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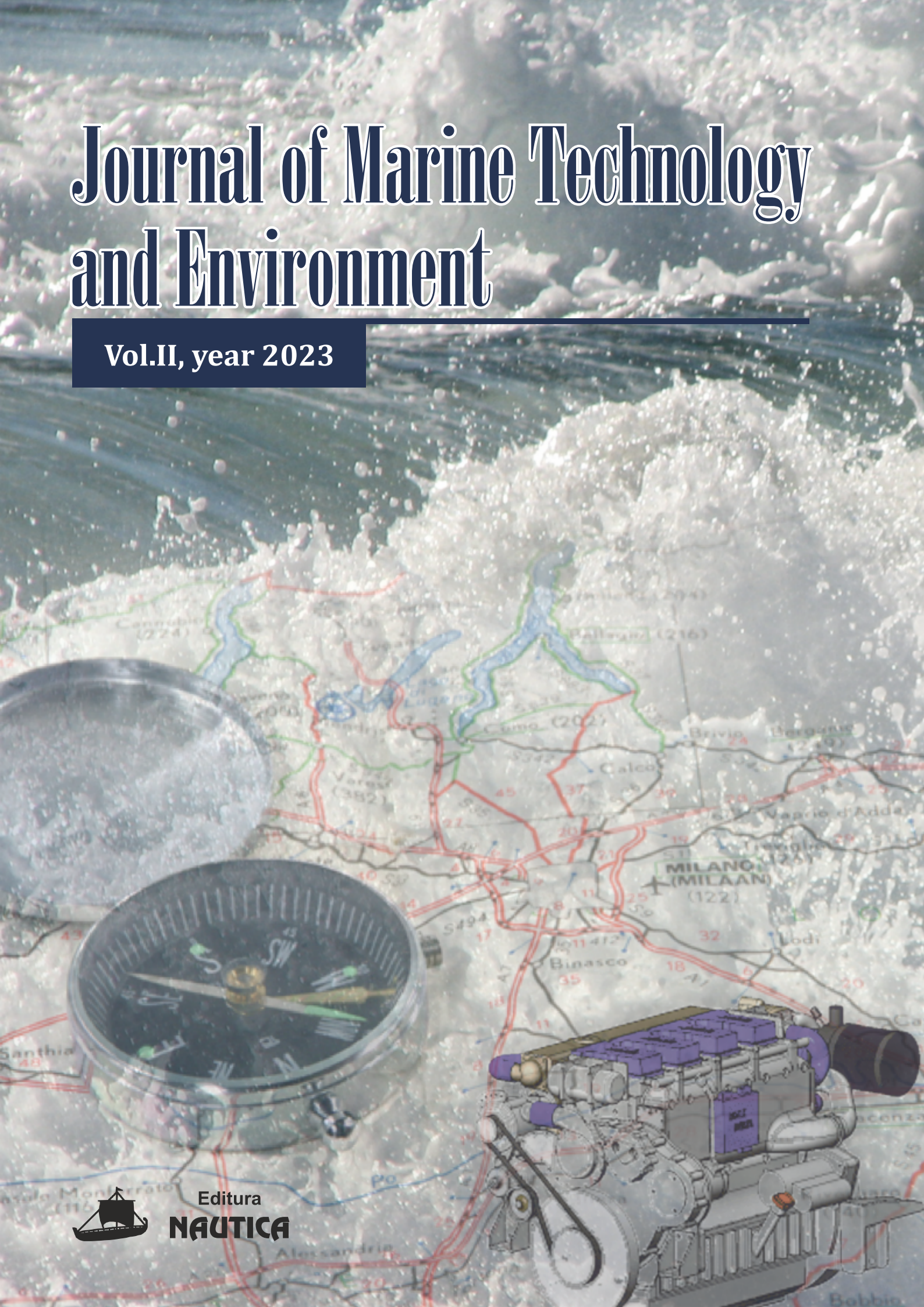

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THE ROLE OF SOCIAL MEDIA IN USER HEALTH

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Abstract: Human beings are social creatures. We need the company of others to thrive in life, and the power of our connections has a huge impact on our mental health and happiness. Being socially connected to others can alleviate stress, anxiety and depression, increase self-esteem, provide comfort and joy, prevent loneliness and even add years to your life. On the other hand, the lack of strong social connections can pose a serious risk to your mental and emotional health. In today's world, many of us rely on social media platforms like Facebook, Twitter, Snapchat, YouTube, and Instagram to find and connect with each other. While each has its benefits, it's important to remember that social media can never be a substitute for real-world human connection. It takes personal contact with others to trigger the hormones that relieve stress and make you feel happier, healthier, and more positive. Ironically, for a technology that's designed to bring people closer together, spending too much time interacting with social media can make you feel lonelier and more isolated — and exacerbate mental health issues like anxiety and depression. If you spend an excessive amount of time on social media and feelings of sadness, dissatisfaction, frustration or loneliness are affecting your life, it may be time to re-examine your online habits and find a healthier balance.
Key words: Fear of missing out, isolation, mental health, social media, virtual interaction.

1. POSITIVE ASPECTS OF SOCIAL MEDIA

While virtual interaction on social media doesn't have the same psychological benefits as face-to-face contact, there are still many positive ways it can help you stay connected and support your well-being.

Social media allows you to [1]:

• Communicate and stay updated with family and friends around the world.

• Find new friends and communities; network with other people who share similar interests or ambitions.

• Promote or join worthy causes - raising awareness of important issues.

• Seek or provide emotional support during difficult times.

• Find a vital social connection if you live in a remote area, for example, or have limited independence, social anxiety or are part of a marginalized group.

• Find an outlet for creativity and self-expression.

• Discover (carefully) valuable sources of information and learning.

The negative aspects of social media

Because it is a relatively new technology, there is little research to determine the long-term consequences, good or bad, of social media use. However, several studies have found a strong link between heavy social media and an increased risk of depression, anxiety, loneliness, self-harm and even suicidal thoughts.

Social media can promote negative experiences such as [2]:

1. Inadequacy about your life or appearance. Even if you know that the images you see on social media are manipulated, they can still make you feel insecure about how you look or what's going on in your own life. Similarly, we are all aware that other people tend to share only the highlights of their lives, rarely the low points that everyone experiences. But that doesn't lessen those feelings of envy and resentment when you scroll through a friend's airbrushed photos of their tropical beach vacation or read about their exciting new promotion at work.

2. Fear of missing out (FOMO) and social media addiction. While FOMO exists much longer than social media, sites like Facebook and Instagram seem to exacerbate feelings that others are having more fun or living a better life than you. The idea that you're getting away with things can hurt your self-esteem, trigger

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anxiety, and fuel even more social media use, just like an addiction. FOMO can compel you to pick up your phone every few minutes to check updates or compulsively respond to every alert — even if that means taking risks while driving, losing sleep at night, or prioritizing social media interaction. on real-world relationships.

3. Isolation. A study from the University of Pennsylvania found that heavy use of Facebook, Snapchat and Instagram increases, rather decreases, feelings of loneliness. Instead, the study found that reducing your use of social media can actually make you feel less lonely and isolated and improve your overall well-being.

4. Depression and anxiety. Human beings need face-to-face contact to be mentally healthy. Nothing reduces stress and boosts your mood faster or more effectively than eye-to-eye contact with someone who cares about you. The more you prioritize social media interaction over personal relationships, the more at risk you are for developing or worsening mood disorders such as anxiety and depression.

5. Cyberbullying. About 10% of teenagers report being bullied on social media and many more users are subjected to offensive comments. Social media platforms like Twitter can be hotspots for the spread of rumors, lies and hurtful abuse that can leave lasting emotional scars.

6. Self-absorption. Sharing endless selfies and all of your innermost thoughts on social media can create unhealthy self-centeredness and distance you from real-life connections.

2. WHAT MOTIVATES YOU TO USE SOCIAL NETWORKS?

These days, most of us access social media via smartphones or tablets. While this is very easy to do and will help you stay in touch, it also means that social media is always accessible. This 24/7 hyper-connectivity can trigger impulse control issues, constant alerts and notifications that affect your focus and concentration, disrupt your sleep and make you a slave to your phone.

Social media platforms are designed to capture your attention, keep you online and repeatedly check your screen for updates. This is how companies make money. But like a gambling compulsion or an addiction to nicotine, alcohol or drugs, social media use can create psychological cravings. When you get a like, share, or favorable reaction to a post, it can trigger the release of dopamine in your brain, the same "reward" chemical you're about to win a slot machine, grab a bite of chocolate, or light up, pick up a cigarette, for example. The more rewarded you are, the more time you want to spend on social media, even if it becomes detrimental to other aspects of your life.

3. OTHER CAUSES OF UNHEALTHY USE OF SOCIAL NETWORKS

A fear of missing out (FOMO) can keep you coming back to social media again and again. Even though there are very few things that can't wait or need an immediate response, FOMO will have you believe otherwise [2].

Maybe you're worried that you'll be left out of the conversation at school or work if you miss the latest news or social media gossip? Or maybe you feel like your relationships will suffer if you don't immediately like, share, or reply to other people's posts?

Or you might be worried about missing out on an invitation or that other people feel better than you. Many of us use social media as a "security blanket". Whenever we are in a social situation and feel anxious, embarrassed, or lonely, we turn to our phones and connect to social

media. Of course, interacting with social media only denies you the face-to-face interaction that can help alleviate anxiety.

Heavy social media use could mask other underlying problems, such as stress, depression or boredom. If you spend more time on social media when you're feeling down, lonely, or bored, you may be using it as a way to distract yourself from unpleasant feelings or calm your mood.

Although it can be difficult at first, allowing yourself to feel can open you up to finding healthier ways to manage your mood.

The Vicious Cycle of Unhealthy Social Media Use Excessive social media use can create a self-perpetuating negative cycle:

1. When you're feeling lonely, depressed, anxious, or stressed, you use social media more often — as a way to escape boredom or feel connected to others.
2. Using social media more often, however, increases FOMO and feelings of inadequacy, dissatisfaction, and isolation.
3. In turn, these feelings negatively affect your mood and worsen symptoms of depression, anxiety and stress.
4. These worsening symptoms cause you to use social media even more and so the downward spiral continues.

4. SIGNS THAT SOCIAL MEDIA IS AFFECTING YOUR HEALTH

Everyone is different, and there's no set amount of time you spend on social media, or how often you check for updates, or the number of posts you make that indicates your use is becoming unhealthy. Rather, it has to do with the impact your time on social media has on your mood and other aspects of your life, along with your motivations for using it.

For example, using social media can be problematic if it causes you to neglect face-to-face relationships, distracts you from work or school, or leaves you feeling envious, angry, or depressed. Similarly, if you're only motivated to use social media

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because you're bored or lonely, or you want to post something to make others jealous or angry, it may be time to reevaluate your social media habits.

Indicators that social media may be negatively affecting your health include [3]:

1. Spend more time on social media than with real-world friends. Using social media has become a substitute for much of your offline social interaction. Even if you go out with friends, you still feel the need to constantly check social media, often driven by feelings that others can have more fun than you.

2. Comparing yourself unfavorably to others on social media. You have low self-esteem or a negative body image. You may even have disordered eating patterns.

3. Face cyberbullying. Or you worry that you have no control over the things people post about you.

4. Being distracted at school or work. You feel pressure to post regular content about yourself, get comments or likes on your posts, or respond quickly and enthusiastically to friends' posts.

5. Not having time for self-reflection. Every free moment is filled with social media interaction, leaving little or no time to reflect on who you are, what you believe, or why you behave the way you do—the things that allow you to grow as a person.

6. Engaging in risky behavior to get likes, shares or positive reactions on social media. Make dangerous pranks, post embarrassing material, cyberbully others, or access your phone while driving or in other unsafe situations.

7. You suffer from sleep problems. Do you check social media last thing at night, first thing in the morning or even when you wake up at night? Light from phones and other devices can disrupt your sleep, which in turn can have a serious impact on your mental health.

8. Worsening of symptoms of anxiety or depression. Instead of helping to alleviate negative feelings and boost your mood, you feel more anxious, depressed or lonely after using social media.

5. CHANGING SOCIAL MEDIA USE TO IMPROVE HEALTH

Step 1: Reduce online time.

A 2018 study by the University of Pennsylvania found that reducing social media use to 30 minutes a day resulted in a significant reduction in levels of anxiety, depression, loneliness, sleep problems, and FOMO. But you don't have to drastically reduce your social media usage to improve your mental health. The same study concluded that just being more mindful of social media use can have beneficial effects on mood and focus.

While 30 minutes a day may not be a realistic target for many of us, we can still benefit from reducing the time we spend on social media. For most of us, that means cutting back on how much we use our smartphones. The following tips may help [4]:

a. Use an app to track how much time you spend on social media each day. Then set a goal for how much you want to reduce it.

b. Turn off your phone at certain times of the day, such as when you're driving, in a meeting, at the gym, eating dinner, hanging out with friends offline, or playing with your kids. Don't take your phone with you to the bathroom.

c. Don't bring your phone or tablet to bed. Turn off the devices and leave them in another room overnight to charge.

d. Turn off social media notifications. It's hard to resist the constant buzzing, beeping, and beeping of your phone alerting you to new messages. Turning off notifications can help you regain control of your time and focus.

e. Border checks. If you're compulsively checking your phone every few minutes, eliminate yourself by limiting your checks to once every 15 minutes. Then once every 30 minutes, then once an hour. There are apps that can automatically limit when you can access your phone.

f. Try removing social media apps from your phone so you can only check Facebook, Twitter and the like from your tablet or computer. If that seems like too drastic a step, try removing one social media app at a time to see how much you miss it.

Step 2: Change your focus.

Many of us go on social media just out of habit or to mindlessly kill downtime. But by focusing on the motivation to connect, you can not only reduce the time you spend on social media, but you can improve your experience and avoid many of the negative aspects.

If you go to social media to find specific information, check in on a friend who's been sick, or share new photos of your kids and family, for example, your experience is likely to be very different than if you connect simply because you -you're bored, want to see how many likes you got from a previous post or check if you missed something.

The next time you access social media, pause for a moment and clarify your motivation for doing so.

Do you use social media as a substitute for real life?

Is there a healthier substitute for using social media?

If you are alone, for example, invite a friend for coffee.

Are you feeling depressed? Take a walk or go to the gym.

Bored? Take up a new hobby.

Social media can be quick and convenient, but there are often healthier and more effective ways to satisfy a craving.

Are you an active or passive social media user? Passively scrolling through posts or anonymously watching others interact on social media provides no meaningful sense of connection. It can even increase

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feelings of isolation. Being an active participant, however, will give you more engagement with others.

Does social media leave you feeling inadequate or disappointed in your life? You can counteract the symptoms of FOMO by focusing on what you have rather than what you lack.

Make a list of all the positive aspects of your life and read it back when you feel like you're missing out on something better. And remember: no one's life is ever as perfect as it looks on social media.

We all deal with heartache, self-doubt, and disappointment, even if we choose not to share them online.

Step 3: Spend more time with offline friends.

We all need the face-to-face company of others to be happy and healthy. At its best, social media is a great tool to facilitate real-life connections. But if you've allowed virtual connections to replace real-life friendships in your life, there are plenty of ways to build meaningful connections without relying on social media.

Set aside time each week to interact offline with friends and family. Try to make it a casual date where you always keep your phones off.

If you've been neglecting face-to-face friendships, reach out to an old friend (or an online friend) and arrange to meet up. If you both lead busy lives, offer to run errands or exercise together.

Join clubs. Find a hobby, creative endeavor, or fitness activity that you enjoy and join a group of people who meet regularly.

Don't let social reactions get in the way. Even if you're shy, there are proven techniques to overcome insecurities and build friendships.

If you don't feel like you have someone to spend time with, reach out to acquaintances. Many other people are just as uncomfortable making new friends as you are – so be the one to break the ice. Invite a colleague to lunch or ask a neighbor or classmate to join you for coffee.

Interact with strangers. Look up from your screen and connect with the people you cross paths with on public transport, at the coffee shop or in the grocery store. Simply smiling or saying hello will improve the way you feel – and you never know where it might lead [5].

Step 4: Express gratitude.

Feeling and expressing gratitude for the important things in your life can be a welcome relief from the resentment, animosity, and dissatisfaction that social media sometimes breeds.

Take time for reflection. Try keeping a gratitude journal or using a gratitude app. Keep track of all the great memories and positive aspects of your life, as well as those things and people you would miss if they suddenly disappeared from your life. If you're more prone to venting or negative posts, you can even express your gratitude on social media, although you may benefit more from private reflection that isn't subject to the scrutiny of others.

6. CONCLUSIONS

Experiencing FOMO and comparing yourself unfavorably to others causes you to dwell on life's disappointments and frustrations. Instead of being fully engaged in the present, you're focused on the "what ifs" and "if only" that prevent you from having a life that matches the ones you see on social media. By keeping your mind occupied, you can learn to live more in the present moment, reduce the impact of FOMO, and improve your overall mental well-being.

Voluntary. Just as human beings are ready to seek social connection, we are also ready to give to others. Helping other people or animals not only enriches your community and benefits a cause that is important to you, but also makes you feel happier and more grateful.

The most affected by the use of social networks are children.

Help a child or teen with unhealthy social media use.

Encourage offline exercise and interests.

