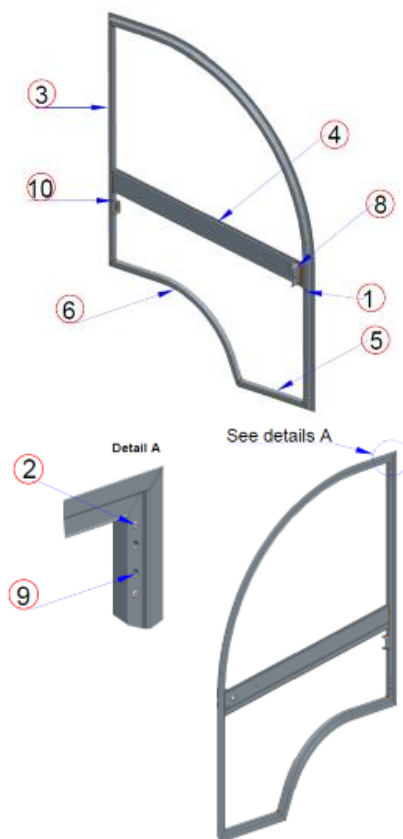


Fig. 3 Design of the electric vehicle doors [6]

The design department generates the 2D drawing of the matrix and sends it to the production department. The production department analyzes the conditions of the production with the aluminum profile and generates the production process technological cards. In the automotive sector, specific tolerances of the product range from 0.15 - 0.3 mm, and deviation from these tolerances is intolerable. The production process is shown in Figure 4.

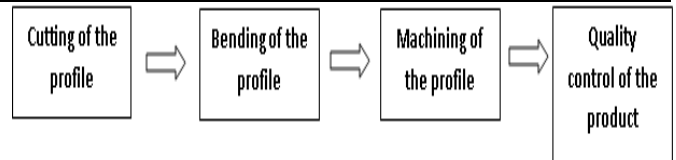


Fig. 4 Design of the electric vehicle doors [6]



Fig. 5 Final product assembly after production [6]

4. Quality control and PFME analysis

Quality control of the produced parts is very necessary for the Everest Shpk Company according to the ISO standards and to the client's requests. The company has implemented ISO 9001-2015 for the production and the company management. The Flow Chart diagram of the production process is shown in Figure 6.

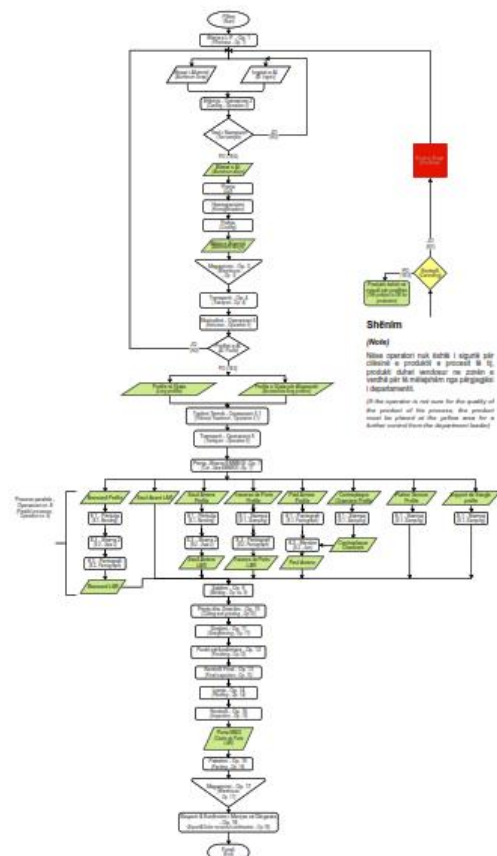


Fig. 6 Flow chart diagram of production [6]

After preparing the Process Flow Diagram, should be prepared the PFMEA-Potential Failure Mode and Effect Analysis. Failure mode and effects analysis, or PFMEA, is a methodology that aims to allow organizations to anticipate in discover failure opportunities during the design phase by identifying them during the design or manufacturing process [7]. PFMEA was developed in the 1950s and was one of the earliest methods used for the analyses. Today it remains a very effective method to reduce the possibility of failure. For Everest Shpk Company these are some of the characteristics that can affect the production process:

1. Material properties.
2. Product Geometry.
3. Product Tolerances.
4. Interactions with other components and/or systems.
5. Environments, use, degradation, interactions of systems.
6. Human factors.
7. Methods followed during material processing.
8. Materials used.
9. Machines used.
10. Impact of measurement systems on acceptance.
11. Environmental factors during the process of work.

Based on these factors Figure 7 shows the PFMEA diagram and analysis for the production process of electric vehicles.

GA PFMEA - SEVERITY RANKING				GA PFMEA - OCCURRENCE RANKING				GA PFMEA - DETECTION RANKING			
Effect on Product/Component	Rank	Effect on Process/Manufacturing	Rank	Failure Mode	Rank	Failure Mode	Rank	Effect on Product/Component	Rank	Effect on Process/Manufacturing	Rank
SAFETY critical - NECESSARY FOR THE PRODUCT TO BE USED	10	SAFETY critical - NECESSARY FOR THE PRODUCT TO BE USED	10	100 per 100,000	10	100 per 100,000	10	SAFETY critical - NECESSARY FOR THE PRODUCT TO BE USED	10	SAFETY critical - NECESSARY FOR THE PRODUCT TO BE USED	10
SAFETY critical - NECESSARY FOR THE PRODUCT TO BE USED	9	SAFETY critical - NECESSARY FOR THE PRODUCT TO BE USED	9	20 per 100,000	9	20 per 100,000	9	SAFETY critical - NECESSARY FOR THE PRODUCT TO BE USED	9	SAFETY critical - NECESSARY FOR THE PRODUCT TO BE USED	9
LOSS OF PRIMARY FUNCTION	8	LOSS OF PRIMARY FUNCTION	8	10 per 100,000	8	10 per 100,000	8	LOSS OF PRIMARY FUNCTION	8	LOSS OF PRIMARY FUNCTION	8
DEGRADATION OF PRIMARY FUNCTION	7	DEGRADATION OF PRIMARY FUNCTION	7	5 per 100,000	7	5 per 100,000	7	DEGRADATION OF PRIMARY FUNCTION	7	DEGRADATION OF PRIMARY FUNCTION	7
LOSS OF SECONDARY FUNCTION	6	LOSS OF SECONDARY FUNCTION	6	2 per 100,000	6	2 per 100,000	6	LOSS OF SECONDARY FUNCTION	6	LOSS OF SECONDARY FUNCTION	6
DEGRADATION OF SECONDARY FUNCTION	5	DEGRADATION OF SECONDARY FUNCTION	5	1 per 100,000	5	1 per 100,000	5	DEGRADATION OF SECONDARY FUNCTION	5	DEGRADATION OF SECONDARY FUNCTION	5
ABSENCE of critical to safety	4	ABSENCE of critical to safety	4	0.5 per 100,000	4	0.5 per 100,000	4	ABSENCE of critical to safety	4	ABSENCE of critical to safety	4
ABSENCE of critical to safety	3	ABSENCE of critical to safety	3	0.1 per 100,000	3	0.1 per 100,000	3	ABSENCE of critical to safety	3	ABSENCE of critical to safety	3
ABSENCE of critical to safety	2	ABSENCE of critical to safety	2	0.05 per 100,000	2	0.05 per 100,000	2	ABSENCE of critical to safety	2	ABSENCE of critical to safety	2
NO EFFECT	1	NO EFFECT	1	0.01 per 100,000	1	0.01 per 100,000	1	NO EFFECT	1	NO EFFECT	1

Fig. 7 PFMEA diagram of production process [6]

The three main factors represented in the PFMEA diagram are: 1. Severity; 2. Occurrence; and 3. Detection. To evaluate and calculate the risk of occurring failures, it is used the formula:

$$RPN = Severity \times Occurrence \times Detection$$

By analyzing the results from PFMEA analysis we can discover that the main factor resulting in failure is the chemical compound of aluminum alloy because it will directly affect the product quality. For the other processes, the possibility of the occurrence is 1, so the failures are eliminated during the design process.

5. Conclusions

Quality Management is one of the most invested areas in today's industry and in Everest Shpk Company. Its continuous research and further development have brought and continue to bring a lot of benefits for the company that has invested in the creation of a quality department.

The above documents are a good start to implementing TQM. The main improvements brought by the implementation of the Quality Management System in Everest Shpk Company to produce the electric vehicle parts are:

1. Clear identification of work processes and elimination of losses based on Lean manufacturing.
2. Using the 5S method enables better visual control and reduces the possibility of making a mistake.
3. The involvement of workers in the implementation of this system has improved climate cooperation. Workers feel more involved and valued.
4. Investment needs in some processes of design and production are identified.

6. Acknowledgement

The authors would like to thank the Everest Shpk Company for the collaboration and the materials used in this article.

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Impact of e-commerce on the logistics sector

Katina Valeva¹, Valentina Alexieva-Nikolova²

Business Faculty – University of Food Technology -Plovdiv, Bulgaria, tomika_888@yahoo.com¹

Business Faculty – University of Food Technology -Plovdiv, Bulgaria, valentina_nikolova@abv.bg²

Abstract: The introduction of digital technologies into modern life has turned e-commerce into a global industry, having a significant impact on the logistics sector and supply chain management. The Covid-19 pandemic has contributed to the rapid growth of online commerce, creating additional challenges for companies in the logistics sector. **The purpose of this report** is to examine the trend in the development of e-commerce and its relationship with the logistics sector. The results of a study related to the differences in costs in electronic and traditional commerce are presented.