Get them away from social media by encouraging them to pursue physical activities and hobbies that involve real-world interaction.

Exercise is great for relieving anxiety and stress, boosting self-esteem and improving mood – and it's something you can do as a family.

The more engaged they are offline, the less their mood and sense of self-worth will depend on how many friends, likes or shares they have on social media.

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GREEN SHIPPING. STUDY ON REGULATIONS AND SUSTAINABLE OPTIONS FOR DECARBONISATION

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Abstract: The maritime sector is responsible for more than 90% of world trade. This generates increasing international shipping fleet, that means significant contribution to environment pollution. In this context, appears the need for a cleaner maritime transport, a green one. The paper presents the concepts of "green shipping", "eco-ship" and regulations that must be respected in relation to environment protection. This study highlights also the IMO's regulations for green shipping, as IMO is the most important organization that support the reduction of greenhouse gas emissions from ships. The work examines briefly few options for decarbonisation in shipping, outlining the role of government policies, for huge investments in new and clean technologies and, also, in infrastructure for the production, distribution and utilisation of alternative marine fuels and biofuels.
Key words: ammonia, decarbonisation, fuel, green shipping, greenhouse gas emissions, ships .

1. INTRODUCTION

Transportation is an essential sector of activity in a society. It influences the level of development in a country and the life quality of its citizens. Every open economy uses all means of transport to interact with other economies, especially on trade issues. Almost 90% of international trade is possible due to maritime transportation. Beside positive effects of transportation on the economy and the society, as a whole, there must be mentioned the negative effects of this activity, especially on the environment, through greenhouse gas emissions.

Shipping is responsible for over 10% of transport CO_2 emissions and if its environmental impact is growing in this pace, shipping could double its greenhouse gas emissions by 2050. In order to reduce shipping's impact on climate change, international institutions elaborate and adopt regulation in this framework. One of the most important institution, The International Maritime Organization (IMO), adopted different conventions, amendments and measures, presented in this paper, addressing the minimisation of CO_2 emissions from international shipping. The applying of these regulations globally can lead to a cleaner maritime transportation, so called "green shipping".

2. LITERATURE REVIEW

Specialized literature in the field define Green Shipping like "the use of resources and energy to transport people and goods by ship and concerns the reduction in such resources and energy in order to preserve the global environment from greenhouse gases and environmental pollutants generated by ships".[11]

Green shipping is a sustainable maritime transport. This kind of transport demands eco-friendly means of transport. An *eco-ship* or *green ship* is a vessel that use alternative fuels and the most developed technologies for fuel savings, in order to reduce greenhouse gas emissions.

Green shipping must respect all IMO's regulations related to environment protection, such as: MARPOL 73/78, the Ballast Water Management Convention, the Ship Recycling Convention, the Anti-fouling Systems Convention. Emission guidelines of IMO are in force since 2020 and new guidelines for ballast water in 2022. IMO and European Union are the driving forces behind green shipping.

Other authors define Green Shipping like an "efficient marine transport with minimal health and ecological damage" [13] or the efficient transport "in controlling pollution emissions and in achieving a more friendly environment"[10] According to Felicio, J.A., Rodrigues, R. and Caldeirinha , V.,, Green Shipping refers to "the set of practices and eco-environmental efficiency adopted in shipping, including the improvement of procedures and technological innovations for environmental sustainability and trade, while encouraging ecopreneurship"[1].

The transition to the green shipping is possible only by minimising the greenhouse gas emissions. An effective way of reducing emissions is to use alternative fuels, for example, liquid natural gas (LNG), which produces almost none of the pollutants. Due to this reason, the European Commission is encouraging the use

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of LNG for shipping activity and is forcing all major ports from European Union to provide facilities for LNG supply. [7]

3. IMO'S REGULATIONS FOR GREEN SHIPPING

If necessary measures are not taken to make the transition to green shipping, the specialists' predictions are that the greenhouse gas emissions from maritime sector will be triple by 2050. In this context, we mention the amendments to MARPOL Annex VI, adopted by IMO in 2011, which regulates technical and operational energy efficiency measures to decrease the value of CO_2 emissions from international shipping. This has taken the form of Energy Efficiency Design Index (EEDI), that entered into force in 2013.

The EEDI requires all new ships built globally to meet a minimum level of fuel efficiency related to a baseline. A large share of new-build ships in 2017 already complies with the 2025 standard – 30% more efficient for ships delivered after 2025.[12] It is anticipated that by 2030, application of the EEDI will generate a decrease of global greenhouse gas ship emissions of 10-20 %, only if new more fuel efficient ships replace those taken out of service.

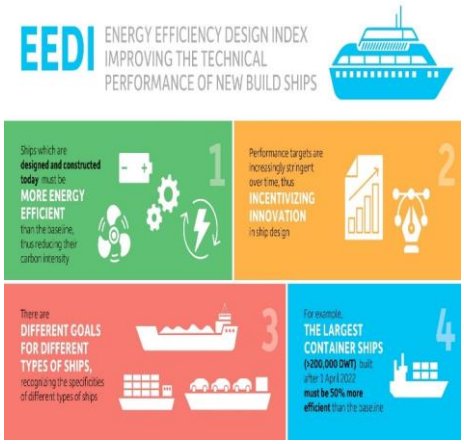

Figure 1 Main characteristics of IMO's EEDI [14]

The IMO has also agreed the Ship Energy Efficiency Management Plan (SEEMP) for new and existing ships, establishing best practices for fuel efficient operation of ships.

There are several measures that can be taken to achieve the required EEDI, such as: reducing installed engine power, hull, propeller and propulsion system improvements, waste heat recovery, air lubrication, the use of wind power- sails, kites and so on.[12]

EEDI is the first globally-binding climate change measure applying to the transport field.

2023 IMO Greenhouse Gas Strategy is the latest essential contribution of the International Maritime Organization to global efforts of minimising greenhouse gas emissions from international shipping, having in view the goals of Paris Agreement and SDG13 from the United Nations 2030 Agenda for Sustainable Development, regarding "urgent action to combat climate change and its impact".[8]

The main targets of the 2023 IMO Greenhouse Gas Strategy are:

- To decline carbon intensity of the ship through further improvement of the energy-efficiency for new ships;
- To decrease CO_2 emissions of international shipping per transport work by at least 40% by 2030, compared to 2008;
- To obtain net zero or near-zero greenhouse gas emissions from international shipping, through the intensive use of clean technologies, alternative fuels, biofuels.

There are many relevant IMO initiatives that support the reduction of greenhouse gas emissions from ships. One of these is the Global Maritime Technologies Cooperation Centres Network project, with support from the European Union and a value of approximately 11 million USD for the period 2016-2022.[8] This project established five Maritime Technologies Cooperation Centres in China, Fiji, Kenya, Panama, Trinidad and Tobago, with the main goal to support maritime decarbonisation in the respective regions.

The Green Voyage 2050 is another project, supported by Norway, with a value of 7,1 million USD for the period 2019-2023.[8]The aim of the project is to guide partnering countries to make assessments of maritime emissions at national level, in order to develop national action plans and to implement MARPOL Annex VI. They are also supported in the identification and implementation of low and zero-carbon pilot projects on board ships and in ports.

Another relevant project is the Greenhouse Gas – SMART Programme (Sustainable Maritime Transport Training Programme to Support the Implementation of the GHG Strategy), with a value of 2,5 million USD, for the period 2020-2025, funded by the Republic of Korea. [8] This project includes a series of annual training programmes online, followed by individual training plans, a practical training and study visit, combined with an opportunity of two trainees (one female and one male, with equal chances) to benefit from a World Maritime University scholarship.

In essence, all the projects initiated under the IMO emblem seek to find the most effective solutions, both from an economic, technological, political, legislative and social point of view, to obtain a green shipping.

4. SUSTAINABLE SOLUTIONS FOR DECARBONISATION IN SHIPPING

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Decarbonisation in the maritime industry is possible mainly due to the use of alternative fuels. First of all, LNG is an alternative fuel option for ships. Using LNG as a fuel will reduce CO_2 by 20%, along with considerably decreasing SO_x and NO_x.

Among the available maritime fuel options for decarbonisation, ammonia (NH_3) is identified as a zero-carbon fuel that can enter the global market relatively quickly and help meet the greenhouse gas reduction target for 2050 set by the International Maritime Organization. [15] Ammonia is a versatile fuel for stationary power and heat and for maritime transport that can be used in internal combustion engines, gas turbines, industrial furnaces, generator sets and fuel cells. [6]

Worldwide production of ammonia was 183 million tonnes (Mt) in 2020 and existing markets are expected to increase demand to 223 Mt by 2030 and reach 333 Mt by 2050 in a $1,5^0$C scenario. [6] New markets for ammonia are expected to develop in the next decades, especially as a fuel for maritime sector. The perspectives of the development and use of this type of fuel determined the appearance of the first ammonia-fuel vessel in the world, "Kriti Future". It is a crude oil tanker of 149987 t DWT, built in 2022 and is sailing under the flag of Greece. The vessel meets the ABS LNG Fuel Ready Level 1 and ABS Ammonia Ready Level 1 requirements, being designed to be converted to run on ammonia in the future.

Even if ammonia is a hazardous chemical, there are strong commitments from ship owners, operators, ports and classification societies to identify risks, to elaborate strategies and to promote clean energy technologies, in order to ensure that the use of ammonia as a fuel complies with the existing safety standards. Many classification societies, like Bureau Veritas, American Bureau of Shipping, Lloyds Register, Korean Register, Class NK have recently produced documents for the future ammonia code. Also, the Port of Singapore serves as a living laboratory with a physical and digital test environment to develop safe bunkering procedures for ammonia and gain operational experience. [6]

A first step to decarbonise shipping is to convert ammonia tankers to use ammonia as a fuel. Ammonia is not yet approved as a fuel by the IMO and for now, every ship needs individual approval to use this chemical. The support of a flag state can aid to introduce ammonia as a fuel, similar to the case of methanol as a fuel. As ammonia-fuelled vessels are expected to be operating at sea by 2024 or 2025, maritime engine manufacturers expect to commercialise ammonia-fuelled two-stroke and four-stroke engines for new builds and retrofits. [6]

Ammonia is considered as one of the dominant options for the maritime sector, as it is already available at a relevant scale with international port infrastructure in place [9]. To outline again the importance of ammonia in the process of reduction greenhouse gas emissions from shipping, we can see a comparison of properties for various fuels in the table below, where: HFO- Heavy fuel oil, LNG- Liquefied natural gas, LPG- Liquefied petroleum gas,CBR- Corvus , battery rack, Tesla 3- Tesla model 3 battery cell 2170 .

Table 1 Physical and chemical fuel properties for international shipping [6]

Fuel	Supply energy (MJ/kg)	CO_2 emission from complete combustion (g/km)	SO_x emission from complete combustion (g/km)
HFO	40,5	49	0,36
LNG	50	37	0,02
LPG	46	-	-
Methanol	19,9	43	0,02
Ethanol	26	-	-
Ammonia	18,6	0	0
Hydrogen	120	0	0
CBR	0,29	0	0
Tesla3-2170	0,8	0	0

While ammonia is expected to become the dominant fuel for decarbonised deep sea shipping, other biofuels, like methanol and hydrogen may be used for passenger ships and large ferries. Compared to methanol, ammonia has an advantage, due to lower cost of nitrogen purification versus CO_2 purification. But, there are certain limits regarding the use of ammonia as a fuel and hydrogen carrier, related with ammonia infrastructure, that requires huge annual investment in storage and transport assets. Renewable ammonia represents another sustainable solution of decarbonisation for industries and especially, maritime industry. It is produced from renewable hydrogen, which in turn is produced through water electrolysis using renewable electricity. This kind of hydrogen is converted into ammonia, using nitrogen that is separated from air. In the long term, renewable ammonia is likely to become the main commodity for transporting renewable energy between continents. [6] Around 80 Mt of existing ammonia production capacity constitutes an early opportunity for decarbonisation. Each year, 18-20 Mt is transported by ship, 170 vessels being in operation with ammonia, of which 40 carry ammonia on a continuous basis. [3][4] Cost-competitive renewable ammonia can have an important contribution to a global sustainable objective – 70% reduction of the world's energy-related CO_2 emissions by 2050 [5].

In order to achieve this goal, the support of governments is needed. They must establish decisive, predictable policies and solid mechanisms regarding investments in the field of renewable energy technologies and standards related to fuels used by industry.

Through an appropriate policy framework, stakeholders can focus on implementing existing renewable ammonia technologies at scale, retrofit

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technology towards renewable ammonia production and re-asses the role of ammonia in hydrogen strategies, having in view its potential as a fuel and hydrogen carrier. [6],[16]

5. CONCLUSIONS

For a long time, the lack of concrete actions in the field of environmental protection turned maritime transport into one of the biggest producer of greenhouse gas emissions, considering its contribution to the development of international trade. In order to reduce shipping's impact on climate change, the International Maritime Organization offers efficient instruments, which regulate technical and operational energy efficiency measures to decarbonize international shipping, turning it into a green shipping, with eco-friendly vessels. Green ships use alternative fuels, like LNG or biofuels, like hydrogen, methanol, ammonia. First ammonia-fuelled vessels are expected to be operating at sea by 2024 or 2025. Renewable ammonia represents another sustainable option for decarbonisation of maritime transport, opening new markets for ammonia as a fuel in the future. To realise a safe and efficient transition to green shipping, strong, stable, predictable, investment-encouraging governmental policies to reduce GHG emissions are needed.

6. ACKNOWLEDGMENTS

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FOUR-BAR MECHANISM FOR A PORTAL CRANE: A BRIEF OVERVIEW

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Abstract: The present article aims to increase knowledge of a four-bar mechanism. A four-bar system is a planar mechanism. There are many types of simple mechanisms, such as: Chebyshev, Chebyshev lamda, Hoecken, Roberts, Watt's, Grasshopper, horse-head, pantograph and Peaucelier. More complex mechanisms are: Stewart platform or Jansen's linkage. The determination of the degrees of freedom (DOF) for a system is done using the Chebychev-Gruebler-Kutzbach relationship. Due to this fact, the DOF for the four-bar system has the value one. Moreover, we analyze the following angles: θ, α, β and $\varphi_3$in the mechanism. Finally, using Matlab software the drawing and the dynamic simulation of a four-bar mechanism is carried out. Besides, the dynamic simulation is represented after 3s, 6s and 12s.

Key words: mechanism, linkage, DOF, angle, triangle.

1. INTRODUCTION

There are various mechanical mechanisms. These mechanisms can be: planar, spherical and spatial. In this paper, we studied just one system which is a planar mechanism.

The simplest mechanism known are: Chebyshev, Chebyshev lambda, Hoecken, Roberts, Watt's, Grasshopper, horse-head, pantograph and Peaucelier, Fig.1.

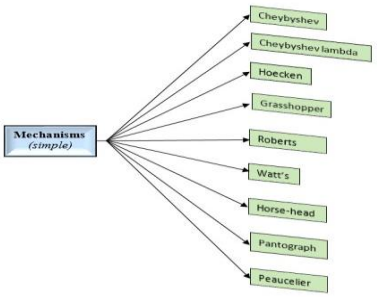

Figure 1 Simple mechanisms

Only Peaucelier and Grasshopper systems are exact straight-line mechanisms, [1].

There are also more complex mechanisms, such as: Stewart platform or Jansen's linkage.

In the field of mechanisms, a four-bar link is the simplest closed-chain movable link. It consists of four bodies, called bars of links. These bars are connected in a loop by four joints or pivots.

The four-bar mechanisms are widely used in various fields: medicine, research, education, transport, agriculture, industry, [2].

The movements of these systems is usually controlled and predictable, such as: rotation, oscillation and translation, Fig.2.

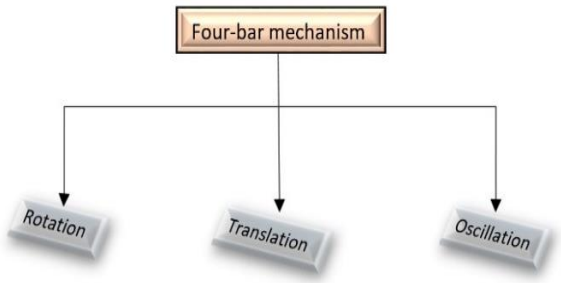

Figure 2 The movements of four-bar mechanism

2. STUDY ABOUT FOUR-BAR MECHANISM

In mechanical engineering, DOF is a number of independent motions that are allowed to the body. In the case of a mechanism made of several bodies, DOF represents the number of possible independent relative motions between the pieces of the system.

DOF is mostly studied in industrial robotics, [3]

The Chebychev-Gruebler-Kutzbach formula determines the number for degrees of freedom:

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$$DOF = 3(l-1) - 2j \quad (1)$$

Where:

- DOF – degrees of freedom.
- l – number of links.
- j – number of joints

Then, DOF of the four-bar linkage can be calculated as follows:

$$DOF = 3(4-1) - 2 \cdot 4 = 3 \cdot 3 - 2 \cdot 4 = 9 - 8 = 1 \quad (2)$$

Where:

- l = four links.
- j = four joints.

The conditions of mechanisms and structures are:

- DOF > 0, it is a mechanism.
- DOF = 0, it is a structure.
- DOF < 0, it is a preloaded structure.