Keywords: e-commerce, logistics sector, logistics services

1. Introduction

The rapid development of information technology (IT) and its implementation in companies is changing their business models for trade and business. [1] Today, most companies have invested, implemented and integrated IT infrastructure to achieve higher economic growth. Using electronic commerce (EC) as a transaction model is a priority for most companies. [2]

In recent years, e-commerce has become one of the fastest growing and most profitable industries. In the past 2022, the size of the e-commerce market has reached \$12.6 trillion. Forecasts for the development of the market until 2032 are for significant growth and reaching 57.22 trillion US dollars at a CAGR of 15% (Fig. 1). [3]

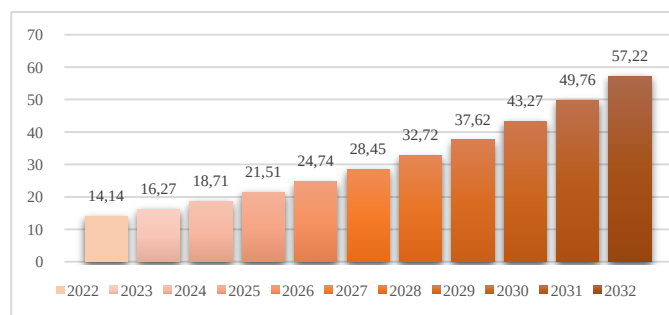


Fig. 1. E-Commerce Market Volume Forecast, 2022-2032, Trillion \$

Source: <https://www.verifiedmarketresearch.com/product/e-commerce-market/>

E-commerce was one of the fast-growing sectors before the pandemic and was growing at double-digit rates, but Covid 19 and consumer demand have further accelerated the shift from brick-and-mortar to online commerce. Among the main reasons for the growing market demand are accepted - the continued spread of the Internet throughout the world, which will lead to an increase in the number of users and the new 5G technology. [4]

Expectations for the period 2022-2032 are that the business-to-business (B2B) segment will hold the larger market share compared to the business-to-consumer (B2C) segment as in 2022, when B2B realizes 65% of the sector's revenue, and B2C forms 35% (Fig. 2).[5]

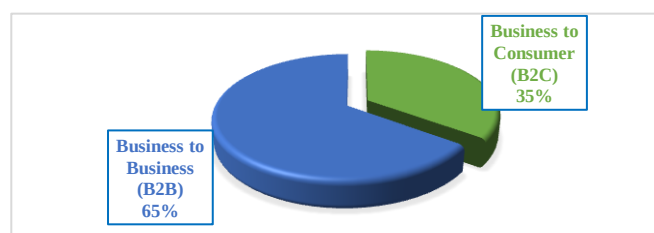


Fig. 2. E-commerce market share by types, 2022 (%) [5]

The breakdown of estimated e-commerce revenue by geographic region for the four-year period from 2022 to 2026 is presented in Fig. 3. The data shows that the largest volume of revenue in the sector will be achieved in the Asia region, followed by the North America and Europe region, with the largest growth of 19% will be the Central and South America and Africa regions.[6]

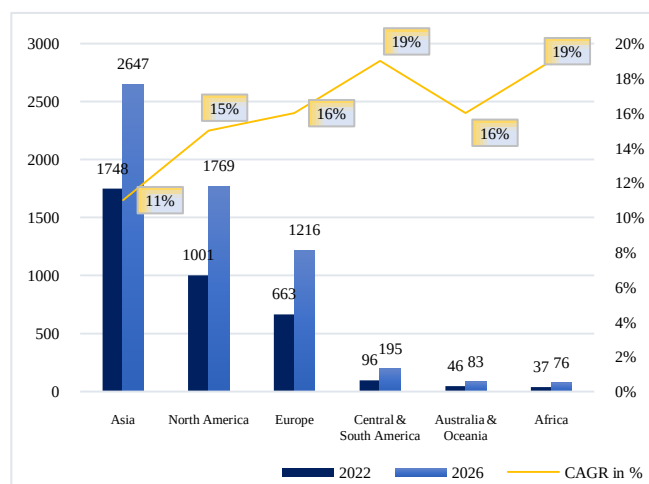


Fig. 3. Forecast e-commerce revenue by region, 2022-2026 in USD billion

Source: <https://ecommercedb.com/insights/the-north-american-ecommerce-market>

2. Literature review

The concept of "electronic commerce" is synonymous with the concept of "internet commerce". The two concepts are used to express a process in which two or more participants enter into transactions using a computer, a local network and the Internet. [7]

The term e-commerce is associated with real-time business transactions over telecommunications networks. This term has a broad application, including the virtual browsing of goods, the selection of goods for purchase and payment methods. In e-commerce, there is no prior agreement between the parties - customer and seller. It is carried out over the Internet by the use of all technologies, or a combination of them, created for the exchange of data, access to data and recording of information. In the National Strategy for Electronic Commerce of the Republic of Bulgaria [8] the term electronic commerce is formulated as "a continuous cycle of data processing and exchange through which a unified and integrated information provision of the participants in the overall commercial transaction regardless of the field of activity, industry, country, etc."

Electronic commerce comes in various forms and varieties, summarized in fig.4 [9]

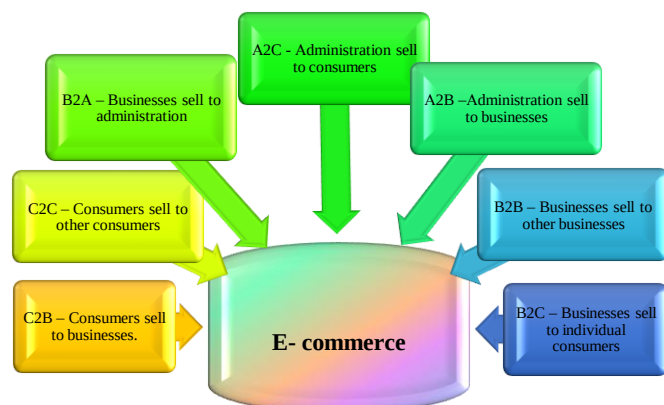


Fig.4. Types of e-commerce

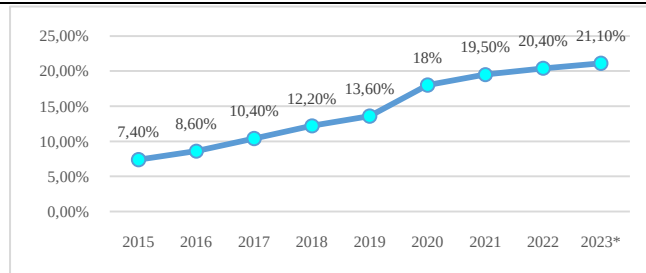
- **Business-to-business (B2B).** This type of E-commerce refers to organizations that provide goods and services to other legal entities. The implementation of transactions requires a very high level of security in the exchange of information. The business-to-business market refers to:
 - Firms selling goods and services to each other, with one organization playing the role of seller and the other playing the role of buyer.
 - Transactions and information related to reverse processes between suppliers, partners or channels, such as ordering, payment, general and advanced procurement services, distribution assistance and logistics management.
- **Business to Consumers (B2C).** This type of E-commerce refers to all companies and organizations that provide goods and services to consumers using the capabilities of the Internet. The company's focus is on the consumer as the end customer or buyer.
- **Consumers to Businesses (C2B).** In this type of E-commerce, consumers demand specific goods or services from the business.
- **Consumer to consumer (C2C).** This type of E-commerce is done through an auction site. One user announces what he offers and another user expresses a desire to purchase the offered product/service. The site owner provides the connection between the buyer and the seller in order for the transaction to take place. Usually, the intermediary keeps a part of the value of the transaction in the form of a fee for the service rendered.
- **Business to administration (B2A).** This type of E-commerce concerns the interaction between businesses, (commercial organizations) and government organizations at local, regional and international levels.
- **Consumer to administration (C2A).** In this type of E-commerce we are talking about interaction between consumers and government authorities, usually in the social and tax spheres, via the Internet.

Depending on the type of goods and services delivered via the Internet, two types of E-commerce can be distinguished - direct and indirect:

1. the direct means requesting, buying and delivering intangible goods and services online, such as software, music, movies, etc.

2. indirect - is the ordering of goods and services over the Internet, but the delivery is carried out physically through traditional delivery methods.

3. Analysis and discussions



An increase in customer preferences for e-commerce was seen in the years before the pandemic, but Covid 19 has further accelerated the shift from brick-and-mortar to online commerce. (fig.5) [13]

Fig. 5. Growth of e-commerce, 2015-2023, in %

Source: <https://www.trade.gov/impact-covid-pandemic-ecommerce>

The growth of e-commerce in recent years has contributed to an increase in demand for logistics services. This also affected investor interest in the logistics sector. (fig.6) [14]

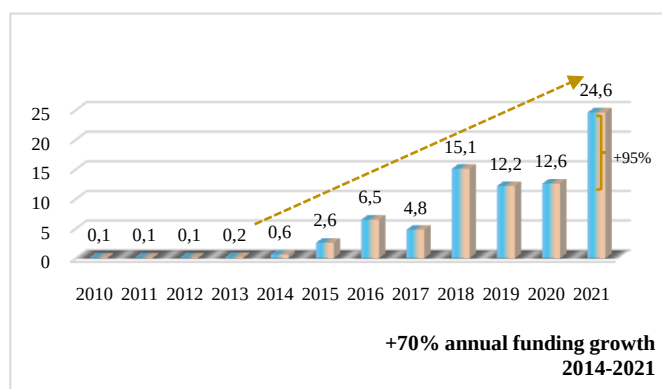
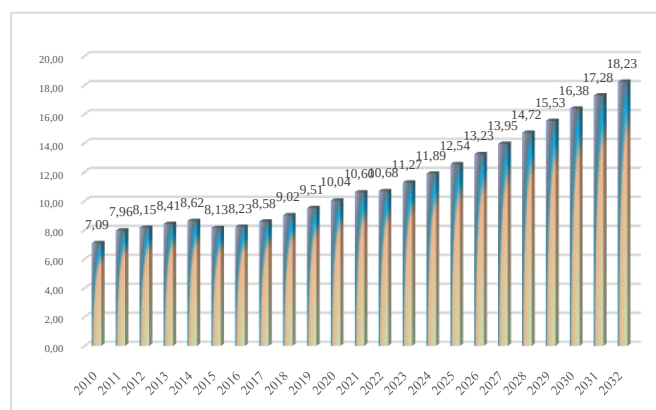


Fig. 6. Globally funding for logistics startups, млрд. \$

Source: <https://www.mckinsey.com/startup-funding-in-logistics>

The data from fig. 6 confirm the financial attractiveness of the logistics sector on a global scale with increased investor interest reported in 2021. After 2014, there has been a significant increase in start-ups in the sector. For the period 2014-2021, the growth was a total of 70%, but for only 2021, the data reported an increase of 95% compared to the previous year.

Logistics is of great importance for achieving economic growth and developing e-commerce. The size of the global logistics market

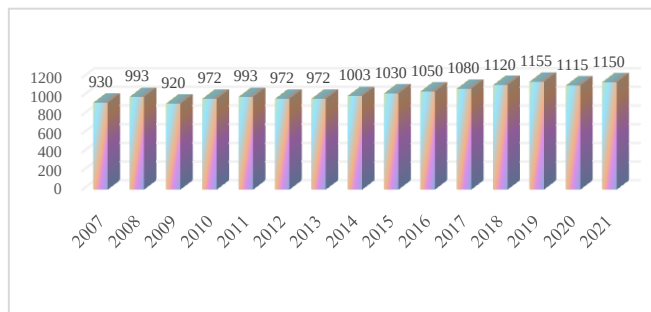


for 2022 is estimated at \$10.68 billion (Fig. 7). Data for the period 2010 – 2022 show stable growth. Expectations for the sector are that by 2032, the market size will grow to about \$18.23 billion with a compound annual growth rate (CAGR) of 5.48%. [15,16]

Fig. 7. Logistics market size, млрд. \$

Source: <https://www.precedenceresearch.com/logistics-market>

Against the background of the global trend, data on the revenue of the logistics sector in Europe for the period 2007-

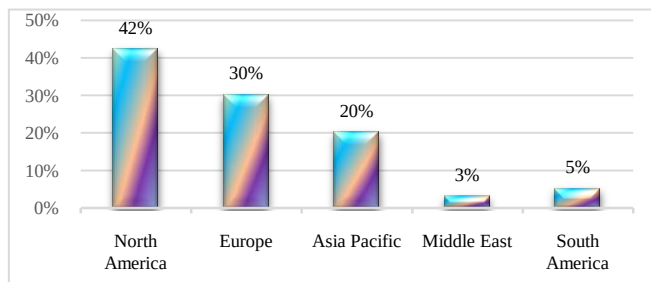


2021 shows relative stability. (Fig. 8) Reported revenue growth over a fifteen-year period is 23.66%, which equates to an average of 1.6% growth per year. [16,18]

Fig. 8. Logistics market size in Europe, billions EUR

Source: <https://www.statista.com/logistics-market-segment-volume-europe/>

The distribution of the global logistics market by geographical regions is presented in fig. 9. According to the data, the largest share of 42% is occupied by North America. In second place is Europe with a share of 30%. In third place are South America with 5%, and in fourth place is the Middle East with 3% of the market



share. [17,18]

Fig. 9. Logistic market by geographical regions

Source: <https://www.maximizemarketresearch.com>

Studies show that there is a shift in customer preferences from brick-and-mortar to online shopping. This growth is due to the advantages that customers are finding in the various levels of online commerce – from product personalization, optimized search through mobile devices, fast and secure payment processes and hassle-free delivery.