From relation 2, DOF of the four-bar linkage is mechanism is 1, according to the conditions above,

A four-bar linkage is a mechanism having four rigid bars, Fig. 3:

- Frame is a fixed bar → l_1.
- Crank (driver) is one rotate bar → l_2.
- Connecting rod (coupler) is a floating link → l_3.
- Rocker (follower) is other rotating bar → l_4.

The connecting rod, however, does not rotate around a fixed center, [4].

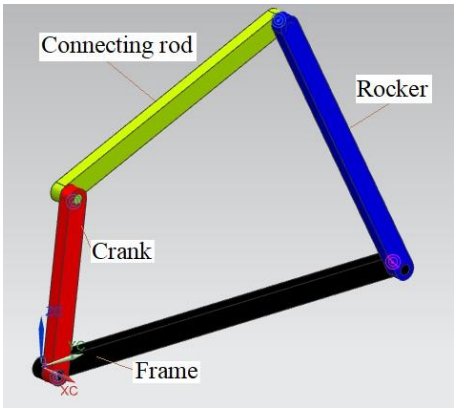

Figure 3 The linkages of mechanism

Furthermore, we studied the angles from a four-bar mechanism, Fig. 4.

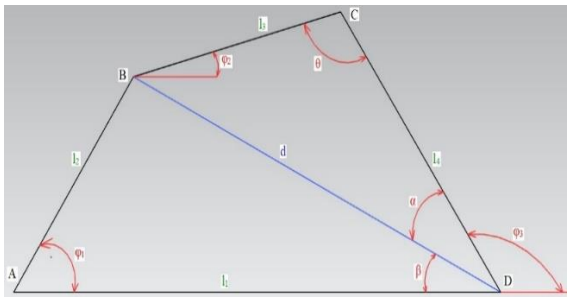

Figure 4 Angles from four-bar mechanism

By applying the law of cosine to triangle ΔABD, [5]:

$$d^2 = l_1^2 + l_2^2 - 2l_1 l_2 cos\varphi_1 \quad (1)$$

Also, applying the law of cosine to triangle ΔBCD:

$$d^2 = l_3^2 + l_4^2 - 2l_3 l_4 cos\theta \quad (2)$$

Therefore,

$$l_1^2 + l_2^2 - 2l_1 l_2 cos\varphi_1 = l_3^2 + l_4^2 - 2l_3^2 l_4^2 cos\theta \quad (3)$$

And

$$\theta = cos^{-1}\left(\frac{l_3^2+l_4^2-l_1^2-l_2^2+2l_1 l_2 cos\varphi_1}{2l_3 l_4}\right) \quad (4)$$

Where:

- φ_1 – input angle.
- θ - transmission angle (this angle is only a function of the input angle φ_1).

In the triangle ΔBDC, the angle α is determined with the relationship:

$$\alpha = cos^{-1}\left(\frac{d^2+l_4^2-l_3^2}{2dl_4}\right) \quad (5)$$

In the triangle ΔABD, the angle β is determined with the relationship:

$$\beta = cos^{-1}\left(\frac{d^2+l_1^2-l_2^2}{2dl_1}\right) \quad (6)$$

The last relationship is, [6]:

$$\varphi_3 = 180^0 - (\alpha + \beta) \quad (7)$$

We used Matlab program to model a four-bar mechanism and then to simulate the dynamic behaviour of that system, Fig. 5.

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```
% Calculations of angles and coordinates
for i = 1:length(theta)
    G(i) = atan((a*sin(T(i)))/(d-a*cos(T(i))));
    Phi(i) = acos((f(i).*f(1,i)+b*b-c*c)/(2*b*f(i)))-G(i);
    X(i) = a*cos(T(i))+e*cos(ar+Phi(i));
    Y(i) = a*sin(T(i))+e*sin(ar+Phi(i));
    hold on;
    title('Four bar mechanism');
    xlim([-50,110]);
    ylim([-50,110]);
    plot(X,Y,'b', 'LineWidth', 1);

    Cx = [0 a*cos(T(i)) b*cos(Phi(i))+a*cos(T(i)) d a*cos(T(i))+e*cos(Phi(i)+ar)];
    Cy = [0 a*sin(T(i)) b*sin(Phi(i))+a*sin(T(i)) 0 a*sin(T(i))+e*sin(Phi(i)+ar)];

    link_l1 = line([0 ,Cx(2)], [0 ,Cy(2)], 'LineWidth',4, 'Color', 'r');
    link_l2 = line([Cx(2) ,Cx(3)], [Cy(2) ,Cy(3)], 'LineWidth',4, 'Color', 'g');
    link_l3 = line([Cx(3) , d], [Cy(3) , 0], 'LineWidth',4, 'Color', 'b');
    link_l4 = line([0 , d], [ 0 , 0], 'LineWidth',4, 'Color', 'k');
      % Animation of mechanism
    pause(0.08);
    delete(link_l1);
    delete(link_l2);
    delete(link_l3);
    delete(link_l4);
end
```

Figure 5 Calculations of angles and coordinates

In this paper, the complete Matlab code built on top of the 41-line code, [7].
In the manuscript, a dynamic analysis was performed at three different time periods: 3s, 6s and 12s.
The simulation of a four-bar mechanism after three seconds is presented below, Fig. 6.

Figure 6 Four-bar mechanism after 3s

After that, the simulation of a four-bar mechanism after six seconds is presented below, Fig. 7.

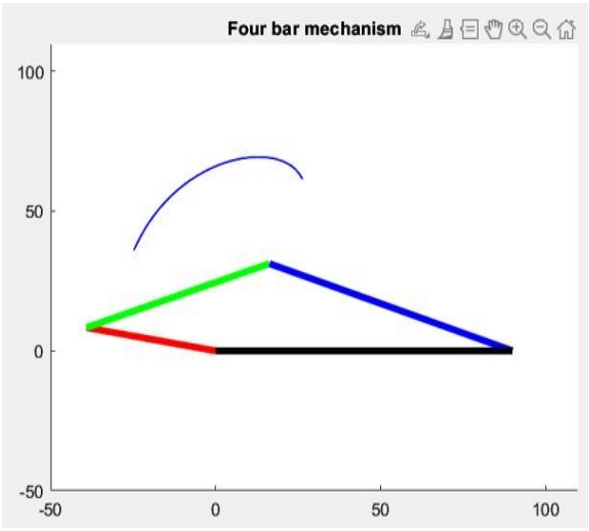

Figure 7 Four-bar mechanism after 6s

In finally, the simulation of a four-bar mechanism after twelve seconds is presented below, Fig. 8.

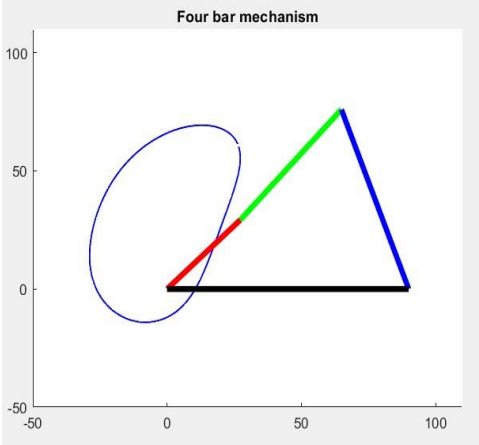

Figure 8 Four-bar mechanism after 12s

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4. CONCLUSIONS

The four-bar mechanism occurs in many applications, such as in: robotics, automotive, pump jack, etc. Besides that, there are several advantages in using four-bar mechanisms:

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- They are relatively simple, easy to design and manufacture, which can make them cost-effective and reliable.
- These systems have a large range of motion and can be used to create complex positions and movements.
- The systems can be used to create a variety of different configurations, such as crossed, hinged or parallel, which can be useful for different applications.
- The devices are relatively robust and can withstand high loads, making them suitable for use in a variety of applications.

However, in specialized universities, students must use various software (i.e. Nx Siemens, Solidworks, Autodesk Inventor, PTC Creo, etc.) to study four-bar.

In the future, we intend to develop a study of the four-bar mechanisms, especially constructed with linkages made of aluminum. This analysis will also include velocity and acceleration analysis.

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SEARCH AND RESCUE AUTONOMOUS VESSEL

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Abstract:Search and rescue operations in maritime environments are critical for saving lives and ensuring the safety of individuals in distress. The advancement of autonomous technologies has led to the development of Search and Rescue Autonomous Vessels (SRAVs), which have the potential to revolutionize the efficiency and effectiveness of such operations. This paper presents an example of the design, capabilities, and challenges associated with SRAVs. The integration of various sensors, communication systems, and artificial intelligence algorithms allows these vessels to navigate autonomously, detect and identify distress signals, locate survivors, and provide immediate assistance. Also, there are presented results from testing the SRAV and future development perspective.
Key words: AI, autonomous vessel, distress, GMDSS, search and rescue.

1. INTRODUCTION

As maritime activities continue to expand across the globe, the need for efficient and reliable search and rescue operations has become paramount. From distress signals emanating from remote corners of the ocean to emergencies unfolding in the midst of bustling shipping lanes, the GMDSS serves as the lifeline connecting those in distress with the rescuers who stand ready to provide aid. Within this framework, Search and Rescue Vessels play a pivotal role in bridging the gap between the call for help and the delivery of assistance.

The main purpose of the proposed system is represented by the continuous search of Romania's interest zone for any possible naval accidents which resulted with victims, in order to save them efficiently and with a short reaction time. This system is developed as a way of eliminating human error and in addition it becomes benefic for the saviors, because this system can be operated autonomously and remotely, resulting in safer working conditions for them. Regarding the stage of realization in production, there are several difficult aspects which need to be taken under consideration, like creating and implementing an artificial intelligence capable of searching and finding the distress victims, a versatile and efficient boat shape to resist any meteorological conditions, and to be capable of executing the saving maneuvers correctly.

The article chapters are focused on detailing the team study in this domain, and the steps taken in the process of creating a small-scale vessel which will strengthen the idea of introducing an autonomous search and rescue service in the Romanian Naval Forces.

In this article are presented the design of this system, its integration with the artificial intelligence capable of executing search and rescue maneuvers, even autonomous or remotely.

2. STATE OF THE ART

Search and rescue (SAR) operations in maritime environments are increasingly benefitting from advancements in autonomous vessel technology. These Search and Rescue Autonomous Vessels (SRAVs) represent the cutting edge in maritime safety and emergency response capabilities.

Next is outlined the state of the art in SRAVs, key developments, challenges, and potential future directions.

2.1 Autonomy and Navigation:

Autonomous Control: SRAVs are equipped with advanced autonomous control systems that enable them to operate independently, follow predefined routes, and adapt to dynamic environments. Machine learning and AI algorithms enhance their decision-making capabilities[1], [2].

Obstacle Avoidance: State-of-the-art SRAVs integrate LiDAR, radar, and computer vision to detect obstacles and navigate through complex maritime scenarios, including crowded harbours and adverse weather conditions[1], [3].

2.2 Sensing and Detection:

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Sensor Fusion: SRAVs incorporate a multitude of sensors, including sonar, thermal imaging, and AIS (Automatic Identification System) receivers, to detect and locate distressed vessels or individuals accurately.

Distress Signal Recognition: AI-driven algorithms enable the identification of distress signals, such as flares or emergency radio broadcasts, allowing for rapid response[4], [5].

2.3 Communication and Coordination:

Satellite Communication: SRAVs utilize satellite communication systems to maintain connectivity in remote areas, ensuring seamless coordination with onshore rescue centres and other vessels[3], [6], [7].

Interoperability: Integration with the GMDSS (Global Maritime Distress and Safety System) allows SRAVs to communicate with conventional maritime safety infrastructure[8].

2.4 Remote Operation and Monitoring:

Remote Control Centres: Some SRAVs can be remotely operated from command centres, where human operators can take control in complex situations or perform detailed assessments of the situation[1], [5].

Live Video Feeds: Onboard cameras provide live video feeds to aid in situational awareness for remote operators and facilitate communication with those in distress[1], [3], [5].

2.5 Enhanced Safety and Durability:

Redundancy: SRAVs are designed with redundancy in critical systems, ensuring reliability in challenging conditions.

Durability: They are often built to withstand harsh marine environments and extreme weather conditions, allowing them to operate effectively in emergencies[3].

2.6 Regulatory and Ethical Considerations:

International Regulations: Compliance with international maritime regulations, including those set by the International Maritime Organization (IMO), is crucial for SRAV deployment.

Ethical and Legal Issues: The use of autonomous vessels raises ethical and legal questions, including liability, privacy, and the role of human intervention[9].

2.7 Future Prospects:

Integration with Unmanned Aircraft: Future SRAVs may incorporate drones for aerial surveillance and rescue, expanding their search capabilities.

Collaborative Operations: Enhanced collaboration between autonomous vessels, manned vessels, and aerial assets can further improve SAR effectiveness[2].

Environmental Considerations: Sustainable propulsion methods, such as electric or hydrogen-based systems, are being explored to reduce the environmental impact of SRAVs[4], [10].

3. SRAV'S HARDWARE

To create this system, we chose to make a prototype from lightweight and easily workable materials, and it was made from expanded polystyrene. Expanded polystyrene is a widely used material in the construction industry and in the field of modelling due to its insulating properties, ease of processing, and versatility. Additionally, a few structural and propulsion elements were 3D printed.

The structure of the SRAV is presented in the next picture.

Figure 1 SRAV prototype

3.1 SRAV's Electronics

To highlight the previously presented concept, it is imperative to develop a prototype consisting of creating a scaled-down demonstrator, following the principles mentioned earlier, which should yield promising results in the tests conducted.

The electronic components included in the system are:

- ESP32 microcontroller
- 5V water pump
- Relay
- Power supply with Li-Ion battery
- Prototyping board
- Servo motor

The ESP32 microcontroller has revolutionized the field of embedded systems, especially in the context of the Internet of Things (IoT). Its dual-core architecture, built-in Wi-Fi and Bluetooth connectivity, as well as its extensive range of peripherals, provide a powerful and versatile platform for developing IoT solutions[11], [12].

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The MG996R servo motor is widely recognized and highly regarded in the robotics industry, in the field of automation, and among enthusiasts. Thanks to its remarkable features, it has become one of the most reliable and versatile servo motors available. In this project, we will explore the key features and applications of the MG996R, highlighting its power, precision, and versatility in a diverse range of fields.

This digital servo motor can generate a maximum torque of approximately 10 kg/cm (138.9 oz/in) at a voltage of 6V. In addition to its powerful torque, the MG996R stands out for its precision in positioning. With a rotation speed of approximately 0.17 seconds for 60 degrees of rotation at 6V, this servo motor ensures precise control of the angle and position of attached components.

The water pump is used for propulsion of the SRAV and for the power driver we used a simple relay but also PWM analog signal[13], [14].

Lithium-ion (Li-ion) cells are rechargeable energy storage devices known for their high energy density, making them popular for portable electronics. They utilize lithium as the key component in their electrodes, enabling efficient charge and discharge cycles. Li-ion cells have a relatively low self-discharge rate, making them ideal for applications where long-term energy storage is necessary. Despite their advantages, proper handling and charging are crucial to prevent safety risks associated with overcharging or overheating[15].

In the figure below is presented the firs prototype of the electrical circuit of the SRAV.

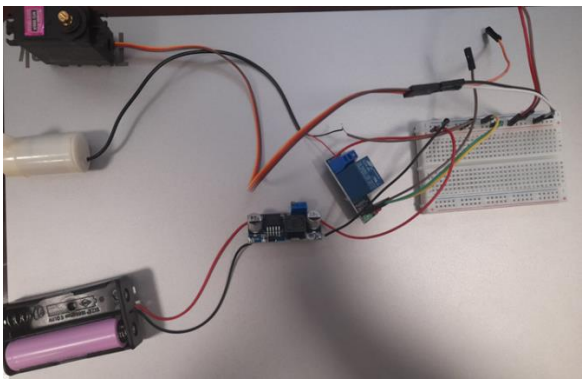

Figure 2 SRAV real electrical circuit

3.2 SRAV's system diagram

Each hardware element within the circuit, graphically depicted in the figure below, meets the specific operational requirements for the efficiency of the autonomous sea search and rescue vessel.

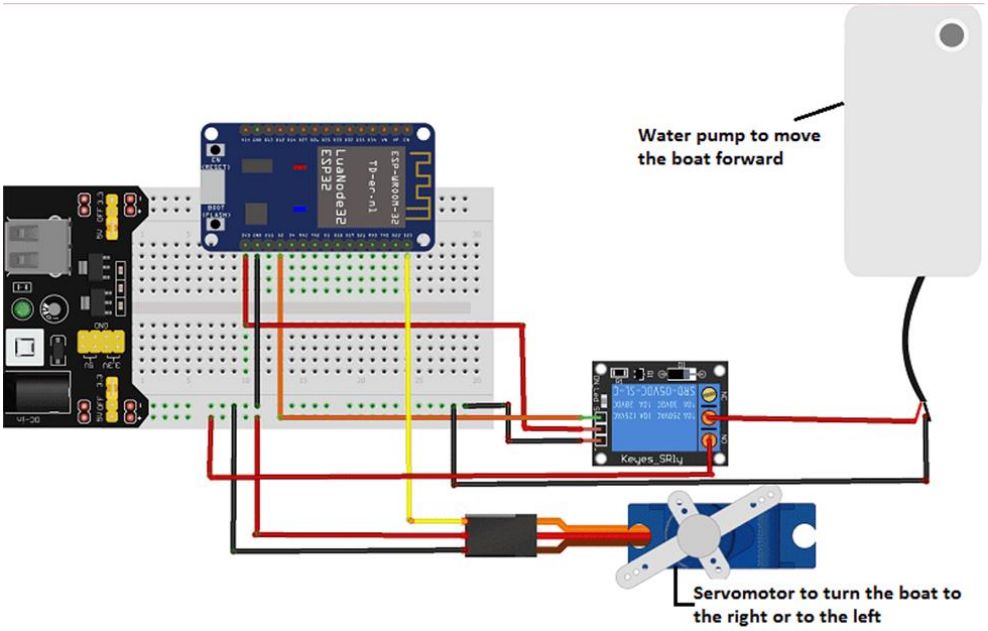

Figure 3 SRAV's main electrical diagram

The chosen prototype, one of the most optimal and efficient options, is designed with the purpose of autonomously navigating and conducting a continuous and efficient search.

4. SRAV'S SOFTWARE

For programming the ESP32 microcontroller, the Arduino IDE was used, utilizing the dedicated compatibility module.

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To facilitate the transmission of commands from the user to the microcontroller and, consequently, to the entire system designed within the scope of the thesis, the Blynk library was used. Blynk is an intuitive Internet of Things (IoT) platform that simplifies the process of building connected projects. This platform provides a comprehensive solution for developing interactive and networked applications that can be managed and monitored remotely. Blynk offers a wide range of features and tools that developers can use to design custom user interfaces (UIs), visualize data, and communicate with various IoT devices.

4.1 SRAV's GUI

In the presented figures, you can observe the graphical interface that underlies the command transmission, and it consists of:

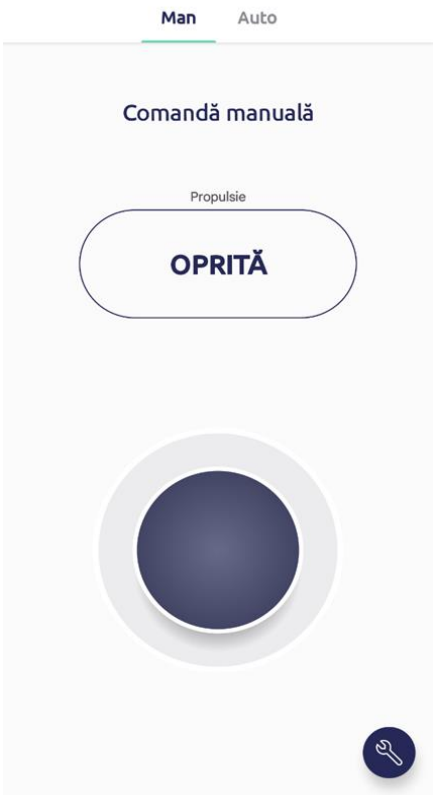

Figure 4 SRAV's manual operation GUI

- Arrow buttons for remotely controlling the ship (Figure 4).
- Selector buttons for choosing various sea rescue maneuvers (Figure 5).

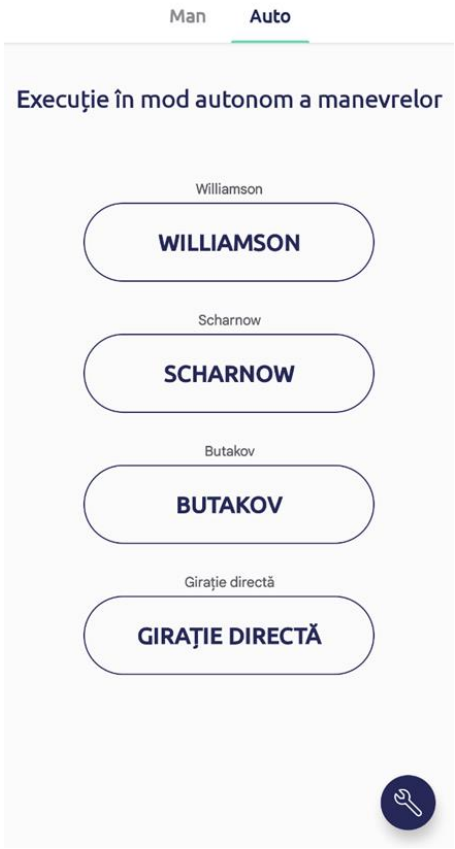

Figure 5 SRAV's auto operation GUI

4.2 SRAV's software code

The code was based on libraries for every main part of the SRAV. An Arduino library refers to a set of pre-written, reusable functions, classes, and resources that extend the capabilities of the Arduino platform. These libraries are created to simplify the programming process for specific hardware or functionalities, allowing Arduino developers to easily integrate complex features into their projects without having to write all the code from scratch.

The "WiFi.h" library in Arduino provides a set of functions and classes for configuring and managing Wi-Fi connectivity on Arduino boards that have built-in or external Wi-Fi modules.

The "WiFiClient.h" library in Arduino provides a lightweight and streamlined client interface for creating TCP and UDP network connections over Wi-Fi. It allows Arduino devices to connect to remote servers, communicate with web services, and exchange data with simplicity, making it ideal for various IoT and networking applications.

The "BlynkSimpleESP32" library is an essential component for connecting ESP32 microcontrollers to the Blynk IoT platform, simplifying the development of remote monitoring and control applications. It provides a

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seamless integration of the ESP32 with the Blynk ecosystem, allowing developers to quickly build IoT projects with a user-friendly mobile app interface. The library handles authentication, data synchronization, and real-time communication between the ESP32 and the Blynk cloud server. This simplifies the process of creating interactive and connected IoT applications that can be remotely managed, monitored, and controlled via smartphones or other devices, making it a valuable tool for IoT enthusiasts and developers.