As e-commerce grows, so does the need for efficient logistics services. Logistics provides a number of benefits, among which – increased competitiveness of the organization in terms of flexibility, delivery, quality and cost, higher level of customer satisfaction, improved delivery performance, lower operating costs, etc.

Research shows a direct link between growth in e-commerce and the logistics sector. Online sales are becoming a major factor having a direct impact on the logistics market. (fig.10) [22, 23]

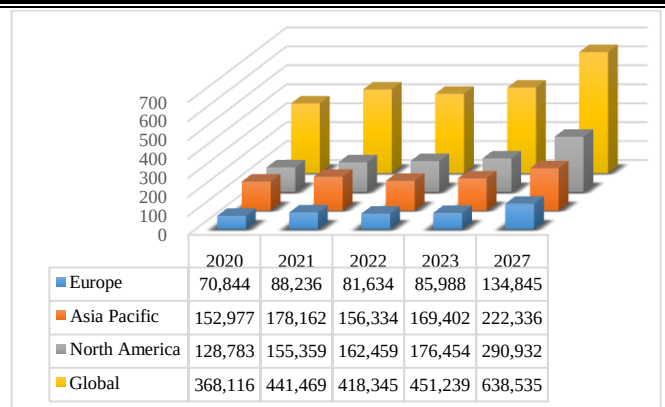


Fig. 10. Global e-commerce logistics market by region 2020-2027, \$ billion

Source: <https://www.giiresearch.com/global-e-commerce-logistics.html>

The data from fig. 9 show that the global e-commerce logistics market is growing annually. In 2022, it is estimated to be \$451.239 billion. Growth for 2023 compared to the previous year is expected to increase by 7.9%. It is forecast to reach \$638.535 billion by 2027 with a CAGR of 10.3%.

The trend for retail sales through e-commerce shows steady growth. (fig. 11) [19]

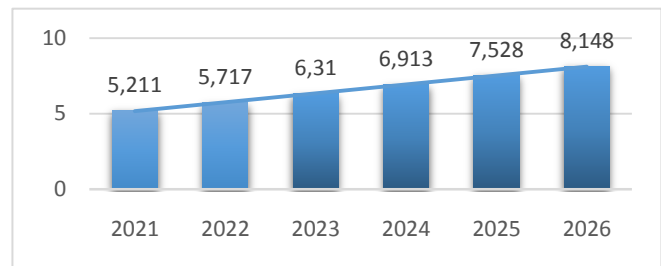


Fig. 11. Global E-Commerce Retail Sales Status and Trend, 2021-2026 in \$ Billion

Source: <https://www.forbes.com/advisor/business/e-commerce-statistics/>

Studies show that there is a shift in customer preferences from traditional to online shopping. This growth is due to the advantages that customers find in the various levels of online commerce - from product customization, optimized search through mobile devices, fast and secure payment processes and hassle-free delivery. In fig. 12 presents the change in the volume of sales through traditional and e-commerce in the period 2015-2022 and forecast until 2026. [20,21]

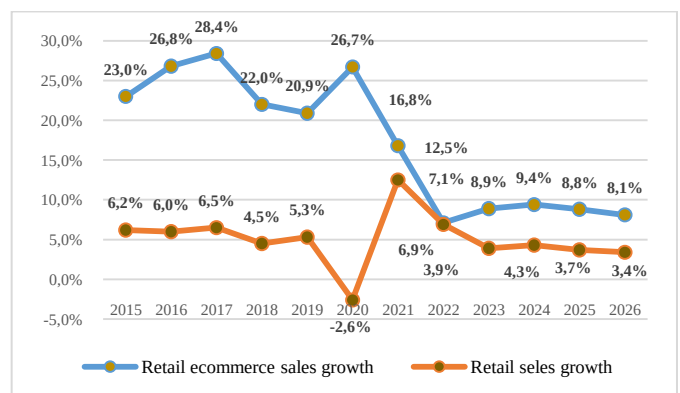


Fig. 12. Comparison between sales volume in electronic and conventional trade

Source: <https://www.insiderintelligence.com/content/global-retail-e-commerce-forecast-2023>

As the volume of e-commerce grows, so does the need for efficient logistics services. [10,11] Logistics provides a number of

benefits, among which – increased competitiveness of the organization in terms of flexibility, delivery, quality and cost, higher level of customer satisfaction, improved delivery performance, lower operating costs, etc.[12,13]

The development of the logistics sector in a country depends not only on the economic conditions and the intensive production and trade of the economic organizations in it, but also on the effectiveness of the conditions that the environment provides. [14,15] In this regard, a study was made of the Logistic Performance Index (LPI) of the World Bank, reflecting the main factors determining the overall efficiency of logistics in a country. The six components of the LPI include:

- ❖ The effectiveness of releasing the goods from border control (speed, simplified procedures, predictability of formalities).
- ❖ The quality of commercial and transport infrastructure (sea, rail, road transport, information technology).
- ❖ Hassle-free organization of cargo at a competitive price.
- ❖ Competence and skills of people providing logistics services (transport operators, customs brokers).
- ❖ The ability to locate and track shipments.
- ❖ Frequency with which the cargo reaches the customer within the scheduled or fixed delivery time.

The data for 2022 put our country in the 51st position (with a score of 3.2) on a par with Romania. (fig. 13). In the survey conducted among more than 1,000 logisticians from 155 countries, the leading place for 2022 is occupied by Singapore with a score of 4.3. The lag behind the leader in the ranking is in the six components. However, the data show that the conditions in Bulgaria in the logistics sector, in all directions, are above the average for the Europe and Central Asia region. [24, 25]

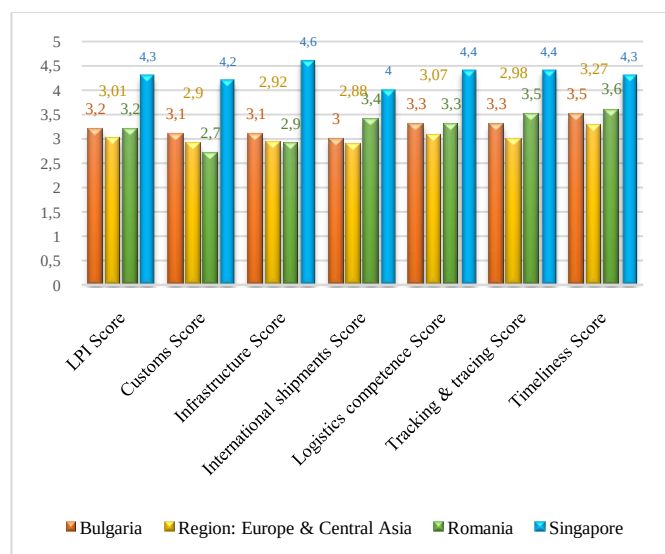


Fig. 13. Comparison of LPI for Bulgaria, Europe and Central Asia, Romania and Singapore, 2023.

Source:
<https://lpi.worldbank.org/international/scorecard/column/C/BGR/2023/R+ECS+2023+C+ROU+2023+C+SGP+2023>

With a score of 3.2, Bulgaria falls on the border between the group of partial performers and consistent performers.

4. Research results

A survey conducted among 173 companies from various industrial sectors in Bulgaria, carrying out online and traditional (conventional) trade shows a percentage distribution of the share of the types of logistics costs that they have to carry out for the same product. The results are presented in Fig. 14 and show the structure of costs in both types of trade - traditional and electronic for the same product. The cost structure in both trades is similar in that production costs (30%) and marketing costs (10%) are the same. In other directions, the cost structure differs significantly:

- **In traditional trade**, labor costs (18%) and rents (15%) occupy the largest share. They depend on the qualifications of the staff employed and the location of the commercial establishment. Other expenses mainly include utility and supply costs. Transport costs represent about 3% of the total logistics costs depending on the origin of the goods.
- In the case of e-commerce, in the structure of costs, operating costs occupy the largest share (20%). These include software and platform costs for financial transactions that require maintenance and periodic updates. Next comes shipping costs (nearly 7%), which are often offered free to customers or at a deep discount, as well as costs that include returns. Warehouse costs are low, around 3%, as most e-commerce distribution centers are located in suburbs or outside cities,

The results show that by offering the same selling price, an online retailer can make about a 30% profit margin, compared to roughly 16% for a retailer choosing a traditional form of trading. In order to increase their market share, online retailers can afford lower price offers.

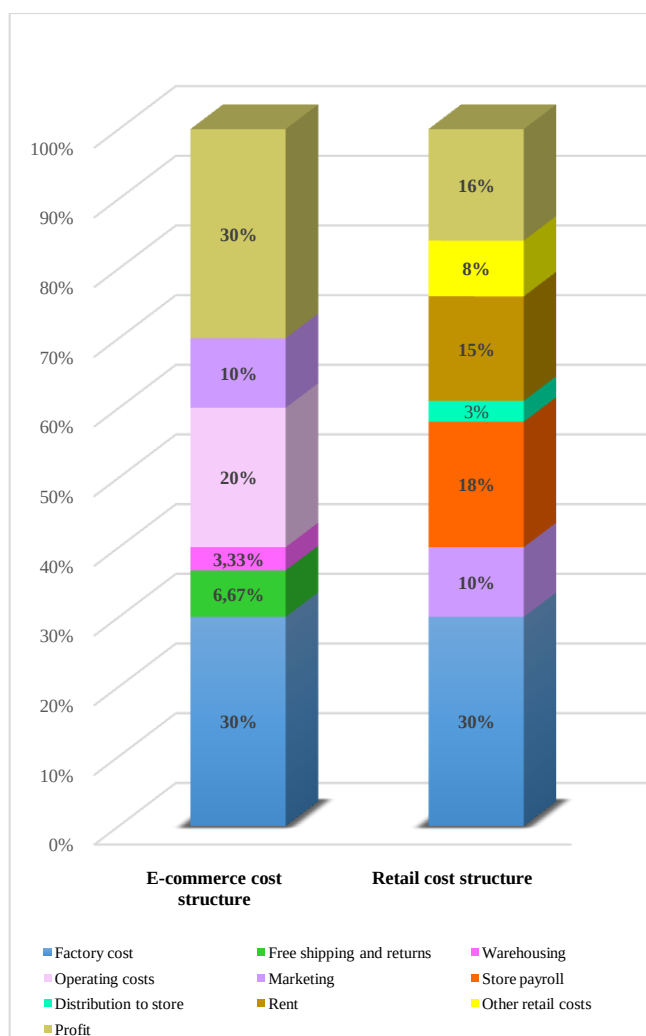


Fig. 14. Distribution of logistics costs in electronic and conventional trade, %

Studies show that e-commerce is becoming an increasingly preferred place for consumers to shop. The reasons for this are:

- ❖ **Convenience, both for the business and the customer.** The consumer can purchase necessary goods and services from any point, and the business must maintain constant availability in its physical locations.
- ❖ **Low costs** - offering a good logistics policy and affordable prices, combined with high quality of goods and services, the merchant that you will be the preferred choice of customers.
- ❖ **Availability** - the advantage of online stores is that they have no working hours or holidays.