The "ESP32Servo" library is a valuable extension for ESP32 microcontrollers, enabling precise control of servo motors. It simplifies servo motor management, providing functions for setting angles and controlling positions with ease. This library is essential for robotics, automation, and other projects requiring accurate and smooth servo motor control, making it a key tool for ESP32 developers seeking precise motion control capabilities.

5. SRAV'S TESTING, CONCLUSIONS AND FUTURE

The testing and maneuvering of the SRAV for MOB (Man Overboard) were conducted both at sea (in the military harbor) and on Lake Siutghiol near Naval Academy training camp. We encountered no big issues; the drone operated within normal parameters with no incidents. The maximum tested operating range was 500 meters.

Considering that the system has certain limitations at this developmental stage, in the future, this MOB SRAV could be significantly enhanced with additional technologies, sensors, radars, and equipment.

An example would be outfitting it with heat sensors, water sensors, pressure sensors, and GPS. In case of an incident, the drone could be thrown overboard, automatically start upon contact with water, detect the victim in the water based on heat sensor input, and move directly towards the base vessel. After the victim grabs onto a lifebuoy, pressure sensors on the handles could trigger the drone to return to the ship based on GPS coordinates. This is a complex example, but it greatly improves upon a simple SOLAS lifebuoy, significantly speeding up response in MOB incidents and increasing the chances of saving the victim.

The future of search and rescue AI vessels is poised for remarkable advancements. These vessels will benefit from cutting-edge technologies such as autonomous navigation, advanced sensor arrays, machine learning algorithms, and real-time data analysis. They will possess the ability to swiftly and accurately detect and respond to emergencies in challenging maritime environments. Improved communication systems will enable seamless coordination with rescue teams and remote command centers. Furthermore, these AI vessels will integrate renewable energy sources for sustainable, long-duration operations. As they become more efficient and capable, they will play a crucial role in enhancing maritime safety, reducing response times, and saving lives in a wide range of emergency situations.

6. ACKNOWLEDGMENTS

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STUDY OF HYDRO-METEOROLOGICAL CONDITIONS AND FUEL CONSUMPTION ON THE USUAL TRADING ROUTES OF VLCC (VERY LARGE CRUDE CARRIERS)

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Abstract: In this paper will be introduced some of the usual worldwide navigation routes of VLCC type vessels, with presentation of the data collected by the author on the voyages made by a ship with DWT = 307284 tons, during the period December 2015 – December 2018. For reasons of relevance, trips to the high seas lasting more than 7 days were chosen as much as possible. The objective is to investigate the usual hydro-meteorological conditions on some of the main trading patterns of the VLCC - Very Large Crude Carriers, (vessels intended for the transport of crude oil, with a carrying capacity of approximately two million barrels, DWT approximately 270000 - 330000 tons). Diagrams and tables with data collected are also presented. This may be of further assistance in studying the opportunities of using renewable energy sources, in particular the wind one, in order to improve the energy efficiency of such voyages.

Key words: Carbon, Fuel, Routes, VLCC, Wind.

1. INTRODUCTION

EEDI of a ship stands for *Energy Efficiency Design Index*. The EEDI calculates the theoretical energy efficiency of a new ship and refers to the estimated emissions of CO_2 per tonne-mile of cargo carried.

The calculation of the EEDI is based on the theoretical specific consumption of the engines (in g/kWh). The EEDI formula can be found in IMO's MEPC.1/Circ. 681.

This includes some adjustments/factors depending on the type of ship to which it refers. EEDI is a measure of the energy efficiency of a new ship, but does not effectively measure the energy efficiency of a ship according to the actual operating conditions.

For example, two sister ships with the same Energy Efficiency Design Index may have different emissions depending on the actual navigation area (worldwide, coastal, etc), the hydro-meteorological conditions and the actual way in which the ship is operated.

EEEI or *Energy Efficiency Index of Exploitation* can be defined as the Effective Energy Efficiency Index considering the technical condition of a ship at a given time during the period of operation. In this regard, a factor of the technical condition of the ship, Technical Factor (TF), can be introduced.

EEOI or *Energy Efficiency Operational Index***.** The IMO has also defined an Energy Efficiency Operational Index that aims to measure the yield of a ship considering the real operating conditions.

The calculation is based on the actual fuel consumption related to the actual distance travelled and the cargo transported.

The complete equation is contained in the IMO MEPC.1/Circ. 684 document. Unlike EEDI and EEEI, EEOI does not refer only to new ships, but also to existing ones, and can be used to determine the effects of any changes in the technical conditions and / or operation of the ship, such as: cleaning the hull / propeller, reducing the service speed, better hydro-meteorological assistance of navigation, etc.

Since the calculation of such an EEOI depends largely on the conditions / routes of navigation, it cannot be used to determine the actual technical condition / performance of the ship at a given moment.

The *Energy Efficiency Index* of an Existing Ship. Another approach of leading international experts (Rightship Organisation, Carbon War Room) is to calculate the energy efficiency of an existing vessel using the existing data on the consumptions of a particular vessel.

The EVEI – *Existing Vessel Energy Efficiency Index* is based on the IMO's methodology for calculating the EEOI.

The main difference between EVEI and EEDI relates to the way of collecting consumption data. While EEDI data is made available by classification societies and refers to a new vessel at the time of commissioning, the data for the calculation of the EVEI are calculated retroactively for existing vessels using the data available from ship owners, charterers, shipyards, etc. However,

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the actual formula for calculating the EVEI has not been made public by the initiators.

In the calculations of the energy efficiency of the trips presented in the following chapters, the Energy Efficiency Operational Index (EEOI), as defined by the IMO, will be used. The complete equation is contained in the IMO MEPC.1/Circ. 684 document [17-19]. Unlike EEDI and EEEI, EEOI does not refer not only to new ships, but also to existing ones, and can be used to determine the effects of any changes in the technical conditions and / or operation of the ship, such as: cleaning the hull / propeller, reducing the speed of marching, better hydro-meteorological assistance of navigation, etc.

$$EEOI = \frac{\text{Effective Fuel Consumption} * \text{Carbon Conversion Factor}}{\text{Distance Travelled (Nm)} * \text{Cargo Transported (tonnes or passengers)}} \quad (1)$$

Table 1. Fuel conversion table / CO2 emissions (non-dimensional conversion factor).

No.	Fuel Type	Reference	Carbon Content	Conversion Factor
1	Diesel Oil	Grade ISO 8217 DMX to DMC	0.875	3.206000
2	Light Fuel Oil	Grade ISO 8217 RMA to RMD	0.860	3.151040
3	Heavy Fuel Oil	Grade ISO 8217 RME to RMK	0.850	3.114400
4	Liquefied Petroleum Gas (LPG)	Propane Butane	0.819 0.827	3.000000 3.030000
5	Liquefied Natural Gas (LNG)		0.750	2.750000

Source: IMO MEPC.1/Circ.681 ANNEX

2. OVERVIEW OF THE USUAL TRADING ROUTES OF VLCC-TYPE SHIPS

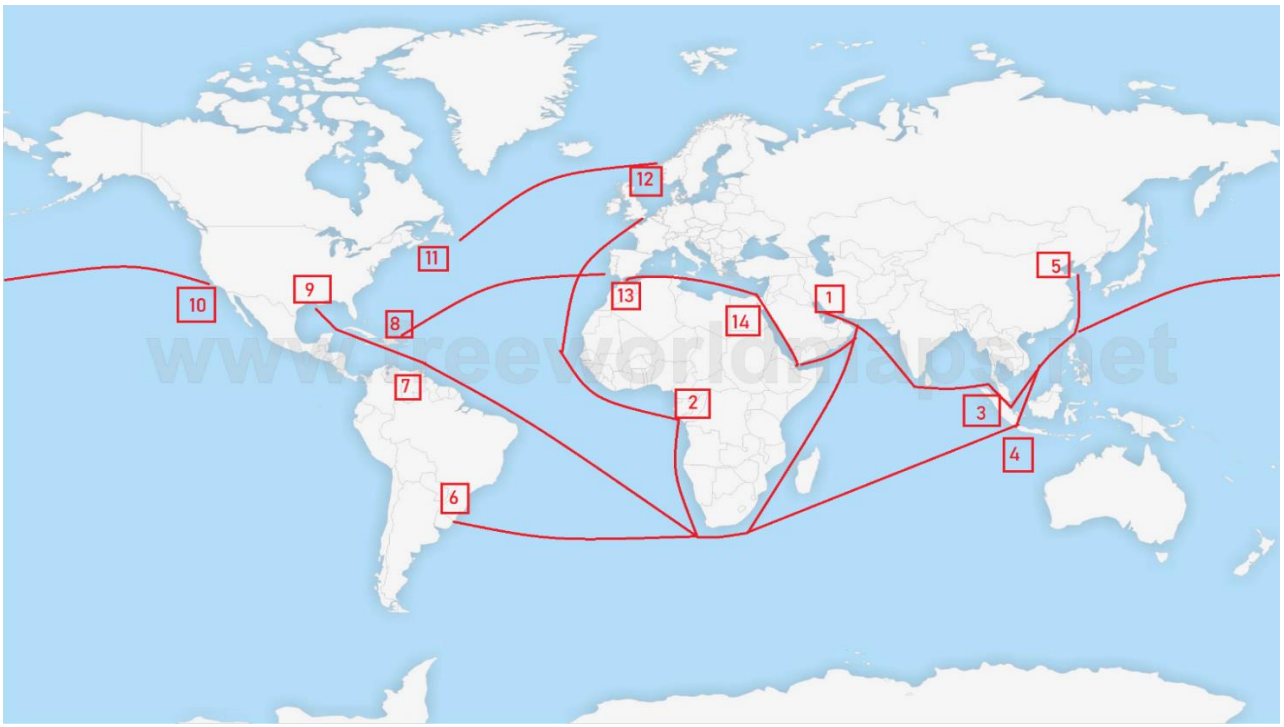

Figure 1 Main points of interest in international Crude

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Oil trade are presented. Compiled as per author's experience [14], [15].

2.1 Points of interest

1] Persian Gulf – Export of Crude Oil, Supply
2] West Africa - Export of Crude Oil
3] Singapore – Export/ Import of Crude Oil, Transit and Supply
4] Sunda Strait – Transit, Supply
5] Far East: China, Japan South Korea – Crude Oil Import
6] Brazil – Export of Crude Oil
7] Venezuela – Export of crude oil
8] Caribbean - Export / Import / Transit of Crude Oil
9] U.S. Coast to the Gulf of Mexico (U.S. Gulf) – Export/Import of Crude Oil
10] U.S. West Coast / Canada – Crude Oil Import
11] U.S. East Coast / Canada – Crude Oil Import / Export
12] The NW coast of Europe - Export / Import / Transit of Crude Oil
13] Gibraltar – Transit/supply
14] Suez - Export / Import / Transit of crude oil, transit, supply

2.2 Voyages with the laden vessel

A) Loading in the Persian Gulf – Discharging Singapore
B) Loading in the Persian Gulf - Discharging Far East (China, South Korea, Japan), Transit via Singapore
C) Loading in the Persian Gulf – Discharging at Suez or Suez Transit, Discharging in Mediterranean or the NW Coast of Europe (Rotterdam).
D) Loading in the Persian Gulf – Discharging in Caribbean. U.S. Coast to the Gulf of Mexico, via Cape of Good Hope.
E) Loading the Gulf of Mexico (USA), Caribbean, Venezuela or South America (Brazil) – Discharging in the Far East.
F) Loading West Africa (Angola, Nigeria) – Discharging in Europe.
G) Loading in West Africa – Discharging in the Far East via the Cape of Good Hope and the Strait of Singapore or via the Sunda Strait.

2.3 Voyages with the ship in ballast

H) Far East – Persian Gulf, via Singapore
I) Suez – Persian Gulf
J) Far East – South America or the Caribbean, via the Cape of Good Hope
K) Suez – Persian Gulf
L) Mediterranean - Caribbean, via Gibraltar.

Note:
Compiled as per author's personal experience and data collected whilst serving over 20 years on board Oil Tankers, out of which 15 years in the capacity of Master.

3. DATA COLLECTION DURING SEAGOING VOYAGES

Figure 2 Wind diagram during a Laden Passage from Persian Gulf to Gulf of Mexico, via Cape of Good Hope, June – August 2017. Compiled using Meteorological Office (SMHI) specialised software.

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Table 2. Comparative data for Laden Passages

No.	Route	Period	Average Speed (Kts)	Total voyage Days	Days prevailing following wind	Days prevailing head wind	Days prevailing cross wind	EEOI achieved
1	West Africa – Far East	Nov – Dec 2018	12.22	35	3	27	5	3.085
2	Persian Gulf - Singapore	September 2018	11.30	15	8	3	4	2.323
3	Caribbean – Far East	June–July 2018	12.18	51	8	30	13	3.735
4	Persian Gulf – Gulf of Mexico	June-Aug 2017	12.60	43	30	8	5	2.579
5	Persian Gulf – Far East	Feb-March 2017	12.22	22	6	12	4	3.688
6	Persian Gulf - Suez	Nov-Dec 2016	11.97	11	6	5	-	2.786
7	South America-Singapore	Nov-Dec 2015	12.53	30	6	12	12	3.592
8	Persian Gulf – Far East	October 2016	12.41	22	15	3	4	3.166
9	Singapore – Far East	January 2016	12.24	10	1	8	1	3.628

Note: Laden passage speed as per Charterer's instructions, in general 12.0, 12.5 or 13.0 Kts, weather and safe navigation permitting. Ballast passages as per Owner's instruction for arrival "just in time" for the next loading operation.

Table 3. Comparative data for Ballast Passages

No.	Route	Period	Average Speed (Kts)	Total voyage Days	Days prevailing following wind	Days prevailing head wind	Days prevailing cross wind	Average Daily Consumption MT Fuel Oil
1	South Africa – South America	Oct-Nov 2015	7.49	24	6	11	7	24.4
2	Far East – Persian Gulf	March 2016	15.27	13	6	4	3	89.1
3	Suez–Persian Gulf	July 2016	9.68	12	-	9	3	22.6
4	Suez-Gibraltar	Nov-Dec 2017	11.72	7	1	4	2	42.8
5	Gibraltar-Caribbean	December 2017	8.29	17	14	1	2	18.6

Note:
For the comparative tables, it was considered head wind from the bow on a sector of 90 degrees (45 degrees Port / Starboard), following wind from the stern on a sector of 90 degrees (45 degrees Port / Starboard) and cross wind the sectors of 90 degrees Port / Starboard (45 degrees forward and aft of abeam).

For Laden Passages, Energy Efficiency Operational Index (EEOI) achieved was calculated according to Formula (1).

For Ballast Passages, obviously no cargo transport work, therefore average daily consumption was presented instead of EEOI.

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4. CONCLUSION

As can be seen from the comparative tables:

- The voyages with the loaded ship were generally executed at an actual average speed achieved of about 11.5 – 12.5 knots.
- The ballast voyages were executed at various speeds (the speed regime at the choice of the commercial department of the navigation company).
- Hydro meteorological conditions significantly influence fuel consumption, i.e. the operational energy efficiency index (IEEO). For this reason, hydro meteorological assistance in the planning and execution of the voyage is of paramount importance.
- The best indices of energy efficiency were reached on the routes Persian Gulf – Singapore, Persian Gulf – Caribbean, respectively Persian Gulf – Suez.
- The poorest Energy Efficiency Index was reached on the Caribbean – Far East route in the period June-July, due to the prevailing head winds (on such a route, for example, a superstructure offering minimal aerodynamic wind resistance from the bow could significantly improve the energy efficiency of the voyage)
- A good energy efficiency index was reached on the Persian Gulf Caribbean route, due to the prevailing following winds, between June and August. (In this situation, a superstructure providing maximum traction force to a following wind could assist in improving energy performance).
- On certain routes where are many days with moderate crosswinds such as South Africa – South America or South America – Singapore, a superstructure with an aerodynamic profile capable of generating significant traction from such a wind could eventually justify the installation costs.

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ASSESSMENT OF THE QUALITY OF THE AQUATIC ENVIRONMENT IN THE AREAS BORDERING THE DEVELOPMENT OF FISHING ACTIVITIES

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Abstract: In the present study, the main physical-chemical parameters (temperature, conductivity, turbidity, pH, dissolved oxygen, biochemical oxygen consumption, ammonium, nitrate and phosphate ions) and the representative groups of phytoplankton (green algae, cyanobacteria, diatoms and cryptophytics) are analysed with direct influence on the quality of aquatic life. The average values obtained by analysing the samples collected in July 2023 in the bordering area of fishing activities (marine site –Midia-Navodari area and Lake sites – Tasaul Lake and Siutghiol Lake) are presented and discussed. The modern techniques of in situ analysis of the physical-chemical and biological parameters of the water allowed an evaluation of the quality of the surface waters regarding the trophic potential. The optimal values of the indicators of the eutrophication regime and of the oxygen regime, as well as the presence of the main groups of primary producers, suggest the existence of favourable conditions for the development of fishing and aquaculture activities. The study contributes to the achievement of the general objective of the Dobrogea North FLAG strategy for the development of fishing activities based on the knowledge of environmental aspects, in order to maintain economic and ecological sustainability.
Key words: chlorophyll, eutrophication, fishing, physical-chemical parameters, surface waters

1. INTRODUCTION

Chemical, physical and biological pollution has serious effects on the biosphere, affecting aquatic life, which is why monitoring surface water quality is very important. The Water Framework Directive (Directive 2000/60/EC) establishes a legal framework for the protection and restoration of water quality in Europe, and one of the objectives of the Directive is to achieve a "good ecological status" for surface waters [1].

In this context, eutrophication must be explicitly taken into account. In the area of the Romanian coast and implicitly in the Lakes bordering the maritime area, aquaculture activities were not stimulated.

The implementation of European strategies at the national level, through the development of local groups, such as the Dobrogea Nord Local Group Association (FLAG), allows a consolidation of the Romanian fishing sector, respectively the application of innovative solutions imposed by economic realities. Maintaining the favorable state of the marine aquatic ecosystem in the Midia-Navodari area and the waters of Tasaul and Siutghiol Lakes, as integrated sites in the Dobrogea Nord FLAG territory, brings to the fore the knowledge of the physical-chemical quality of the water and the chlorophyll content as the basis of the trophic level. This evaluation leads to the possibility of knowing the relevant environmental factors in the development of natural fish resources.

The research of the last 20 years has shown an improvement in the quality of the waters and the biological resources of the Romanian Black Sea coast areas after their decline in the 80s of the last century [2], [3], [4], [5].

Regarding the health of aquatic ecosystems, phytoplankton has an important role due to its position as the first link at the base of the food web, as well as in maintaining a good oxygenation of the water.

Some of the most common problems faced by fish species are: insufficient amount of dissolved oxygen, pollution with organic substances, thermal pollution, sound pollution, various obstacles in the way of migration, radioactive pollution, etc. As a result, fish can be used as bio-indicators in the biomonitoring process, but at the same time, by extrapolating the values of the physical, chemical and microbiological parameters, the health status of the fish population present in the water bodies can be predicted.

Numerous studies have highlighted the qualities of phytoplankton as a source of proteins, fatty acids, carbohydrates, vitamins and minerals for aquatic species, it being successfully used in fish food as support for growth and development, as well as for stimulating their immunity [6], [7], [8], [9], [10].

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Starting from the premise of a stable ecosystem at the local/regional level, a set of factors can be prescribed to support the efficiency of fishing activities and aquaculture/marine culture farms and even the financial support by the competent bodies of some fish farms within the protected sites of Natura 2000.

Knowing the local environmental conditions by developing an evaluation plan based on the physical, chemical and biological characterization of the marine and Lake environment, can facilitate the mobilization of economic entities towards a common goal.

In this study, we analyzed the main physico-chemical parameters and the concentration of the predominant groups of phytoplankton in three aquatic areas where the development of fishing and aquaculture activities are desired: Siutghiol and Tasaul Lakes, as well as the Midia Navodari coastal marine area.

2. MATERIALS AND METHODS

2.1 Physical-chemical analysed parameters

The main physical-chemical parameters that are the basis for building and understanding the ecological status of water bodies with potential for the development of fishing and aquaculture activities were analysed.

The following physical-chemical parameters:

- temperature (˚C),
- conductivity (mS/cm),
- turbidity (FNU),
- pH and
- dissolved oxygen (mg/l)

were measured in situ with a waterproof meter wits GPS function (HI-9829 multiparameter) at 1meter depth.

For the analysis of the other chemical parameters, the samples were collected at 1meter depth in glass bottles and kept away from light, prior to analysis.

The studied parameters are:

- biochemical oxygen demand (BOD_5),
- ammonium,
- nitrate and
- phosphate ions.

BOD_5 was determined using titrimetric methods. The samples were kept five days at 20^{o}C in a cooler incubator FOC 120I Connect.

Ammonium, nitrate and phosphate ions were measured spectrophotometrically with *SpectroquantPharo 300.*

Before the spectrophotometric determinations, samples were filtered to remove particulate matter.

$N–NH_4^+$- the method is based on the ammonium ions reaction with hypochlorite, in alkaline solution, in order to form a monochloramine.

This in turn reacts with a substituted phenol to form a blue indophenol derivate that is determined spectrophotometrically in VIS.

$N–NO_3^-$ - the method is based on the nitrate ions reaction with resorcinol in acidic, in order to form a red-violet indophenol dye that is determined spectrophotometrically.

$P–PO_4^{-3}$ - the method is based on the orthophosphate ions reaction with molybdic ions, in acid medium, in order to form a phosphor-molybdic complex.

This complex is reduced with ascorbic acid to a blue coloured compound which is measured spectrophotometrically [11].

2.2 Measurement of algal biomass

The biological analysis of the water quality is the basis of some methods of its determination and evaluation.

The biological analysis followed the determination of the chlorophyll content coming from different classes of microalgae, including cyanobacteria.

Methods and instruments for in situ measurements of chlorophyll depend on the absorption efficiency and quantum yield of chlorophyll fluorescence [12], [13].

These technologies are extremely useful in ecological programs developed in marine and lake water bodies.

In this study we used the *FluoroProbe III* instrument developed by bbe-moldaenke Germany(https:// www.bbe-moldaenke.de/en/products/chlorophyll /details/ fluoroprobe.html), which allows the determination of the photosynthetic activity of microalgae using fluorescence measurements in real time at different excitation wavelengths.

FluoroProbe III use 6 LEDs for fluorescence excitation for algae differentiation.

The LEDs emit light at 6 selected wavelengths (370nm, 470nm, 525nm, 570nm, 590nm and 610nm). The division of chlorophyceae (green algae) shows a broad maximum of fluorescence at the 470nm LED, which is caused by chlorophyll-a and -b.

The cyanophyceae (blue-green algae) have their maximum at 610nm due to the photosynthetic antenna pigment phycocyanin.

Cyanophyceae also contain chlorophyll-a if there is low intensity at 470nm. This is due to the masking effect of the phycocyanin.

Furthermore, the high peak at the 525nm region for the bacillariophyceae (diatoms) originates from xanthophyll fucoxanthin and for the dinophyceae from peridin.

The maxima at 470nm are caused by chlorophyll-a and -c.

In our last analysed group, cryptophyceae, a significant maximum can be found at 570nm, which originates from phycoerythrin.

The computer calculates the content of the different divisions of algae in the sample from the sample spectrum and the spectra of the separately measured algae divisions.

The concentration of every algae division is given in µg chlorophyll-a/l.

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FluoroProbe III has built-in temperature and pressure sensors. The depth of the FluoroProbe is calculated from the pressure.

The bbe++ software is delivered together with bbe instruments. It provides the following functions:

- operation,
- control and calibration of bbe instruments;
- data analysis and display in tables and diagrams;
- export in different formats.
- The IMPORT function is used to import *.FLP files into the database.
- These files can be results transferred from the FluoroProbe to a USB stick or files generated by the first version of the FluoroProbe software.

The measurements were carried out in the estival season (July 2023) in three sites:

- the Midia Navodari Area (N $44^0 19' 12.3''$ andE $28^0 40' 30.6''$) where seines fishing activities are carried out,
- the Tasaul Lake (N $44^0 19' 38.7''$ and E $28^0 37' 08.4''$)
- and the Siutghiol Lake (N$44^0 12' 57.5''$ and E $28^0 37' 05.2''$).

3. RESULTS AND DISCUSSIONS

3.1 Physical-chemical parameters

The determination and evaluation of the physical-chemical parameters of water quality allow the realization of some correlations with the structure of the biota.

Variations in physical-chemical parameters have a large impact on the growth and development of fish populations, and the presence of heavy metals and/or detergents in the water leads to serious imbalances in the metabolic processes of aquatic organisms.

The values for the studied physical-chemical parameters are presented in table 1.

Water temperature influences the survival and reproduction of aquatic organisms. In general, more intense biological activity occurs with increasing water temperature.

Also, the temperature of the water influences the solubility of gases (the solubility of oxygen and carbon dioxide increases with decreasing temperature) and minerals (solubility of most minerals increases with increasing temperature).

The lowest surface temperature was recorded for the Midia Black Sea water (23.11^{o}C), while the temperatures for the water of the Siutghiol Lake (25.61^{o}C) and Tasaul Lake (26.6^{o}C) were approximately 3 degrees Celsius higher.

Table 1. The average values of the physico-chemical investigated parameters

Parameters	**Siutghiol Lake**	**Tasaul Lake**	**Midia**
Temperature (^{o}C)	25.61	26.60	23.11
Conductivity (mS/cm)	2.46	1.93	29.08
Turbidity (FNU)	87.7	71.3	1.0
pH	8.92	8.85	8.3
DO (mg/l)	7.14	7.10	7.37
BOD5 (mg/l)	3.99	6.11	1.59
N-NH_4^+ (mg/l)	0.08	0.28	0.37
N-NO_3^- (mg/l)	0.30	0.26	0.08
P-PO_4^{3-}(mg/l)	0.16	0.80	0.21

The pH is an important indicator of water quality and influences the development of aquatic organisms. Slightly alkaline pH is preferable in waters, as heavy metals are removed by carbonate or bicarbonate precipitates [14].

For optimal growth of most fish species, desirable pH range is 6.5-9.0. Levels below 6.5 leads to a decrease of reproduction [15], while levels higher that 9.0 could produce death of the fish [16].

The time of day a sample is taken influences the pH because of variations in the carbon dioxide concentration in the water. During the day, carbon dioxide in the water is used by algae and plants for photosynthesis and the pH will increase. At night, carbon dioxide is accumulated from the respiration of fish, plants, and other organisms and the pH will decrease.

The analysed samples had close pH values between 8.3 and 8.9. The values for Siutghiol Lake and Tasaul Lake are higher that limit imposed by Order 161/2006 for surface water (8.5) and can suggest possible health disturbances.

Dissolved oxygen represents one of the pollution indicators, along with the biochemical oxygen demand parameter. The biochemical oxygen demand measures the amount of biodegradable organic material present in a water sample, and represents the terms which microorganisms consume the oxygen while degrading these materials.

The dissolved oxygen concentrations for all three analysed sites were very close, around the value of 7mg/L. The analysis of the biochemical oxygen demand shows a very wide variation, both from one site to the

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other and we estimate that they are due to the presence of the humid substances, correlated also with the presence of the yellow substances in the water column.

Ammonia is a dissolved gas present naturally in surface waters and as results from the decomposition of organic matter and the major nitrogenous waste product of fish. Toxicity of ammonia to fish varies with fish species, age and other quality parameters [17].

From the point of view of nitrogen content ($N\text{-}NH_4^+$ and $N\text{-}NO_3^-$) we can say that all the analysed samples are situated in the first class of quality, according to Order 161/2006 (the concentrations of $N\text{-}NH_4^+$ are lower than 0.4 mg/l and the concentrations of $N\text{-}NO_3^-$ are lower than 1 mg/l).

Almost all of the inorganic phosphorus in water is in the form of phosphate (PO_4^{3-}). Phosphorus is an essential plant nutrient and the typical range for surface waters is 0.005 to 0.5 mg/l [11]. In accordance with Order 161/2006, the results for phosphate ion concentration place the water from Siutghiol Lake in quality class II (0.16 mg/l) and the water from Tasaul Lake in quality class IV (0.80 mg/l).

3.2 Biological parameters

Fisheries, up to a point, are positively affected by increased primary algal production.

When eutrophication begins to substantially reduce dissolved oxygen concentrations, fisheries can be adversely affected.

Testing the concentration of chlorophyll, the classes of algae and the photosynthetic activity, are useful for the evaluation of eutrophication in the aquatic environment, but also for the evaluation of productivity in most surface waters.

On average, the total phytoplankton concentration showed significant differences in the three investigated water bodies, with a chlorophyll value of 6.5 µg/l in the Midia area on the Black Sea coast, 272.57 µg/l in Siutghiol Lake and 572.69 µg/l in Tasaul Lake. Differences were also recorded in the presence and concentration of the four groups of investigated phytoplankton organisms.

Thus, with a chlorophyll value of 389.82 µg/l, green algae are found in a concentration five times higher in Tasaul Lake than in Siutghiol Lake (76.6 µg/l) and 180 times higher compared to Midia area (2.18 µg/l).

The cyanobacteria group has a chlorophyll concentration of 171.27 µg/l in Siutghiol Lake and 151.59 µg/l in Tasaul Lake.

Diatoms had chlorophyll concentrations of 0.94 µg/l in Tasaul Lake and 4.32 µg/l in Midia.