- ❖ **Opportunity for greater profits** - by accessing a much larger number of potential customers, at lower costs.
- ❖ **Faster adaptation and changes** – the pace of development of e-commerce makes it easier and faster to adapt to the continuous changes of the market.
- ❖ **Security** - e-commerce provides access to secure statistical information for easy control of stock availability or number of orders. It also relies on security mechanisms for both parties regarding payments and transactions.

4. Conclusion

With the growth of the e-commerce market on a global scale, the growth of the logistics services market is being reported. This dependence attracts significant investor interest in the logistics sector. Bulgaria lags behind in terms of the six indicators included in the Logistic Performance Index (LPI) of the World Bank compared to the leader in the ranking for 2022. However, the conditions in Bulgaria in the logistics sector, in all directions, are above the average for the European region and Central Asia. This shows that the logistics services market in the country is in the process of development and follows the trends in the development of the logistics services market in the world. Studies show that e-commerce is becoming an increasingly preferred place for consumers to shop.

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Climate change and its impact on long-term sustainability of the road infrastructure in Bulgaria

Stoyanka Ivanova ^{1,*}, Simeon Matev ², Evelina Ivanova ¹
 University of Architecture, Construction and Geodesy, Sofia, Bulgaria ¹
 Sofia University, Bulgaria ²
 siva_fce@uacg.bg

Summary: Climate changes are having an increasingly strong impact on the sustainability and safety of the road infrastructure in Bulgaria. This paper analyzes how changes in climatic conditions over the last three decades affect the condition and functioning of the road network. The aim is to identify critical factors and propose methodological guidelines for design and maintenance that include adaptive strategies to address climate risks. The work emphasizes the need for a complex multidisciplinary approach combining scientific research, strategic planning, and practical implementation.

Keywords: CLIMATE CHANGE, ROAD INFRASTRUCTURE SUSTAINABILITY, LONG-TERM STRATEGIES, ROAD SAFETY, CLIMATE RISKS, MULTIDISCIPLINARY APPROACH, STRATEGIC PLANNING, ADAPTIVE MEASURES.

1. Introduction

Climate changes are having an increasingly strong impact on the sustainability and safety of the road infrastructure in Bulgaria. The country is distinguished by specific geographical and climatic features – in a relatively small territory. There is a wide variety of relief, a wide temperature range, fluctuations in precipitation, and snow cover, which are essential factors for the operational efficiency of the road network.

In recent decades, the climatic conditions in Bulgaria have changed with great intensity [1]. This creates serious challenges for road infrastructure and requires new design and maintenance strategies. As climate change progresses, these challenges are expected to deepen and become more complex.

This article analyzes how changes in climatic conditions affect the condition and functioning of the road network in Bulgaria. The aim is to identify critical factors and propose methodological guidelines for design and maintenance that include adaptive strategies to address climate risks.

This analysis is conducted in the context of growing interest and concern for the future of the country's road infrastructure due to the need to adapt to the consequences of climate change. By bringing together scientific research, strategic planning, and practical implementation, it is possible to improve the resilience of the road network, reduce losses, and protect public safety.

2. Climatic changes in Bulgaria during the last three decades

The last three decades have seen a global increase in temperatures, which has significant consequences on various climate elements. They are discussed in detail in [1, 2]. Among these key changes are:

Increase in average temperature: In Bulgaria, as well as worldwide, the average annual temperature is increasing. This has important consequences for climate and the environment, including a greater frequency of extreme weather events. In places with a moderate continental climate, the increase in the average annual minimum temperature is about 1.1 °C, and in the rest of the country – about 0.5 °C [2]. Increases in minimum temperatures during the period 1991–2020 relative to 1961–1990 are greater in hilly regions compared to plains.

Seasonal changes: Climate change leads to shifting seasons and extended periods of extreme conditions. The biggest change is noticed in the summer, which is natural, while in the winter, the change is the smallest. The reasons for these seasonal changes are to be found mainly in the circulation conditions [3, 4]. In general, the summer is getting longer, and the winter season is getting shorter and warmer, which affects the snow cover and precipitation. In turn, less snowfall leads to a higher terrestrial albedo, which in turn leads to greater amounts of solar energy absorbed by the terrain, which is converted into heat and leads to an additional increase in surface air temperatures.

Intense rainfall and drought: In recent years, cases of intense rain in Bulgaria have become more frequent [5]. This happens most often in the summer period, but the cases of intense precipitation also begin to increase during the cold part of the year. They occur more often in the eastern half of the country and the southern regions. An increase in intense rainfall can lead to floods, landslides, collapses, and infrastructure damage. At the same time, prolonged periods of drought, especially in summer, and the reduction of water resources create a risk of fires.

3. Analysis of the impact of climate change on road infrastructure

Transport infrastructure and all modes of transport are vulnerable to climate change. The more important cases of sensitivity and the corresponding significance for road infrastructure can be summarized in the following cases:

3.1 Extremely high temperatures. Prolonged periods of high to peak temperatures

Among the environmental factors, the air temperature has the most significant influence on the temperature of the asphalt pavement. Positive temperature values affect the quality of the transport infrastructure and the service provided by it in three main cases – extreme values, a wide temperature range, and prolonged periods of high average day-night temperatures [6, 7]. Within these three groups, the following climate-induced risks for the transport system are distinguished for our country:

Influence of high temperatures on asphalt coatings:

- Temperature sensitivity of asphalt mixtures: Asphalt coatings are susceptible to temperature changes. At high temperatures, which can reach 70 °C on the surface, standard (unmodified) asphalt coatings increase their plasticity (soften). This leads to a reduction in their carrying capacity and can lead to various types of damage, such as rutting, waves, shearing, and others.

- Modification of mixtures to improve their temperature characteristics: With additives in the composition of the asphalt mixture, the temperature of the surface can be lowered, usually in the range of about 60 °C. This is also positive for the cases of prolonged periods with high average day-night temperatures, which prevents the asphalt concrete from cooling. However, this increases the cost of the material.

- Temperature amplitude and mechanical stresses: Large temperature amplitudes, especially when changing low – high-temperature values, can cause block, transverse, or longitudinal cracks due to mechanical stresses resulting from the expansion and contraction of asphalt concrete coatings.

- Solar radiation and albedo: Asphalt pavements have a low albedo and absorb much of the solar radiation. This further increases the temperature of the coating and can lead to the formation of ruts, waves, and other deformations.

- Specific cases such as airstrips: the same effects are observed on the asphalt pavements of airstrips for taxiing, where the conditions for load-bearing capacity and safety are even stricter.

Impact of high temperatures on railway infrastructure and surface urban rail tracks [8]:

- Thermal expansion of rails: At high temperatures, rails can expand to impede the movement of rolling stock. This may cause traffic to stop or reduce mileage.
- Overheating of cables: High temperatures can cause catenary cables to overheat, which can interrupt rail traffic or reduce running speeds.
- Temperature amplitude: The thermal gaps of the long-welded rails track are sensitive to the variation of the temperature range, which leads to tension/pressure in the track and is directly related to its normal and safe operation.

Effect of high temperatures on fire risk:

- Correlation with periods of drought: High temperatures often coincide with periods of drought, leading to increased fire risk. They can have a destructive impact on road infrastructure, including asphalt surfaces, curb systems, and road bodies.
- Impact on structural elements: Fires can cause severe damage to some structural elements of the road structure, road accessories, and facilities such as bridges, tunnels, etc. This could lead to temporary or long-term closure of key transport routes.
- Safety and traffic issues: Fires and smoke can reduce visibility and create hazardous driving conditions. This can increase accidents, traffic disruptions, and even human casualties.
- Erosion and geological risks: Periods of drought and high temperatures can activate processes of destruction in the soil massifs, which become more susceptible to wind and precipitation erosion. This can create additional geological risks, such as landslides, rockslides, and road closures.

3.2 Rainfall, storms, and rainfall-type floods.

In a changing climate, precipitation and water conditions pose a significant risk to transport infrastructure, affecting its sustainability, safety, and functionality.

Floods and water quantities:

- Floods with a priority precipitation nature can cause flooding of various sections of the transport infrastructure.
- Flooding and undermining of bridge facilities, which can lead to the direct destruction of the substructure bridge, in which the superstructure is also compromised. Complete destruction of the bridges is also possible.

Waterlogged soil from the terrestrial body:

- The primary source of waterlogging is surface water, which can cause loss compaction, undermining, transport of particles, displacements of layers, and destruction of slopes during excavations and embankments.
- In second place are underground waters, which move along a capillary path and form wetlands and transfer particles, which also leads to deformations in them and damage to pavements, unevenness, and network-like cracks.

Hydraulic capacity and drainage systems:

- Exceeding the hydraulic capacity of drainage and small facilities (type culverts) on roads and railways.
- Overloading drainage systems in urbanized areas is especially important for the traction of pavements and the safety of car traffic.

Surface conditions and safety:

- Retention of a thick film of water on pavements can cause loss of traction and cases of aquaplaning.
- During rain, storms, and hail, visibility is impaired, which disrupts the continuity and safety of traffic.

Erosion and geological risks:

- Intensification of erosion processes, especially rain and wind erosion, in various parts of the transport infrastructure.
- Increasing the degree of geological risk, such as landslides and rockslides, especially at high wind speeds or after prolonged periods of drought.

Additional factors:

- Water retention: Water retention in road pavement cracks, which freezes and expands as temperatures drop.
- Groundwater: Prolonged retention of high groundwater levels can compromise the structural linings of underground facilities such as tunnels and subways.

3.3 Extremely low temperatures, prolonged colds with low temperatures, temperature amplitudes

The tendency is for extremely cold days (so-called "ice days") to decrease in Bulgaria. However, climate change can lead to disturbances in atmospheric conditions, resulting in extremely low temperatures in limited areas. For this reason, adaptation to climate change must necessarily include measures aimed at the consequences of very low temperatures:

Impact on road structures:

- Extremely low temperatures: In addition to the deterioration of bitumen elasticity, low temperatures presuppose the appearance of cracks and freezing of water in already existing cracks.
- Temperature cracks: With sudden temperature drops, frozen areas form in the earth's body, and temperature cracks, holes, and pits can form in the coating.