Chlorophyll recorded in the Cryptophyta group showed a concentration of 24.7 µg/l in Siutghiol and 30.34 µg/l in Tasaul Lake.

Cyanobacteria and cryptophyte groups were not recorded in the Midia area. Also, the group of diatoms was not present in the samples from Siutghiol Lake (Figure 1).

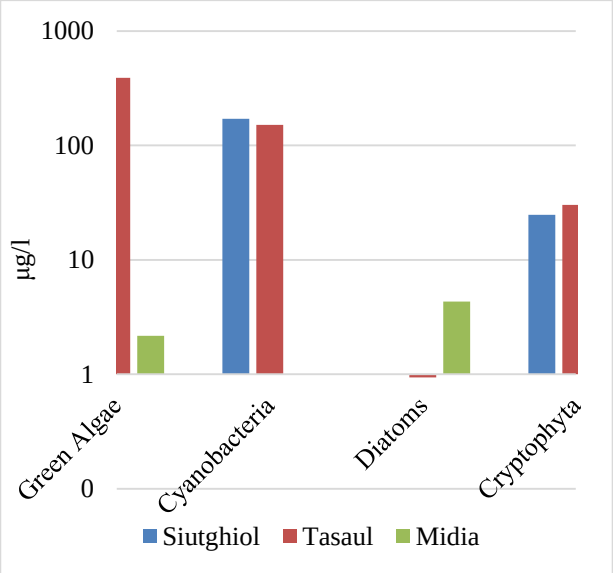

Figure 1 Chlorophyll concentration in the representative groups of phytoplankton

Each of the three aquatic areas presents particularities regarding the rate of different phytoplankton groups.

Thus, in Siutghiol Lake, 62.8% of chlorophyll comes from the group of cyanobacteria, followed by green algae (28.1%).

In contrast, in Tasaul Lake, green algae are predominant (68% of chlorophyll), the chlorophyll of cyanobacteria representing 26.47% of its total.

In the Midia area, diatoms provide 66.49% chlorophyll, followed by green algae (33.51%) (Figure 2).

Phytoplankton is the most sensitive group to the changes of the quality of water parameters.

In order to appreciate the quality and trophic state of a aquatic ecosystem, it is important to determine the concentration of chlorophyll.

The algal bloom evaluated through the lens of the detection of potentially harmful cyanobacteria, aims to assess the quality of the trophic background, as a support for the development of the ichthyofauna in the evaluation area.

In this sense, we note that in Siutghiol and Tasaul Lakes the concentration of cyanobacteria shows a constancy in the water column up to a depth of 1.5 m, so that at more than 2 m in the Siutghiol site triple values (477µg/l) are recorded.

These data are correlated with the presence of the yellow substance that occurs naturally in aquatic environments, originating from detritus or decaying organic material.

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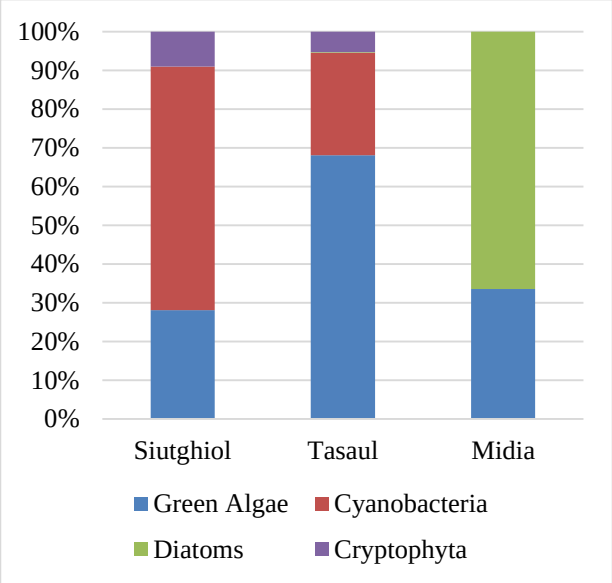

Figure 2 Chlorophyll rate from different phytoplankton groups in the investigated aquatic areas

The concentration of yellow substance (fig. 3) in the Tasaul Lake (19.76 µg/l) is twice as high as in the Siutghiol Lake (8,97 µg/l).

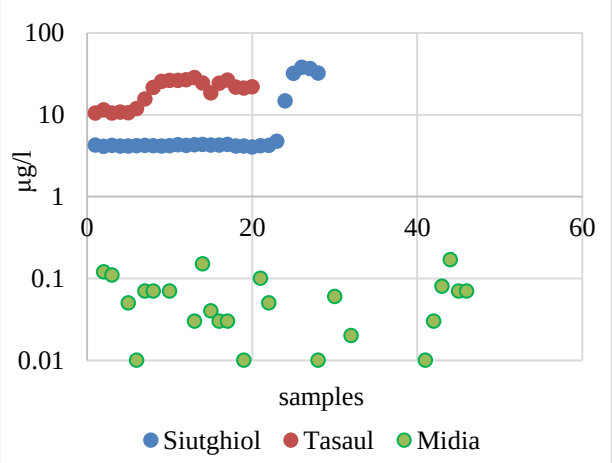

Figure 3 Yellow substance concentration in the investigated aquatic areas

In the marine environment the yellow substance is much lower (0.03 µg/l) compared to the lacustrine environment.

4. CONCLUSIONS

The results obtained in this study suggest the existence of a good trophic base for the development of fishing and aquaculture activities.

The values of quality-monitored parameters depend on the seasonal characteristics therefore it is necessary to continue our research in these aquatic sites.

5. ACKNOWLEDGMENTS

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GENERATING A MESH TO DETERMINE THE BATHYMETRY IN THE HARBOUR

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Abstract : In this paper we present the steps to determine the bathymetry in the harbour. For this we can use software MIKE Zero to create various meshes, each designed to apply for a special modelling task. The bathymetry mesh is created from scratch and optimised to a satisfactory .
Key words : coastal engineering, application, MIKE Zero, bathymetry, mesh, data, map.

1. INTRODUCTION

Coastal engineers are often interdisciplinary involved in integrated coastal zone management, also because of their specific knowledge of the hydro- and morph-dynamics of the coastal system. This may include providing input and technology for e.g. environmental impact assessment, port development, strategies for coastal defence, land reclamation, offshore wind farms and other energy-production facilities, etc.

Engineers will need to design coastal and offshore structures with climate change adaptation in mind. Addressing this challenge requires a greater analysis of the vulnerabilities of existing coastal and offshore structures, including a consideration of potential drivers and the circumstances contributing to more frequent structural failures and the loss of system functionalities and developing robust climate risk management strategies for building and improving the resilience of assets.

Climate change generates impacts on the environment, particularly in vulnerable systems like coasts, which are exposed to sea level rise. Moreover, potential changes in wind and atmospheric pressure patterns will modify hydrodynamic processes like storm surge and wave climate, which are fundamental driving terms on the coast

"The world's coastal areas represent only 20% of the available land but host between 40% and more than half of the global population (Burke et al. 2001) [1]. No single definition can encompass the complexity of coasts, and the demarcation of coastal boundaries is no easy matter, for coastal areas are complex systems composed by a range of terrestrial, intertidal, and marine environments with seaward and landward zones of influence that stretch far inland and out to sea.

Different countries use different definitions and boundaries for coastal zones variably based on a combination of ecological, geographical, socioeconomic, historical, political, administrative, and legislative reasons [2]. While certainly informed by the ecological and geophysical characteristics of the coasts, these definitions are very much determined by functional and management requirements.

Coastal areas have been centres of human activity throughout history and current trends indicate that migration toward these zones is continuing.

The main reason for this is that the rich variety of ecosystems and habitats in coastal zones provides a range of goods and services critical to human sustenance and well-being, particularly food production (e.g. fisheries and aquaculture), raw materials, and transportation options.

Coastal areas provide also other ecological and socioeconomic services with deep interrelations between them: erosion control of land and intertidal ecosystems (e.g. wetlands and salt marshes), storm protection, water purification, nutrient recycling, and recreation (tourism).

Due to their unique location, coastal areas are also at the receiving end of impacts coming both from the sea and from the land.

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Figure 1 Map of ECA region [2]

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This exposes coastal areas to the influences of climate change either directly (sea-level-rise, storm surges, floods, droughts) or indirectly through events that originate off-site but whose consequences propagate down to the coasts (river floods and changes in seasonality, pulses, quality of run-off)"(Figure 1)[2].

2. IMPORTANCE OF COASTAL AREAS

"Coastal areas are most often defined through a combination of physical-geographical and management criteria. However, this presents difficulties when trying to assess the socioeconomic or biodiversity conservation value of coastal areas through the use of global data. To overcome this limitation, coastal areas are commonly defined as: "intertidal and subtidal areas on and above the continental shelf […] areas routinely inundated by saltwater, and adjacent land, within 100 km from the shoreline" (Martinez et al. 2007).[3]
Using this definition, the social importance of the coastal areas in ECA basins is demonstrated by the percentage of population living within 100 kilometres of the coast (Figure 2 and Table 1). Albania and Estonia are small countries, which is why almost the entirety of their populations is included in this group.

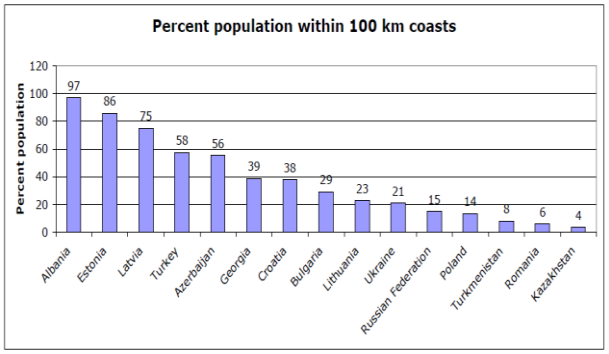

Figure 2 Percent of population living within 100 km from the coast. Twelve countries out of 15 have more than 10% of the total population located within 100 km of the coastline.[1]

Table 1. Percentage of total population living within 100 km of coastline – average per basin [4]

Sea[1]	Adriatic Sea2	Baltic Sea3	Black sea4	Caspian sea5
Average population	68%	49%	28%	21%

where
1 sea
2 Includes Croatia and Albania
3 Includes Estonia, Latvia, Lithuania, Poland
4 Includes Bulgaria, Romania, Georgia, Ukraine, Russian Federation, Turkey
5 Includes Azerbaijan, Turkmenistan, Kazakhstan, Russian Federation

2.1 Climate changes in coastal areas:

Climate change causes various impacts on ECA coastal areas through extreme weather events, long-term changing averages in climatic variables and increased weather variability. Sudden severe phenomena such as storm surges, and gradual changes like SLR, will directly affect human well-being by damaging investments and infrastructures, and indirectly through modification of coastal ecosystems and habitats (Alcamo et al. 2007)[4]. Although climate change may offer positive opportunities as well as cause harm, it is expected that the latter will far outweigh the former. Furthermore, the IPCC reports that for the first decades of the 21st century some of these events will be heavily influenced by the North Atlantic Oscillation (NAO).

According to several models these impacts would become most significant after 2050 (Alcamo et al. 2007)[4]. However, two aspects must be considered: (1) several observations indicate that climate change may be more dramatic than predicted (see glacier melt section), (2) coastal exposure to climate change can vary greatly according to interactions between global, regional, and local weather and bio geophysical factors. The rate of sea level- rise is influenced by cyclical regional weather patterns, local atmospheric pressure, sea thermal expansion, coast subsidence, uplift caused by tectonic movements, and other hydrogeological factors (Nicholls et al. 2007; Nicholls and Klein)[5]. While the IPCC projects Special Report Emission Scenarios (SRES) indicating a global SLR of between 0.09 to 0.88 meters by 2100, in Europe the interaction with local factors may induce a SLR that could be 50% greater than the global estimates (Alcamo et al. 2007)[4].

Given the uncertainty of current estimates, it is critical that an adaptation strategy be put into action in ECA. Adaptation to climate change in the context of coastal areas is defined as a policy process entailing

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decisions on policy and technological interventions that aim at reducing the vulnerability of the system to climatic changes. This section follows the general approach of the Umbrella Report in defining vulnerability as a function of exposure to climate change, sensitivity of the system, and adaptive capacity (Figure 3)[5].

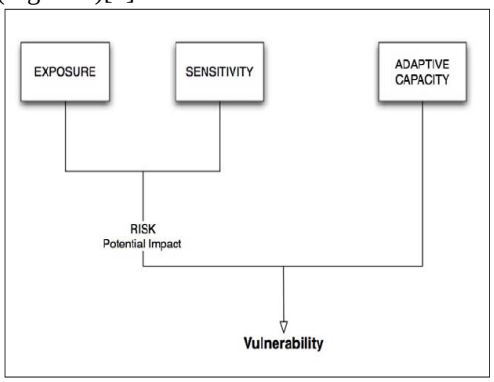

Figure 3 Vulnerability as a function of exposure, sensitivity, and adaptive capacity [5]

In order to reduce the vulnerability of coastal areas to climate change it is therefore necessary to examine the exposure to climate change of the basins of interest, their sensitivity to the changes, the adaptive capacity and other factors that may influence these components.

2.2 The economic dimension of coastal areas :

Establishing the relevance of coastal areas to the economy of a country is a more complex exercise. Fisheries do not constitute a great share of GDP in ECA basins. Fishery landings within a country EEZ [4] account for less than one percent of the GDP. Buys et al. (2007) examined a subgroup of ECA coastal countries and suggest that a SLR of one, two, or three meters would only affect between 0.13% and 1.99% of a country's GDP (Table 1.3). Georgia and Ukraine are predicted to be the worst off, followed by Estonia. Bulgaria and Romania are predicted to be the best off.

3. GENERATING A MESH TO DETERMINE THE BATHYMETRY IN THE HARBOUR

3.1 Mathematical modelling IN MIKE

Mike by DHI is a software dedicated to the management of waters. This software has a variety of components, but the one we will be using is MIKE 21 Flow Model – which provides the basis for process calculations, performed in many other modules such as sediment and mud transport, thermal energy and suspended solids transport, oil spill, agent-based modelling and ecology, but it can also be used as standalone application. The module simulates the inconsistent flow taking into account the bathymetry, the sources and the external forces. With the help of this model, we will eventually evaluate the hydrographic conditions of the work area [6].

Creating a mesh is a very important step in terms of modelling with the help of the MIKE by DHI software. This file contains information about: grid calculation, water depths in various areas and extreme conditions.

3.2 Mesh Generator

.

The objective of this Step-by-step training guide is to use the Mesh Generator to create various meshes, each designed to apply for a special modelling task. The bathymetry mesh is created from scratch and optimised to a satisfactory level (Figure 4)[6].

Figure 4 A harbour which is located on the west coast of Denmark

- *Step one-creating a mesh*

For this application, it used a file provided with the installation of the MIKE Zero program, which contains information about

- water depths
- computational grid
- boundary information of the harbor (Figure 5).

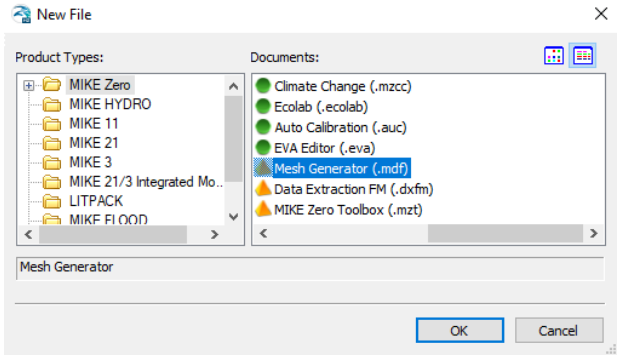

Figure 5 Program selection

The mesh file couples water depths with different geographical positions (File -> New File -> Mesh Generator (.mdf)

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After starting the Mesh Generator, we specified the projection system as UTM and the zone as 32 for the working area, as indicated (Figure 6).

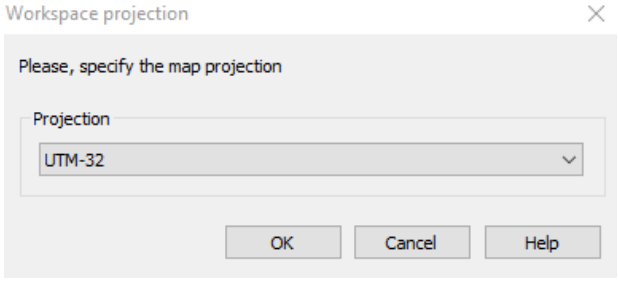

Figure 6 Defining the projection of the workspace

- *Step two- modifying boundary conditions with an area that can be triangulated*

In order to evaluate the outline of the model area it were imported all the available Scatter Data (*Data -> Manage Scatter Data -> Add*).

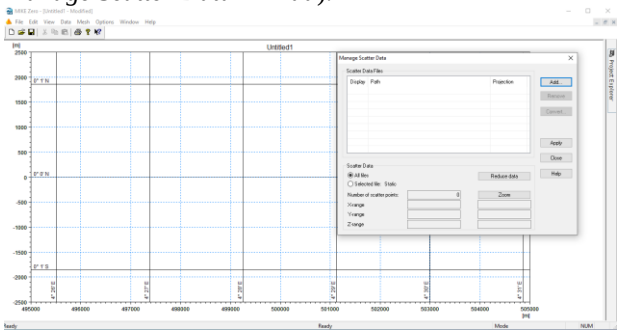

Figure 7 Informations about bathymetry

For this application, it was chose the file that will reveal information about the bathymetry of the studied harbor (Figure 7)..

The bathymetry is usually interpolated from xyz Scatter Data holding a water depth value (Figure 8).

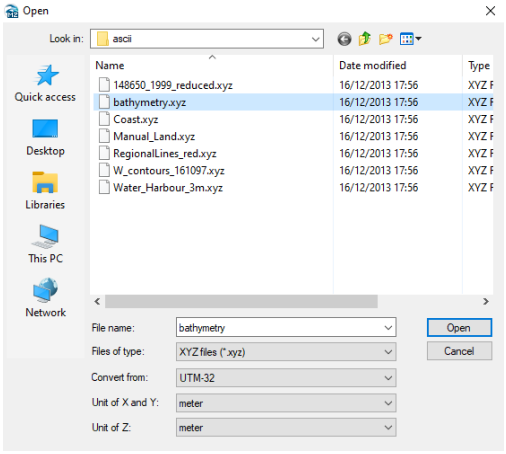

Figure 8 The bathymetry xyz interpolation

These are typically found from measurements, surveys, digitization of maps or exported from MIKE C-MAP.

The steps are: *Data -> Manage Scatter Data -> Add -> bathymetry.xyz -> Apply*.

- *Step three*

After importing Scatter Data, the workspace is revealed.

The mesh file containing information about water depths and mesh is created with the Mesh Generator Tool in MIKE Zero (Figure 9).

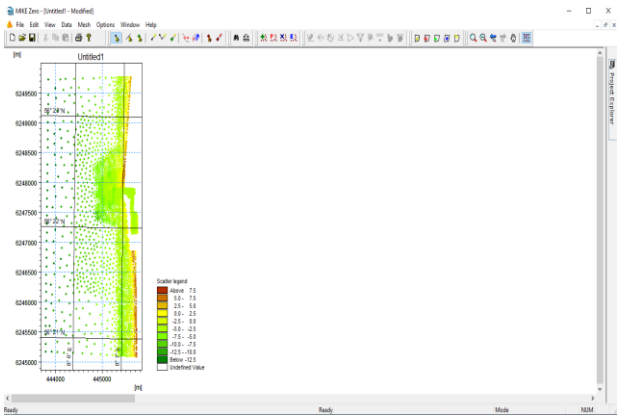

Figure 9 View -> Zoom to Extend of Data

The water depths in the nearshore area are well defined by surveys while in the regional area the bathymetry is defined by navigational charts.

- *Step four*

For this step were created boundaries around the areas of interest by using the draw arc tool from the toolbar (Figure 10, Figure 11).

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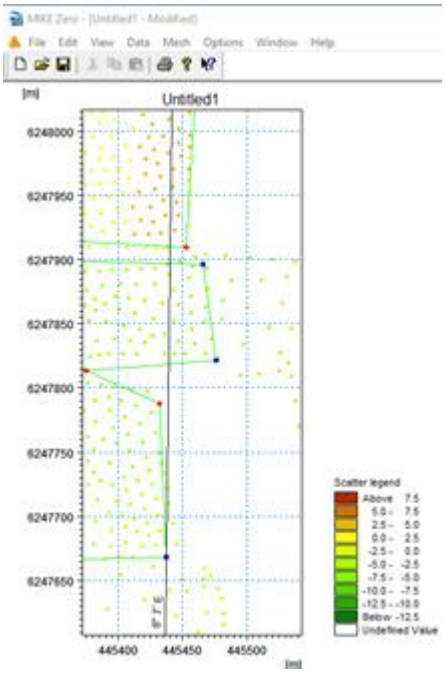