Impact on road safety:

- Black ice: Formed by a combination of low temperatures and fog and is a road safety risk.
- Icy sections: Reduced traction and increased risk to road safety.
- Freezing rain: Leads to the formation of an icy surface on road surfaces, creating a risk to road safety and infrastructure damage.

Impact on railway infrastructure [8]:

- Catenary icing: Causes problems in electrified railway lines.
- Device freeze: railroad switch (cross, connection, the combination of cross and connect) are sensitive to freeze.

Impact on bridges and other facilities:

- Water freezing in drainage elements: This may cause damage to load-bearing and non-load-bearing parts.
- Corrosion from anti-icing ingredients: This is especially risky in the presence of shortened drainage pipes and wind.
- Icing of facilities with steel structural elements.

Impact on harbors and fencing facilities:

- Icing of structures: This can lead to critical infrastructure conditions, especially in bulk breakwaters.

Additional risks:

- Retention of water in cracks in reinforced concrete and asphalt concrete elements: When temperatures drop, water freezes and widens the cracks and increases the degree of damage.

3.4 Precipitation, storms, and rainfall-type floods.

In the conditions of variable climatic factors, rainfall, storms, and rainfall-type floods pose a significant risk to transport infrastructure, affecting safety and traffic continuity.

Accumulation of snow and its consequences

- Accumulation of snow on road surfaces: During winter maintenance, it is a problem because it requires repeated regular snow removal.
- Reduced visibility during heavy snowfall: This leads to problems with transport safety and traffic continuity.
- High-speed snow drifts: This is especially problematic for roads and railways due to the deposition of large amounts of snow and the suspension of snow removal.

Influence of precipitation and wind

- Reduced visibility during heavy precipitation (snowfall): A significant risk factor in transport safety, with a priority impact on the national road network (RPM).
- Snowdrifts in stormy winds and heavy snowfall: This combination leads to significant problems with safety and traffic continuity. Road infrastructure is susceptible to these conditions.

3.5 Water level rise. Wind wave effect.

In the conditions of sea level rise, coastal transport, and port infrastructures are exposed to severe risks:

- Destruction of coastal transport infrastructure and port and coastal defense infrastructure in the presence of high water levels or wave impact. The slopes of the coastal areas are most at risk from the intensification of the erosion processes and the entire port and coastal protection infrastructure from the wave impact.
- Destruction of coastal transport infrastructure as a result of waves or combined with rain erosion of the coastline.

3.6 Other impacts with local relevance to serviceability and traffic – fog, high humidity levels, and others.

Other impacts with local relevance to serviceability and traffic include meteorological factors such as fog and high humidity levels. Fog significantly reduces visibility on the road, which can slow down traffic and increase the risk of road traffic accidents. High humidity levels can deteriorate the adhesion between the road surface and vehicle tires, cause corrosion of the steel elements of the transport infrastructure, cause deformations in the wooden sleepers of the railway superstructure, and others. These factors require special maintenance and monitoring measures to ensure the safety and efficiency of the transport system.

4. Methodological guidelines for design and maintenance

4.1 Adaptive strategies to deal with climate risks

Adaptive strategies to address climate risks in road infrastructure are vital to ensure the safety, resilience, and efficiency of transport systems in a changing climate. Here are some potential strategies that could be implemented in the coming years:

Sustainable design and construction

This includes developing sustainable and adaptive road infrastructure designs that consider climate change and extreme weather conditions. When designing, the use of materials that are resistant to climatic influences such as high temperatures, floods, and freezing should be foreseen.

Technological innovations

These could include the integration of Intelligent Transportation Systems (ITS) [9, 10], which offer real-time traffic monitoring and management, as well as warnings of hazardous conditions. This necessitates the application of weather forecasting and monitoring technologies to help respond quickly to extreme weather conditions [11]. Artificial Neural Networks (ANN) and Artificial Intelligence (AI) [12], often combined with the Internet of Things (IoT), are essential to adaptive strategies against climate risks. They help in the analysis and forecasting of climatic conditions, as well as in the automation of responses to extreme events. IoT sensors monitor parameters in real-time, while AI analyzes the data for quick response and warning.

Improved planning and management

This group includes developing risk management plans and emergency plans to address potential climate threats and ensure a rapid and effective response. This means the need to regularly reassess and update climate risk management plans and strategies based on new data and research.

A typical example of key risks is fires and floods, for which it is necessary to define safety measures and adaptation strategies, which include both technological and organizational measures for their

prevention and combating them. This may include optimization of materials and methods, early warning systems, and staff training.

Training and awareness-raising

In this regard, training and awareness-raising campaigns among the public and key stakeholders on the impact of climate change on road infrastructure are envisaged, including cooperation with local, national, and international organizations to share knowledge and resources.

Funding and Investments

Adaptation requires providing adequate funding and investment to improve the sustainability of road infrastructure and to develop new technologies.

Legislative framework

All of the above strategies require the development of legislation and regulations to support the sustainable development and adaptation of road infrastructure to climate change.

These strategies can be implemented through a coordinated effort between various stakeholders, including government bodies, local communities, industry, and the scientific community.

4.2 Integrating climate resilience into infrastructure projects

Integrating climate resilience into infrastructure projects requires a holistic approach that covers every stage of road infrastructure design and construction. This can be done as follows:

Advance planning and analysis

It is necessary to start with detailed climate risk analyses and vulnerability assessments to understand how climate change may affect the project, considering different climate scenarios and predicting possible impacts on infrastructure.

Conceptual and detailed design

Climate resilience measures should be integrated in the initial stages of design, considering future climate projections. This also includes the choice of materials and construction solutions resistant to extreme weather conditions.

Construction

In the construction phase, sustainable construction practices and materials should be used that reduce the impact on the environment and increase the project's resilience to climate risks. At the same time, risk management strategies must be implemented during construction to prevent or minimize damage from extreme weather events.

Monitoring and evaluation

It is important to verify the conformity of the predicted behavior and state of the infrastructure and its actual state during operation. This requires the development and implementation of plans to monitor and assess the climate resilience of the project after its construction, followed by the collection and analysis of data on the actual behavior of the infrastructure in response to climate conditions and the use of this information to improve future projects.

Support and management

During operation, it is essential to implement a maintenance and management plan that includes measures to maintain climate resilience long-term. This plan should be continuously updated based on new information on climate change and best practices.

By integrating these and other measures at every stage of design and construction, it can be ensured that road infrastructure can withstand the challenges of climate change and continue to serve society efficiently and safely.

4.3 Opportunities to optimize support

Optimizing road infrastructure maintenance is critical to improving resilience, reducing costs, and increasing road safety. One of the key opportunities for optimization is the introduction of Intelligent Transport Systems (ITS), which provide automated solutions for traffic management, road surface condition monitoring, and real-time incident response. Innovations in materials also offer opportunities to improve the durability and resilience of road surfaces

by using durable and high-performance materials that reduce the need for frequent repairs. Also, precise data from satellite and drone technologies can support the effective planning and execution of maintenance operations by providing accurate information on the condition of the infrastructure in real-time.

Another aspect of optimization is the development of effective maintenance strategies and procedures based on best practices and data analysis. An example is the application of preventive condition monitoring to identify and fix problems before they lead to severe damage or costly repairs. Integrating information and communication technologies [12] can improve coordination and communication between different units in the maintenance process and facilitate rapid response to incidents.

5. Complex and multidisciplinary approach

5.1 The importance of research and monitoring

A comprehensive and multidisciplinary approach is key to understanding and addressing the impact of climate change on road infrastructure. Scientific research plays a significant role in providing the necessary knowledge about how climate factors affect infrastructure systems, including the materials and structures most resistant to these conditions. The multidisciplinary nature of the research allows analysis of various aspects of road infrastructure, from geotechnical and material issues to traffic planning and management.

Systematic monitoring is another critical element in this comprehensive approach. Continuous monitoring and collecting real-time climate data allows engineers and governing bodies to monitor climate change and its impacts on infrastructure. This monitoring includes monitoring of atmospheric conditions, road surface conditions, and traffic. Collected data is analyzed to identify trends, predict future problems, and develop adaptation strategies, which provides a science-based basis for decision-making and rapid response to changing conditions.

5.2 The role of strategic planning and management

Strategic planning and management play a central role in adapting road infrastructure to climate change.

Strategic planning is crucial to the adaptation of road infrastructure to climate change. It helps to define long-term goals and priorities, as well as to develop a concrete framework for action. In this context, an analysis of potential risks and opportunities, as well as the necessary resources for successful adaptation, is carried out.

Strategic management allows effective coordination of the adaptation process. It includes coordination between different stakeholders, management of resources, and monitoring of progress. Ensures that decisions are scientifically sound and conform to established policies and regulations.

Strategic planning and management support a cycle of continuous learning and improvement. Through periodic reviews and evaluations, successful practices and improvement areas are identified. This allows the adaptation of strategies in response to new information or changing conditions.

6. Conclusions

In the conditions of the climate trends, the road infrastructure in Bulgaria faces several challenges, and in the future, this process will deepen. Climate change leads to adverse climatic consequences that make traffic difficult and increase the risk of accidents. Adapting these changes using research and monitoring is essential to improve knowledge of these risks and develop effective strategies to address them.

Adaptability and innovation are critical to improving the sustainability of road infrastructure. Preventive maintenance, intelligent transport systems, and new materials and technologies can help reduce the impact of climate change. Flexibility in strategic planning and management is also essential, as it allows organizations to respond quickly to changing conditions and improve their

practices based on new scientific discoveries and technological innovations.

Success in climate change adaptation requires collaboration between the scientific community, industry, and the public sector, which can accelerate the development and deployment of innovative solutions and improve coordination and resource planning in response to climate challenges. Sharing knowledge and experience between different sectors can help create a resilient infrastructure that can cope with future climate change. These findings highlight the importance of an integrated approach to climate change adaptation and innovation in infrastructure projects in Bulgaria to ensure the long-term sustainability and safety of the road network.

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Analysis of available climate data reflecting the impact of climate change on the road infrastructure in Bulgaria

Simeon Matev ¹, Stoyanka Ivanova ^{2,*}, Evelina Ivanova ²

Sofia University, Bulgaria ¹

University of Architecture, Construction and Geodesy, Sofia, Bulgaria ²

siva_fce@uacg.bg

Summary: The article presents an in-depth analysis of the data related to the assessment of the impact of climate change on the road infrastructure in Bulgaria. It is necessary to systematically collect, store, and analyze territorial data on the dynamics of changes in various climatic factors such as temperature, snow cover, precipitation, winds, etc. The article examines the main sources of such information in Bulgaria, their limitations, and shortcomings. Identifying the needs and weaknesses in finding usable data is an important step on the way to building a strategy to solve this task.

Keywords: CLIMATE CHANGE, ROAD INFRASTRUCTURE, CLIMATE DATA ANALYSIS, INTENSE RAINFALL, CLIMATE RISK, CLIMATE MONITORING, ADAPTATION STRATEGIES

1. Introduction

In recent years, the public's attention and interest have been drawn to climate change, which is manifested by global warming, more frequent extreme weather events, rising sea levels, and melting glaciers. Climate change is the subject of research and analysis by a growing number of interested institutions due to its significant impact on various social and economic processes.

Observed changes in the atmosphere, oceans, glaciers, and biosphere clearly indicate that the planet is warming. The latest report of the Intergovernmental Panel on Climate Change (IPCC, 2021 [1]) reports that the average global temperature has increased by about 1.09 °C from the end of the 19th century to 2020. According to the data, the last decade, from 2011 to 2020, is the hottest since systematic meteorological observations began. Warming was felt more strongly on land, where the average temperature rose by 1.59 °C, compared to 0.88 °C over the oceans. Changes in air temperatures and indices of temperature extremes such as ice days, tropical nights, and heat waves are sources of important information in the study of climate change.

A 1 °C increase in surface temperature leads to a 7% increase in atmospheric water vapor. This affects rainfall, storms, hurricanes, and extreme weather events. In some places, precipitation decreases significantly, and dry periods become longer and more frequent. Nationally, the increased frequency of intense rainfall events results in more compromised elements of the transport infrastructure, with the republican and municipal road network being the most affected.

The increase in temperatures also affects the rise of the sea level – since the beginning of the 20th century, it has risen by approximately 20 cm, and the speed of this process is increasing. In the last century, that rate was greater than in any other century in the previous 3000 years [1].

The many changes in climate and related indicators observed in the last 50 years are occurring at a rate never before recorded in the previous 2000 years. This dynamic has a severe impact on socio-economic life and existing infrastructure. Studying these changes and their connection to different economic sectors answers many questions for the future. This highlights the importance of further research on impending climate change and its socio-economic footprint.

This publication aims to analyze the availability of meteorological and climate data relevant to the transport infrastructure in Bulgaria. With it, we continue the work of a previous publication by the same team, which describes the impact of different climate elements on the road network [2].

2. Methodology of climate data analysis

2.1 Collection and storage of climate data

Climate data collection is an important process that provides information on climate change and is essential for research, analysis, and development of climate change adaptation strategies. Here are some of the ways to collect climate data:

Climate Stations: These special weather stations are located at various locations and regularly measure climate elements such as temperature, humidity, atmospheric pressure, rainfall, and winds. This data is recorded regularly and used to analyze the climate.

Satellites and sensors: Satellites orbit the Earth and collect, with the help of various sensors and measuring devices, information about the climate – the temperature of the Earth's surface, the state of the glaciers, the concentration of greenhouse gases, and other parameters. This data is available through international agencies such as NASA and ESA.

Buoys, deep-sea probes, and floating platforms: These devices are located in the oceans and seas and measure water temperature, salinity, oxygen concentration, and sea currents. They are particularly useful for monitoring physical conditions in the World Ocean.

Aerosondes and balloons: Special aerosondes and weather balloons are used to measure parameters at altitude and observe atmospheric phenomena.

Automated systems and IoT: These enable continuous real-time data collection. This facilitates climate monitoring and provides up-to-date information.

Climate models: Climate models collect and process data from various sources, including stations, satellites, and probes, to create complex predictions of the future climate.

Global databases: Various organizations and agencies maintain global databases of climate information, such as NOAA, Copernicus, and NASA. These data are available for research and publicity.

Collecting climate data is a complex and continuous process that requires technological advances and cooperation between different institutions. This information is essential for understanding climate change and making adaptation decisions. Climate data collection needs to be systematic and consistent for several main reasons:

Understanding trends: Systematic and consistent collection of climate data allows scientists to understand trends and changes in climate over time. This process allows patterns to be drawn and future changes to be predicted.

Climate Risk Assessment: Climate data is essential in assessing the risks associated with climate change. They provide information about extreme events such as floods, droughts, tornadoes, and hurricanes that can devastate society and the economy.

Scientific research and modeling: Systematic climate data are used for scientific research and developing models that provide a better understanding of the climate and predict the future.

Planning adaptation strategies: Data are needed to prepare adaptation strategies to climate change. With their help, it can be determined what measures should be taken to reduce the vulnerability of society and infrastructure.

Informing the public and policymakers: Public and political understanding of climate change and its consequences is based on the availability of systematic data. They provide an objective basis for decision-making and policy formulation.

Comparison and coordination: Systematic data collection allows different regions and periods to be compared. This is essential for the analysis of global trends and for the coordination of measures to reduce emissions and adapt to climate change.

The long-term view: Climate change is the result of natural processes developing over millions of years and of anthropogenic activity over the past 200 years or so. Systematic data collection makes it possible to monitor the climate's long-term evolution and take action based on this long-term view.

Systematic and consistent collection of climate data is a key component in understanding and adapting to climate change and its societal and ecosystem impacts. This process provides a sound and objective basis for research, adaptation, and decision-making.

2.2 Types of climate data: temperature, snow cover, precipitation, winds, etc.

Collecting climate data to assess the impact of climate change on infrastructure requires measuring and recording various climate elements and indicators, such as:

Temperature: its measured values are essential for understanding climate change.

Snow cover: measuring its changes is important, especially in regions with snowfall.

Precipitation: information on the amount and intensity of precipitation is needed to predict flooding and erosion.

Winds: their speed and direction are essential for understanding climate conditions.

Atmospheric pressure: its measurement helps in predicting atmospheric processes and phenomena.

Humidity: it is an essential factor for climatic conditions.

Sea level and wind wave impact: these are important for areas at risk of flooding and those with coastal infrastructure.

Intensity of solar radiation: Measuring solar radiation is vital for understanding climate processes and the planet's heat balance.

Collecting this data in real-time and monitoring its dynamics is a key element for infrastructure protection and adaptation to climate change. This kind of information allows society to plan and take the necessary measures to preserve and improve infrastructure and address increasing climate challenges.

2.3 Climate Change Impact Assessment

Climate change impact assessment is a key process that helps understand how climate change affects the environment, society, and the economy. One of the first steps in this process is the analysis of climate factors and their trends. Here is how this analysis is performed:

Identification of key climate factors: The analysis begins with identifying key climate factors that can potentially influence a given region or system. These factors include temperature, precipitation, humidity, winds, sea level, etc.

Data collection: To perform the analysis, it is necessary to collect data on climatic factors. This may include information from weather stations, satellite observations, marine measurements, and other sources. The data must be systematic and reliable.

Time series and trends: After the data is collected, time series are created that show the dynamics of climate factors over the years. This analysis allows the identification of trends such as an increase in average temperature or an increase in precipitation.

Statistical analysis: To assess the degree of influence of climate change, mathematical-statistical methods are used. This may include correlations between climate factors and various parameters such as flood counts, average sea surface temperatures, etc.

Modeling: Some assessments require climate models that simulate future climate scenarios. These models are based on analyzing current trends and are used to predict future changes.

Interpretation of the results: The final step in analyzing climatic factors and their trends is interpreting the results. This

includes determining the possible environmental, economic, and societal impacts.

Analysis of climate factors and their trends is a fundamental step in determining the risks and opportunities associated with climate change. It provides a scientific basis for decision-making and policy formulation for adaptation and mitigation of climate risks.

2.4 The relationship between climate factors and road infrastructure

Climatic factors have a major impact on road infrastructure's design, construction, maintenance, and adaptability. The following more important aspects can illustrate this:

Temperature: The extreme temperatures and the wide temperature range negatively affect a significant group of characteristics and design parameters of the road infrastructure, respectively, the quality of the service it provides. Given the density and characteristics of roads, it is the mode of transport most affected by temperature limits in terms of durability, serviceability, and sustainability of service, compared to rail, water, and air.

Precipitation and flooding: This group of factors affects roads in a wide range of effects – from retention of surface water and reduction of traction through an increase in soil water quantities to local damage, defects, or destruction of roads and their facilities. They are important for the development of erosion-induced conditions and for increasing the geological risk in the area of landslides and collapses. The reason is reduced visibility (throughput), increased risk of road accidents, and forced traffic stops.

Snow cover and icing: These factors affect winter maintenance, traffic continuity, and durability of materials subjected to anti-icing additives. Cases of ice, "black ice," and snow cover are significantly relevant to road safety.

Extreme winds and storms: Within the scope of the routes, they can cause damage to the contact network of electrified transport, the power grid, and other damages. They are related to traffic safety and in cases of combination with hail, rain, and others. They are a prerequisite for fire risks. They increase the degree of surface wind erosion.

Sea level rise and wind wave impact: If the sea level rises due to climate change, coastal roads and bridges may be at risk of flooding. This aspect is particularly important for coastal regions. Under certain wind conditions, transport, port, and coastal protection facilities can be destroyed due to wave action.

Intense heat waves: Prolonged periods of high to peak temperatures affect the durability and wearability of road surfaces. They overdry the surface of the slopes, as a result of which they increase the surface weathering and the prerequisites for accelerated erosion. They are a prerequisite for fires and damage to the infrastructure resulting from the sensitivity of the building materials.

3. Sources of meteorological and climate data in Bulgaria

3.1 National climate networks and stations

The initial information for the climatic changes is the meteorological data – raw data from observations in more than 30 first-class synoptic stations in Bulgaria, with data submission every three hours in the international exchange. The stations that participate in the research must fulfill two criteria: 1) the possibility of public access to meteorological information, and 2) reflect the physical-geographical diversity of our country to the maximum extent. Nine stations meet these two conditions at the moment in the non-mountainous territory of our country, four of which are in Northern Bulgaria – Vidin, Lovech, Razgrad, and Varna and five in the South – Sliven, Kardjali, Sandanski, Burgas, and Sofia.

There are also several private sites where information from automatic weather stations can be accessed, but they do not always meet the requirements for representativeness and correctness of the data.

Meteorological information can also be obtained from the archives of the stations located at some of the civil and military airports and the Executive Agency for Maintenance and Research of the Danube River.

A distinction must be made between meteorological and climate data. The former focuses on short-term atmospheric conditions. Climatic data are averaged weather data collected over long periods and serve to analyze long-term climate trends.

3.2 Climate prediction models

Climate prediction models are implemented in computer programs and systems that simulate and predict climate conditions in the future. These models use mathematical equations, statistical data, and physical parameters to predict temperature, precipitation, winds, humidity, and other climate characteristics of specific localities and regions.

Climate prediction models are based on scientific research and gather information about current climate conditions and their changes over time. They can be used to analyze climate trends, make short-term and long-term climate forecasts, and assess the impact of climate change on various sectors such as agriculture, energy, and infrastructure.

Copernicus and NASA are most often used, adapted using different methods for the territory of our country. In some institutions such as NIMH, UACEG, SU, TU, etc., mathematical models with a regional orientation are being developed, which can forecast climatic conditions and analyze their consequences on the buildings and road infrastructure in the country.

3.3 International organizations and activities

Several international institutions, programs, and initiatives are engaged in collecting, analyzing, and sharing climate data and climate change information. These organizations and activities facilitate cooperation between different countries and regions to understand climate change and manage its consequences. Some of them are:

International Panel on Climate Change (IPCC [3]): This is an essential scientific organization that collects and evaluates scientific data on climate change and provides assessments and projections of its effects.

World Meteorological Organization (WMO [4]): It plays a key role in collecting and disseminating climate data and meteorological information on a global scale.

The United Nations Convention on Climate Change (UNFCCC [5]): This convention promotes international cooperation on climate change issues and requires countries to provide data and information on their climate action.

European Union projects and programs: The EU funds a number of climate-related projects and programs (e.g., PVGIS [6]) and collects data on climate change in the region.

These international organizations and activities can be important sources of information that are used for analyses and strategies for adaptation to climate change in the Balkans and Bulgaria.

4. Limitations and shortcomings of available data

The limitations and shortcomings of available climate data are important factors to consider in their use and analysis.

4.1 Issues with data limitations and deficiencies

When analyzing and interpreting climate data, it is important to understand their limitations and shortcomings:

Insufficient spatial coverage: In some cases, climate data may only be collected from a limited number of weather stations or regions. This means that there are places for which no data are available, and their climate dynamics remain unknown.

Insufficient time span of data: To analyze climate trends and changes over time, long-term information is required. Lack of data over a long period can make analysis and forecasting difficult.

Errors and inaccuracies: Every measuring instrument and method has its own errors and inaccuracies. This can result in data that does not always accurately reflect actual climate conditions.

Lack of standardization: Different weather stations and data sources may use different methods and tools, making data comparison and analysis difficult.

Heterogeneous data: Climate information is collected from various sources, including weather stations, satellite observations, climate prediction models, and more. Integrating this disparate data can be challenging due to different formats and collection methods.

Unforeseen omissions: In rare cases, data may contain unforeseeable omissions or information gaps, making analysis and forecasting difficult.

All of these issues and limitations must be considered in data analysis to improve the accuracy and reliability of analyses and predictions.

4.2 Problems with access to climate data in Bulgaria

A common practice when seeking meteorological information for various needs, including government departments and problem-solving institutions requiring such information, is to request it from the authority that manages, maintains, and is responsible for meteorological observations in the country. In most countries, this is done by the national weather service. In Bulgaria, it is the National Institute of Meteorology and Hydrology (NIMH [7]). For much of the operational work related to the operation of the meteorological network, the institute receives a government subsidy. Unfortunately, the institute does not present the detailed results of the station measurements in the public space. Only data from measurements in synoptic conditions are freely available, and only for part of the synoptic stations are available [8]. The data is superficial, with rounded values, and there is no information, such as extreme temperature, wind, precipitation, etc.

Due to the lack of archival information on the official page of NIMH, in any force majeure circumstances, such as disruption of road infrastructure, the concerned services and persons should request meteorological information through an official way from NIMH. They, in turn, decide if, when, and what information to provide, often for a fee. Information containing a time series with a longer range is also needed for some needs. NIMH can then provide the so-called "raw data" [9]. They are not provided immediately and in complete form, but multiple visits to the NIMH archive are required, which consumes an enormous amount of time and resources. A fee is also required for some of the information, which can sometimes be prohibitive for the concerned authority. For some needs, such as organizing fieldwork, planning repair, and construction activities, as well as several outdoor activities for better planning, climatic information is needed, such as the number of days with precipitation, amount of precipitation per month and years, average monthly temperatures, temperature extremes, etc. Such summary information cannot be found on NIMH pages, and published climate reference books contain information based on data from the middle of the last century [10].

It should be noted that NIMH makes publicly available monthly and annual summaries in which limited information can be found on average and extreme values of temperature, precipitation, wind, and other elements for a relatively small number of stations after 2007 [11]. In Bulgaria's neighboring countries, access to meteorological information is wider, and data can be found for many stations for at least 60 years. Serbia [12] and Romania [13] are leading meteorological services in this regard, which can provide a range of freely available climate and meteorological information on request. Climatic information for the last 60 years can be freely accessed on the websites of the meteorological services of most European countries. However, everyday information requires more specialized communication with the service in question, and most countries only provide such information for a fee. However, for some stations that are in the international exchange of the World Meteorological Organization [14], the daily data can be found on different sites, such as [15] or [16]. Information about some extreme data can be found

on the pages of meteorological yearbooks (such as those published in Bulgaria until 1982), statistical yearbooks, and publications in the media. Unfortunately, collecting information this way is not always successful, as it usually covers a small number of stations, has many missing data, and sometimes includes many errors.

The need for meteorological information to solve road infrastructure problems is paramount. Therefore, easy access to it will facilitate teams working on infrastructure projects.

5. Importance of quality climate data for transport decisions

In light of the challenge of accelerating climate change, developing and implementing a climate data collection and analysis strategy is of great importance. This strategy should be based on collecting, analyzing, and disseminating accurate and reliable climate-related data to support the sustainable and effective management of road infrastructure and road safety.

Without extensive and up-to-date information on climate conditions, we are powerless to address the impacts of climate change on road infrastructure. This data provides us with the necessary basis for:

Forecasting and planning: with the correct data, we can predict climate risk and plan infrastructure changes and improvements to address the challenges ahead.

Vulnerability assessment: we can assess the vulnerability of the road network and facilities, such as bridges and tunnels, to climate change and identify where investments in remediation and renovation are needed.

Improving safety: with data on climate risks, we can develop more effective road safety strategies, including warnings and infrastructure changes, to prevent disasters.

Resource optimization: by using climate information, we can optimize the use of resources such as salt, snow-, and ice-cleaners.

The current and future generations of designers, engineers, and builders must commit to creating and implementing strategies to improve climate data collection in transportation infrastructure areas. This includes support for national and international climate networks and stations, investment in climate prediction models, and active participation in international climate-related organizations and initiatives.

The real meaning of this commitment is manifested in our ability to protect our transport and infrastructure from the adverse effects of climate change and ensure sustainability and safety for future generations. A strategy to improve climate data is not just necessary; it is the key to the next successful steps for sustainable development and preserving the infrastructure that will serve us well in the future.

6. Conclusion

Climate data analysis is critical to road infrastructure and its resilience to the challenges posed by climate change. We have examined various aspects of this analysis in this text and highlighted its key role. It is clear from the exhibition that climate change has an impact on many aspects of infrastructure, including roads and bridges. Rising temperatures, intense rainfall, changes in winds, and other climate phenomena can lead to damage and serious damage to infrastructure.

The presentation examines the types of climate data needed to analyze the impact of climate change. This includes data on temperature, snow cover, precipitation, winds, and other parameters that can be used to assess climate risk to infrastructure. Climate data sources, including national climate networks and stations, climate prediction models, and international organizations, were also considered important sources of information.

The conclusion of this study emphasizes the need to continue and strengthen efforts in the field of climate data analysis for road infrastructure. In light of the growing challenges of climate change, this kind of research and monitoring is proving critical. We need to

invest in better systems for collecting and analyzing climate data and develop models to predict climate risk. This will allow us to create a more resilient infrastructure and prepare for future climate challenges.

Furthermore, the importance of collaboration between the scientific community, the public sector, and industry should be emphasized. We can only create innovative solutions and strategies for adapting to climate change through the combined efforts of all these sectors.

In conclusion, climate data analysis of road infrastructure is vital to maintain its functionality and resilience to climate challenges. Our commitment to these efforts will define the future of infrastructure and its ability to cope with climate change.

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The role of the green transition in ensuring societal security in bulgaria

Antoaneta Simeonova¹, Angel Krumov¹

Institute of Metal Science, Equipment and Technology with Hydroaerodynamic Center at Bulgarian Academy of Sciences,
67 Shipchenski Prohod Street, 1574 Sofia, Bulgaria ¹

Abstract: *The Green Transition, aiming for a sustainable and eco-friendly future, plays a crucial role in ensuring societal security. As the world grapples with climate change and environmental degradation, the Green Transition offers a pathway to address these challenges while fostering societal cohesion and resilience. In Bulgaria, the Green Transition is not just an environmental endeavor but also a means to counter disinformation narratives and foreign authoritarian influence. This paper examines Bulgaria's efforts in the Green Transition, its implications for societal security, and the challenges and opportunities it presents.*

KEYWORDS: GREEN TRANSITION, SOCIETAL SECURITY, BULGARIA, CLIMATE CHANGE, RESILIENCE, DISINFORMATION, FOREIGN INFLUENCE.

1. Introduction

The Green Transition, a global movement towards sustainability and environmental responsibility, has emerged as a pivotal strategy in addressing the multifaceted challenges of climate change, environmental degradation, and societal security. This transition, characterized by a shift from fossil fuels to renewable energy sources, sustainable agricultural practices, and eco-friendly innovations, is not just an environmental endeavor but also a socio-economic and political transformation that affects nations at various levels.

In the European context, the Green Transition is not only about mitigating the adverse effects of climate change but also about fostering societal cohesion, resilience, and ensuring long-term security. The urgency of this transition has been further underscored by recent global events, such as the war in Ukraine and the escalating energy prices, which have prompted nations to re-evaluate their energy dependencies and accelerate their green initiatives.

Bulgaria, situated in the southeastern part of Europe, finds itself at a crucial juncture in this global movement. As a member of the European Union, Bulgaria is bound by the collective goals of the bloc, aiming for a carbon-neutral future by 2050. [1] However, the nation's journey towards this green future is intertwined with its unique socio-political and economic landscape. Historically, Bulgaria has grappled with challenges related to its energy sector, political transformations, and societal dynamics. Yet, the Green Transition presents both challenges and opportunities for the country. It offers a pathway to not only address environmental concerns but also to counter disinformation narratives, strengthen democratic processes, and resist foreign authoritarian influences.

This paper delves into Bulgaria's efforts in the Green Transition, examining its implications for societal security and exploring the multifaceted challenges and opportunities it presents. Through a comprehensive analysis, we aim to shed light on how Bulgaria navigates this global movement, aligning its national strategies with broader European objectives while addressing its unique challenges.

2. The Current State of Bulgaria's Green Transition

The Green Transition, while globally recognized as an essential pathway to a sustainable future, is perceived differently across nations, influenced by their unique socio-economic, political, and environmental contexts. In Bulgaria, the journey towards a greener future is marked by a blend of public perception, challenges, and potential opportunities.

2.1 Public Perception and Urgency of the Green Transition in Light of Global Events

Recent global events have significantly influenced the public perception of the Green Transition in Bulgaria. The war in Ukraine, coupled with soaring energy prices, has brought the urgency of the Green Transition to the forefront of public discourse. A survey

conducted by the European Investment Bank revealed that nearly two-thirds of Bulgarians believe that these events should act as a catalyst to accelerate the country's shift towards sustainable energy and eco-friendly practices. This sentiment underscores the growing awareness among Bulgarians about the intertwined nature of global geopolitics, energy security, and environmental sustainability. The prevailing circumstances have highlighted the vulnerabilities of over-reliance on non-renewable energy sources and the pressing need to diversify energy portfolios to ensure long-term security and stability. [2]

2.2 Challenges and Potential in Bulgaria's Green Transition

Bulgaria, with its picturesque landscapes, is at a pivotal juncture in its green transition. While the nation's natural beauty paints a serene picture, the reality of its sustainability efforts reveals a more complex scenario. Economic challenges, such as inflation and rising oil and gas prices, have forced some Bulgarians to revert to wood-burning stoves, as electricity and gas have become unaffordable for many. Additionally, the digital transition has been slow, with only 6% of small and medium businesses selling online, compared to the EU average of 17%. The Covid-19 crisis further strained the economy, causing a 4.2% decline in GDP and a 2.3% annual drop in employment.

However, the European Commission's Recovery and Resilience Plan offers a beacon of hope. Bulgaria is set to receive €6.27 billion in grants, with 58.9% of these funds targeting climate objectives and 25.8% promoting digital transition. This funding will support 56 investments and 47 reforms, all of which Bulgaria aims to implement by August 2026. The nation's rich renewable energy potential, particularly in solar power, is slated to receive significant investment, with plans to boost the use of renewable energy in households and support the construction of renewable energy sources and batteries. [3]

Going back to the complexities of the transition, the country's heavy reliance on coal, especially from the Bobov Dol and Pernik regions, has led to tensions between the need for energy security and the imperative to transition to cleaner energy sources. Protests by miners and energy workers, concerned about job losses and economic implications, have underscored the intricacies of balancing environmental goals with socio-economic realities. These challenges highlight the need for a just transition, ensuring that the shift towards sustainability does not leave behind vulnerable communities.

Addressing these challenges requires a holistic approach, encompassing policy reforms, investments in green skills training, and fostering public-private partnerships to drive the Green Transition while ensuring societal cohesion and security. [4]

3. Bulgaria's Agricultural Sector and the Green Transition

3.1 EU Funds for Bulgarian Agriculture: Emphasis on the Green Transition and Innovation

The European Union's commitment to sustainable agriculture is evident in its allocation of funds to member states, with Bulgaria being a prime beneficiary. As Bulgaria embarks on its journey towards sustainable agriculture, the EU's financial support plays a crucial role in shaping its green and digital transition.

For the period 2023-2027, Bulgaria is set to benefit from the EU's Recovery and Resilience Plan, which has earmarked a significant portion of its budget for the "Green Bulgaria" pillar. This includes an allocation of €2.6 billion, with a focus on sustainable agriculture. Under this initiative, Bulgaria aims to support at least 636 agricultural projects that emphasize technological and environmental modernization. This includes the establishment of centers for marketing and storage of fruits and vegetables, efficient water management, and the enhancement of breeding animal facilities. The total investment for these initiatives stands at €447.3 million, co-financed equally by the Recovery Resilience Plan and private entities.

Furthermore, the plan emphasizes the digitalization of agricultural processes. An investment of €12.2 million is allocated to establish a centralized electronic agricultural information system and a communication network of sensors to monitor soil and weather conditions. This initiative, managed by the Ministry of Agriculture, aims to streamline data flow and improve agricultural efficiency.

In addition to the Recovery Resilience Plan, Bulgaria's CAP strategic plan for 2023-2027 outlines investments in climate-smart agriculture and digitalization, with a total budget of approximately €3.5 billion. Key investments include €420 million for agricultural product processing, €148 million for environmentally-friendly product processing, €140 million for irrigation infrastructure, and €346 million for agricultural holdings. [5]

3.2 The Role of Agriculture in Bulgaria's Green Transition and the Potential for Sustainable Practices

Agriculture has historically been a cornerstone of Bulgaria's economy and societal fabric. As the country embarks on its Green Transition journey, the agricultural sector presents both challenges and opportunities. On the one hand, traditional farming practices, reliant on chemical inputs and intensive land use, pose environmental concerns. On the other hand, Bulgaria's diverse agro-climatic zones and rich biodiversity offer the potential for sustainable and organic farming.

Embracing sustainable agricultural practices is not merely an environmental imperative for Bulgaria but also a socio-economic one. Sustainable farming can lead to higher yields, improved soil health, and enhanced resilience against climate-induced uncertainties. Moreover, organic and eco-friendly products cater to a growing global demand, opening up lucrative markets for Bulgarian farmers.

In this context, initiatives such as agroforestry, conservation tillage, and integrated pest management can play a transformative role. By integrating trees into farmlands, agroforestry not only enhances biodiversity but also improves soil quality and reduces erosion. Conservation tillage, by minimizing soil disruption, aids in carbon sequestration and water conservation. Integrated pest management, by reducing the reliance on chemical pesticides, ensures healthier produce and minimizes environmental contamination.

And so, for Bulgaria, the Green Transition in agriculture is not just about environmental stewardship. It is about reimagining and revitalizing a sector that holds the promise of economic rejuvenation, societal well-being, and a sustainable future.

4. Bulgaria's Recovery and Resilience Plan

4.1 Overview of Bulgaria's Recovery and Resilience Plan as Proposed by the European Commission

The European Commission's Recovery and Resilience Facility (RRF) is a cornerstone initiative aimed at guiding European Union member states towards a sustainable and resilient post-pandemic future. Bulgaria, like other member states, has submitted its Recovery and Resilience Plan (RRP) to the Commission, outlining its strategies and priorities for utilizing the funds allocated under the RRF.

Bulgaria's RRP is a comprehensive document that encapsulates the nation's vision for a post-COVID-19 era. The plan is structured around several key components, each addressing a specific challenge and opportunity presented by the current socio-economic landscape. With an allocation of €6.3 billion in grants under the RRF, Bulgaria's plan is poised to make significant strides in various sectors, ranging from infrastructure and digitalization to education and healthcare.

A salient feature of Bulgaria's RRP is its alignment with the European Commission's country-specific recommendations. By addressing long-standing challenges such as improving the business environment, enhancing public administration, and fostering innovation, the plan aims to bolster Bulgaria's overall competitiveness and socio-economic resilience. [6]

4.2 The Plan's Emphasis on Environmental Sustainability and the Green Transition

Central to Bulgaria's RRP is its commitment to environmental sustainability and the Green Transition. Recognizing the existential threat posed by climate change and environmental degradation, the plan earmarks a significant portion of the allocated funds for green initiatives.

Specifically, Bulgaria's RRP emphasizes the need to accelerate the transition to a low-carbon and circular economy. This entails investments in renewable energy sources, energy efficiency measures, and sustainable transportation. The plan also underscores the importance of biodiversity conservation, sustainable land use, and water resource management.

Furthermore, the RRP acknowledges the socio-economic benefits of the Green Transition. By fostering green innovation, promoting eco-friendly industries, and creating green jobs, the plan envisions a future where environmental sustainability and economic prosperity go hand in hand. Such a holistic approach not only addresses the immediate environmental challenges but also ensures long-term societal security and well-being. [7]

5. Delving Deeper: Specific Hurdles and Emerging Innovations in Bulgaria's Green Journey

Bulgaria's path towards a sustainable future is characterized by a blend of challenges and innovative strides. While the nation confronts the intricacies of the Green Transition, it's crucial to delve into the specific obstacles it encounters and the pioneering initiatives that are shaping its green trajectory.

5.1 The U-turn in Bulgaria's Green Deal and its Implications

Bulgaria's initial enthusiasm towards the European Green Deal was met with a sudden U-turn, raising concerns about the country's commitment to environmental sustainability. The Green Deal, which aims to make Europe the first climate-neutral continent by 2050, requires member states to adopt ambitious measures to reduce carbon emissions and promote green technologies. However, Bulgaria's reluctance to fully embrace the deal stems from concerns about economic implications, particularly for its coal-dependent regions. This hesitation has led to tensions between Bulgaria and the European Union, with potential ramifications for the country's

access to EU funding and its standing in the international community. [8]

5.2 The Concept of a "Just Transition" in Bulgaria and its Significance

The idea of a "just transition" is gaining traction in Bulgaria, emphasizing the need to ensure that the shift towards a green economy is equitable and does not leave vulnerable communities behind. A report by the Center for the Study of Democracy highlights the importance of this concept, noting that the transition should be inclusive, taking into account the needs of workers, regions, and sectors most affected by the move away from fossil fuels. The report suggests that a just transition in Bulgaria would involve measures such as retraining programs for workers, investments in green technologies, and social safety nets to protect those at risk. The significance of this approach lies in its potential to foster social cohesion and prevent societal fractures that could arise from the green transition. [9]

5.3 Industry Innovations and Green Initiatives in Bulgaria's Transition

The recent energy crisis in Europe, coupled with geopolitical events such as the war in Ukraine, has significantly impacted the energy landscape. This has led to a shift in the perception of the "green premium," which was once used to denote the price difference between conventionally produced products and those that are eco-friendly. With the rising costs of fossil fuels, green technologies have become more economically viable than their conventional counterparts.

Bulgaria's industry is undergoing a notable transition towards greener practices. In the construction sector, innovations are being introduced to reduce the carbon footprint. For instance, Aurubis Bulgaria, a copper smelter, produces iron silicate as a by-product, offering an alternative construction material that promotes a circular economy. Cement production is also seeing a shift towards sustainability. Holcim Bulgaria, for example, operates predominantly on alternative fuel and has introduced composite cement brands that incorporate eco-friendly ingredients. Construction companies like Glavbolgarstroy emphasize regional raw material procurement and the use of photovoltaic installations on their sites, indicating a move towards more sustainable practices.

Large companies in Bulgaria are also making strides towards carbon neutrality. Notable firms like Tetrapak and Schneider Electric have adopted comprehensive strategies to manage and reduce their emissions, emphasizing a value chain approach to achieve significant emission cuts.

The potential of green hydrogen is also being explored with increasing interest. The rising costs of natural gas in the EU have made green hydrogen a more attractive alternative. While there's ongoing debate about the immediate steps to be taken—whether to invest in electrolyzers for green hydrogen production or to prioritize building renewables—it's evident that green hydrogen will play a pivotal role in the decarbonization of various sectors.

In light of these developments, Bulgaria's green transition is poised for acceleration. The combination of external factors, industry innovations, and the commitment of large corporations provides a promising foundation for the country's sustainable future. [10]

6. Conclusion

Bulgaria's journey in the Green Transition is emblematic of the broader challenges and opportunities faced by nations striving for a sustainable future. As we have explored throughout this paper, the country's path has been marked by both commendable strides and notable hesitations. From the public's perception of the urgency of the Green Transition in light of global events to the nation's agricultural sector's alignment with green objectives, Bulgaria has

showcased its potential to be at the forefront of environmental sustainability.

However, the road has not been without its bumps. The U-turn in Bulgaria's commitment to the Green Deal and the struggles faced in certain sectors underscore the complexities of balancing economic, societal, and environmental priorities. Yet, the concept of a "just transition" and the opportunities for accelerating the Green Transition highlight the nation's potential to navigate these challenges effectively.

Looking ahead, Bulgaria's future trajectory in the Green Transition will be pivotal not only for its environmental landscape but also for its societal security. The intertwined nature of environmental sustainability and societal cohesion cannot be overstated. As the world grapples with the dual threats of climate change and societal fractures, Bulgaria's continued efforts in the Green Transition will play a crucial role in ensuring a secure, cohesive, and prosperous future for its citizens.

In conclusion, while Bulgaria's journey in the Green Transition has been marked by both challenges and opportunities, its potential to lead in this domain is undeniable. With the right strategies, collaborations, and continued commitment, Bulgaria can set a benchmark for other nations in the quest for a sustainable and secure future.

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