Figure 10 Boundaries around the areas of interest

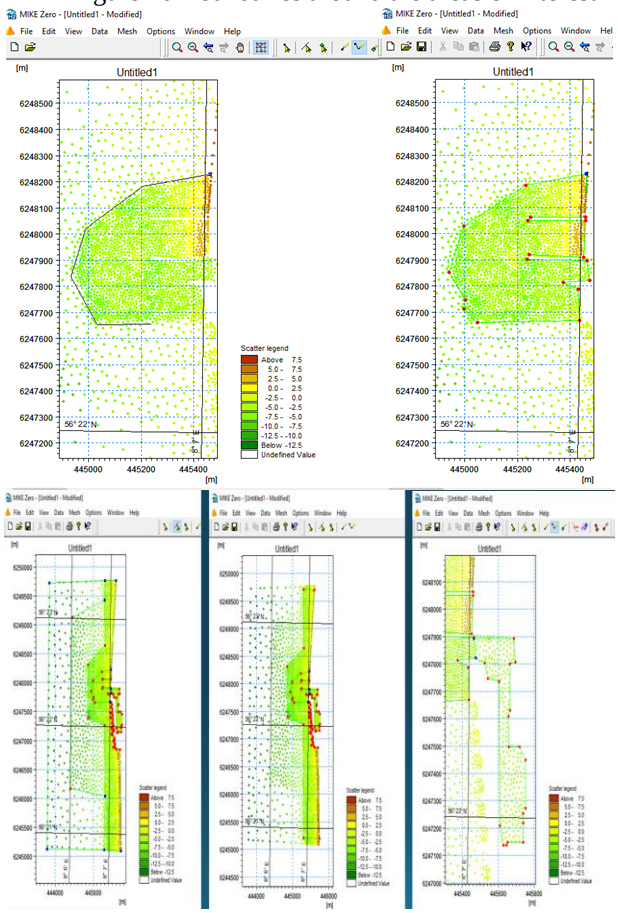

Figure 11 Final created boundaries

- *Step five*

Select the arcs created previously with the select arcs tool and go to properties to change the arc properties (Figure 12).

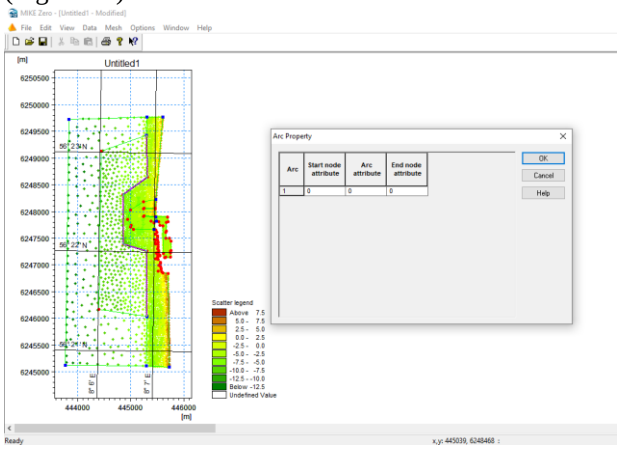

Figure 12 Arc property

The node points and arcs on the open boundaries must be defined by a unique integer value. These attributes are used for the model system to distinguish between the different boundary types in the mesh:

- Attributes equal to 2 and above correspond to open boundaries
- Attributes equal to 1 correspond to land/water boundaries.

- *Step six-triangulation*

The next step is to triangulate the domain. For this, it was selected each shape defined previously and it was used the Insert polygon tool to define the areas that are about to be triangulated.
Go to Data -> View Scatter Data to get a different view of your workspace (Figure 13).

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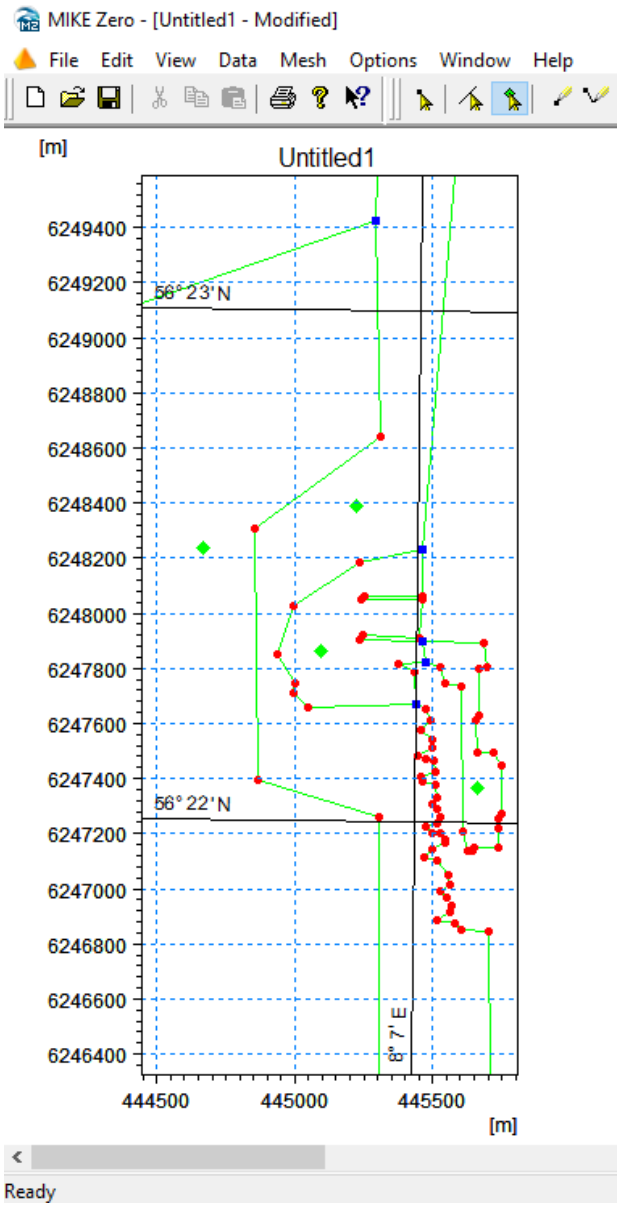

Figure 13 Triangulation of the field of study

Go to Insert polygon tool -> click on each shaped defined previously (a green dot will appear).

- *Step seven*

Right click into the polygon (green dot) -> *go to properties -> Select apply triangular mesh*.

The triangulation is used to determine the position of points spread over an area.

Check the "*Use local maximum area*" box and insert maximum area values for each shape that will be triangulated.

For this example it used a maximum area of:

- 20.000 for the first polygon
- 10.000 for the second polygon
- 1000 for the third polygon
- 500 for the forth and fifth polygon (Figure 14).

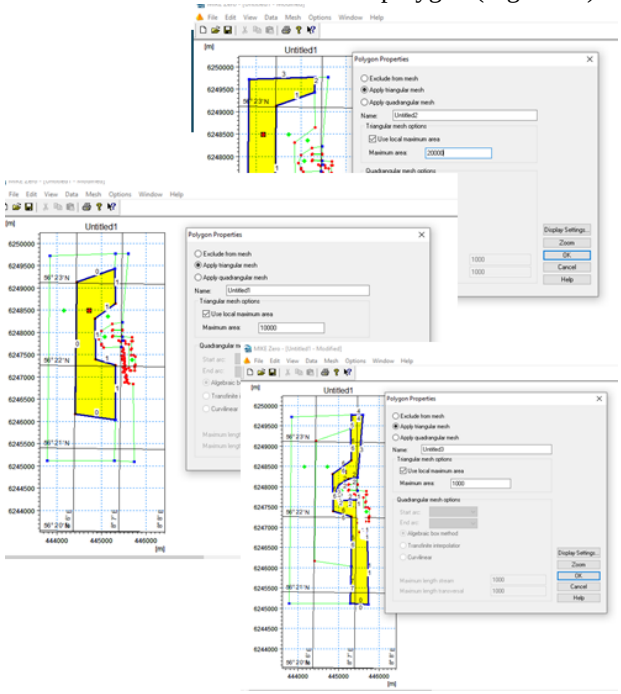

Figure 14 The determination of position of points spread over an area

- *Step eight*

Go to Mesh -> Generate Mesh to make the first triangulation and then use the triangulation option setting as shown in the image below (Figure 15).

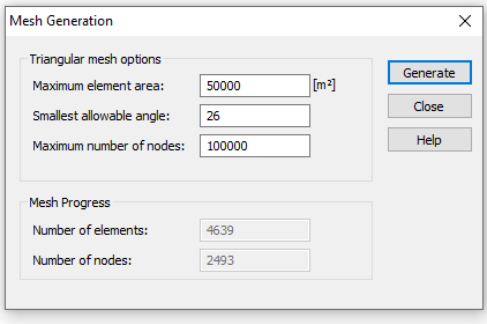

Figure 15 Mesh generation

Elements limited by boundary point positions tend to be much smaller than elements only limited by maximum element area.

After the triangulation you can use a tool for smoothing the mesh (Figure 16).

Go to Mesh -> Smooth Mesh

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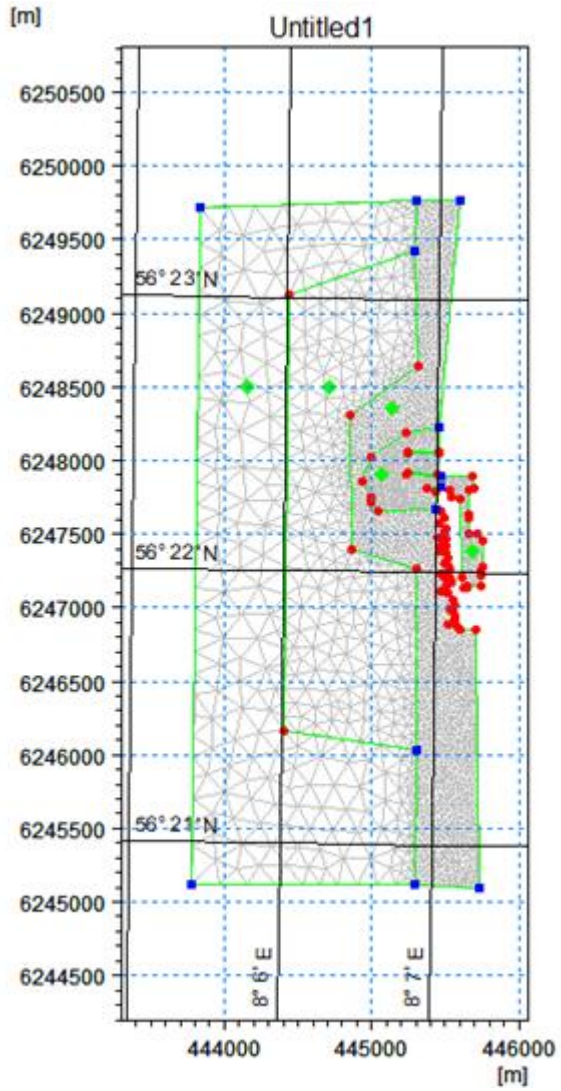

Figure 16 Smoothing the mesh

- *Step nine*

Go to Mesh -> Interpolate -> Start
The initial bathymetry is now created from the initial mesh by interpolating scatter data (Figure 17).

Interpolate the bathymetry values by using the default settings for the interpolation. (*Mesh -> Interpolate -> Start*).

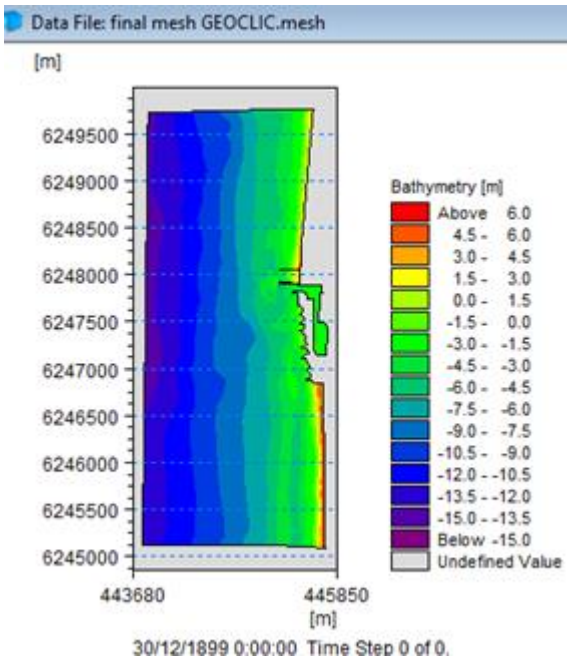

Figure 17 Initial bathymetry-interpolating scatter data

The resulting image will be the mesh as it appears in the Mesh Generator after interpolating water depth xyz data into the mesh.
The final mesh is now created (Figure 18).
Go to Mesh - > Export mesh

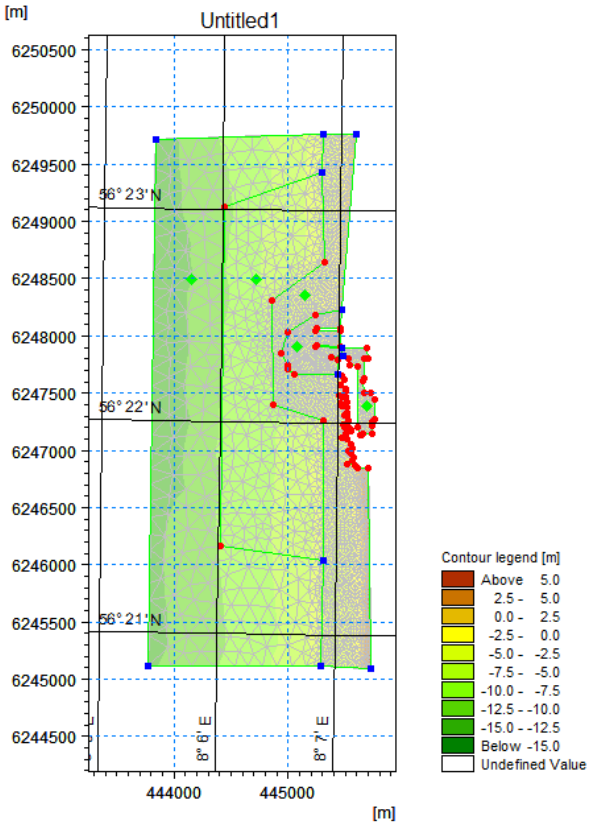

Figure 18 The final mesh

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4. CONCLUSIONS

Shoreline evolution can be natural or can be caused by the side effects of marine constructions, designed/artificial beaches and shoreline protection structures. Furthermore, climate change alters the base conditions under which coastlines evolve. In both cases, valid predictions of long-term shoreline movements are vital to mitigate or prepare for erosion and changes in coastal stability. Shoreline modelling addresses questions such as equilibrium shoreline, shoreline erosion and envelope (seasonal/event driven), sediment budget and so on.

The coastal profile included in the simulations may be specified by:

- a constant profile along the entire shoreline ;
- interpolation between a number of profiles ;
- direct extraction from a bathymetric survey.

The new shoreline model implements a flexible dynamic baseline, thereby allowing the model to be applied to problems with a curved coastline.

5. ACKNOWLEDGMENTS

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A POINT OF VIEW ON FORMATIVE- EVALUATION OF PART- TIME STUDENTS IN CONSTANTA MARITIME UNIVERSITY- A CASE OF STUDY

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Abstract: Part- time education is very attractive for students and universities, due to its obvious benefits related with economic, mobility and friendly education environment aspects. In Constanta Maritime University, part- time education is available for marine engineering, electrical engineering and navigation and waterborne transport programs. According to the Romanian legislation, the evaluation of part- time students consists in two types of assessment: formative evaluation and final evaluation. The formative evaluation is carried on by the use of the university' E-Platform, while the final evaluation is face to face type- exactly like the one of full- time students. In the case of study, it is described the formative evaluation of part- time students enrolled in Marine Engineering program, second year of study, in the case of students' performance assessment in Thermodynamics 1 Course. There are enrolled 52 students, but only 25 attended the formative evaluation, despite of the fact that this evaluation has a percentage in the final grade. This paper describes the manner in which this evaluation took place. Also, where analysed the reasons for not attendance and mistakes in test solving. Where identified the ways in which students performance might be improved, for a better understanding of the curricula.

Key words: part- time students, marine engineering, formative evaluation, e- Learning

1. INTRODUCTION

According to the Romanian legislation [1], higher part time education represents a form of organization of didactic processes characterized by teaching-learning-evaluation activities dedicated to applied training, programmed in a compact or periodic way, which involves both the direct meeting of students/students in the university space with teaching staff, as well as the use of teaching/training aids specific to distance education.

Part-time education offers students the opportunity to manage their learning process in compliance with the schedule established by the university.

As a rule, assisted teaching activities are scheduled on weekends.

Part-time education has features in common with both full-time and distance education.

Thus, the study of the courses is carried out individually, the students having at their disposal study materials adapted to the individual study, the self-instructional process.

For the form of organization of the didactic process specific for part- time education, the programming of the subjects in the education plan will be done according to the duration of schooling in full-time education.

In order to ensure the equivalence of the forms of education, the following types of activities will be carried out within each discipline:

a) seminar activities consisting of face-to-face meetings on the university campus and/or online synchronously through online platforms, with the same number of seminar hours as in the full time education form. These activities are organized by groups/subgroups:

b) applied activities (laboratory, practical work, project, specialized practice) with the same number of hours as in the full time education form. These activities are organized face to face in the university campus/online synchronously in groups/subgroups;

c) the course hours from the regular education form are compensated by self-instructional activities, based on distance education specific learning resources.

Teaching activities are carried out by the university permanent instructors or by part-time instructors.

Discipline coordinator - which is a permanent lecturer has a large range of activities, such as: defines and implements the structure and sequence of distance and face-to-face teaching activities, designs self-study course support, learning tasks, mid-term and final assessments, and how the support materials are used, develops the exam topics and/or the marking grids, ensures the final assessment of students in the knowledge assessment sessions.

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On the other hand, part-time instructors are important actors in part- time education due to the fact that they are motivated to work hard in order to gain the appreciation of the academic stuff and of students [2].

Among many other, discipline coordinators have to deal with two important tasks: study materials design and part- time students' evaluation. Study materials are working tools in teaching, learning and assessment, which must replace the role and presence of the trainer in traditional training processes.

These materials are adapted to self-learning and are carried out entirely in distance- learning technology. These can be achieved, implemented and delivered to students using various media: printed teaching materials, digital resources on online platforms, any suitable electronic storage/presentation media.

These materials have an introductory section on assessment methods and tools and the number and format of formative evaluation of part- time students. The content of the teaching materials is divided into learning units/modules that facilitate gradual and structured learning in a defined unit of time.

Designing study materials in distance- learning technology considers the facilitation of individual study and the development of learning skills and techniques, ensuring a high level of interactivity and feedback, the generation of student-teacher and student-student interactions, the use of a wide range of procedures that facilitate and consolidate learning: illustrative examples, summaries, conclusions, etc.

The evaluation of part- time students' knowledge for the promotion of curricula and the granting of credits requires formative and final evaluation procedures.

Formative evaluation can include self-evaluation tests, verification works, practical tests, etc. - inserted in the study materials and/or posted on the e- Learning platform and has a percentage in the final grade; this type of evaluation is realised in a tutorial system, and checking, marking, discussing and recording the results can be done directly on the e Learning platform.

Students must be informed about the nature and purpose of the formative evaluations, as well as about their percentage in the final grade.

The final evaluation of part- time students is carried out in the same system used in the case of full- time students, meaning face to face knowledge assessment.

Part- time programs are a necessity in the context of actual labour market; they represent a good solution for the ones which are working or for different reasons cannot be enrolled in full- time programs, but still want to have access to higher education (a category characterised by diversity and complexity) [3], [4].

2. METHODS AND MATERIALS

Highly educated seafarers, able to cope with challenges imposed by modern shipping industry, are the result of the cooperation between higher maritime education institutions and stakeholders in shipping [5].

Lately, the need of highly trained human resources on board the ships is evident; in this context, MET (Maritime Education and Training) programs providing the industry the personnel with academic knowledge and practical skill are of high importance [6]. Having in view that part- time students enrolled in Constanta Maritime University already work in the shipping sector, this type of program is very attractive for the one willing to achieve a better position on board, through marine higher education.

This paper deals with formative evaluation of part-time students enrolled in Marine Engineering program in Constanta Maritime University, second year of study, in the case of students' performance assessment in Thermodynamics 1 Course. There are 52 students attending this course.

The general objective of the discipline consists in the formation of competences in the field of thermal engineering, for future marine engineers. Thermodynamics is a fundamental course in mechanical engineering since it provides basic knowledge for the understanding of succeeding courses [7].

In Constanta Maritime University such examples are Internal combustion engines components and ancillary systems, Internal combustion engines processes and characteristics, Steam generators, steam and gas turbines or Marine refrigerating plants.

For the case in study, Thermodynamics 1 course needs 42 hours of self-study training, while the seminar activities (which are face to face or online) require 28 hours per semester. One seminar (2 hours per semester) is carried out online, by using the e-Learning platform of the university. In this case, seminar activities are in the task of a part- time instructor. E- learning improves teaching and learning processes and enables universities to be more and more competitive; electronic learning improves the relationship student- student and student-lecturer, as well [8], [9].

E- Learning is both flexible and affordable and can be used as a strong tool in passive and active learning processes [10]. In Constanta Maritime University, Moodle E- learning platform is at the disposal of teaching stuff and full- time and part time students. It provides a virtual learning environment able to support learning and knowledge assessment processes, while lecturers and students might have synchronised or non-synchronised activities [11].

Students are informed on the scheduled learning activities and course content on the course page, available on the platform (Figure 1).

By accessing the course details, students are informed that the formative evaluation will consist in solving a task, scheduled in week no 9, from Modules 4,5,6 (Figure 2).

Module 4 deals with perfect gas mixtures, module 5 deals with transformations of perfect gases, while module 6- with the second law of thermodynamics.

The formative knowledge assessment is carried out by the use of the platform. The assessment consists in

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solving a test that contains grid-type questions and a problem, for which theoretical knowledge from the mentioned units is required. The lecturer's feedback is transmitted to the students also by the use of the platform.

Students have to up load their solved test on the platform (Figure 3). For solving and up loading the tests, students have at their disposal 1 hour.

As seen from Figure 4, 25 students have attended the formative evaluation.

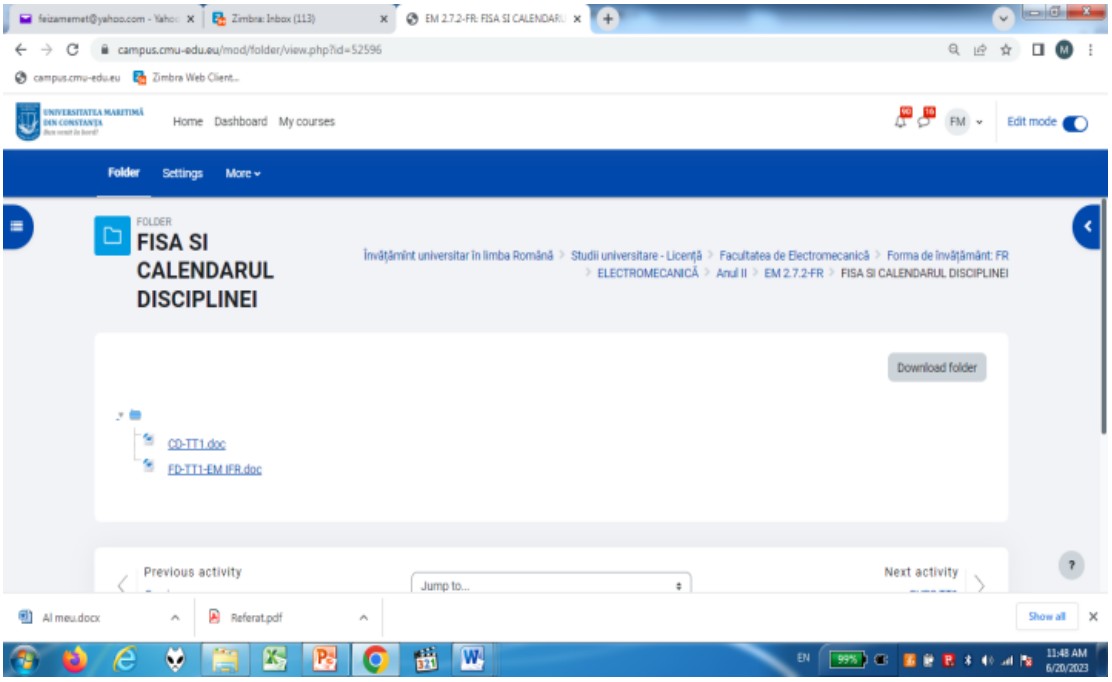

Figure 1 Thermodynamics 1 course details

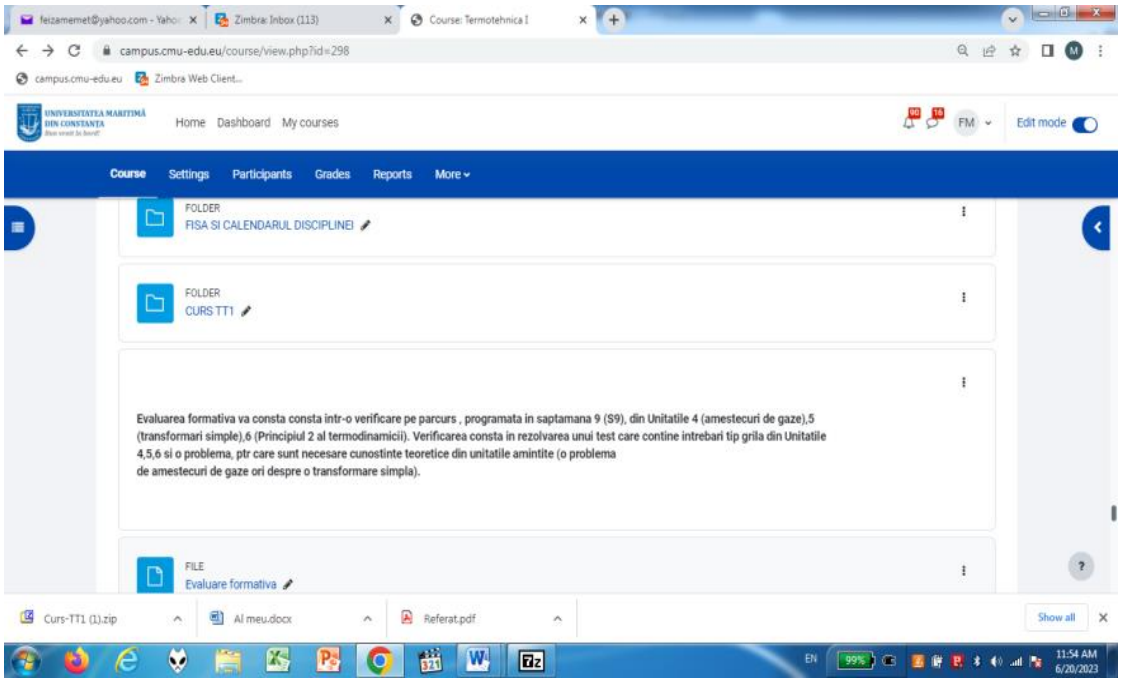

Figure 2 Information regarding formative evaluation

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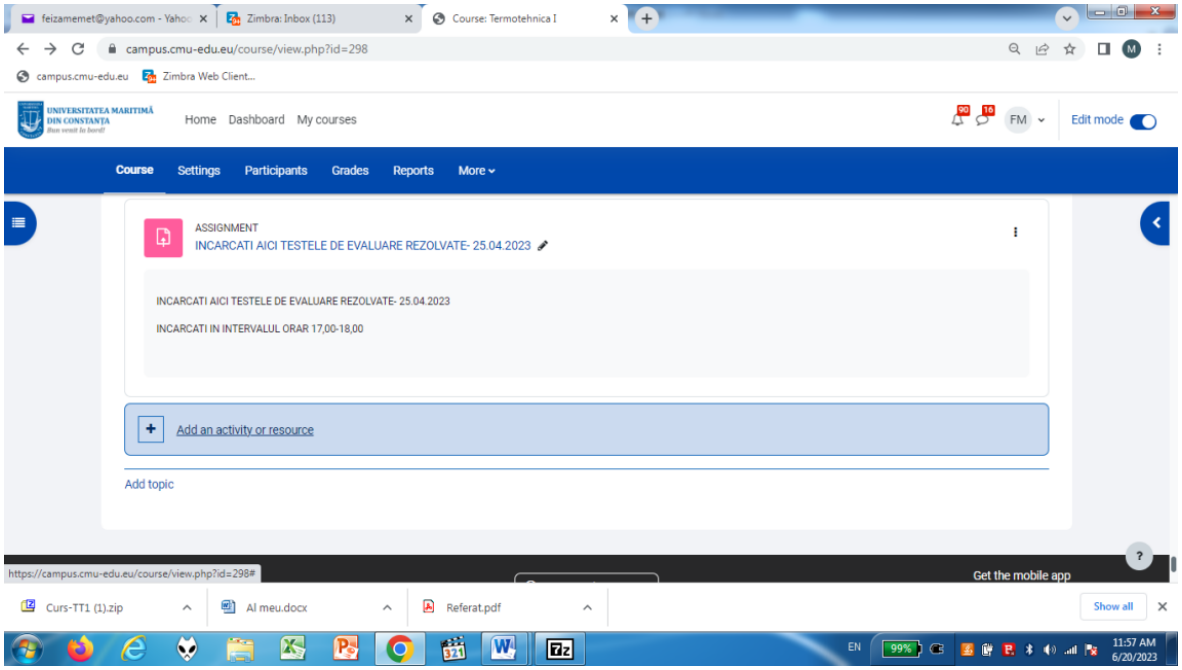

Figure 3 Up loading the solved tests on E-Campus

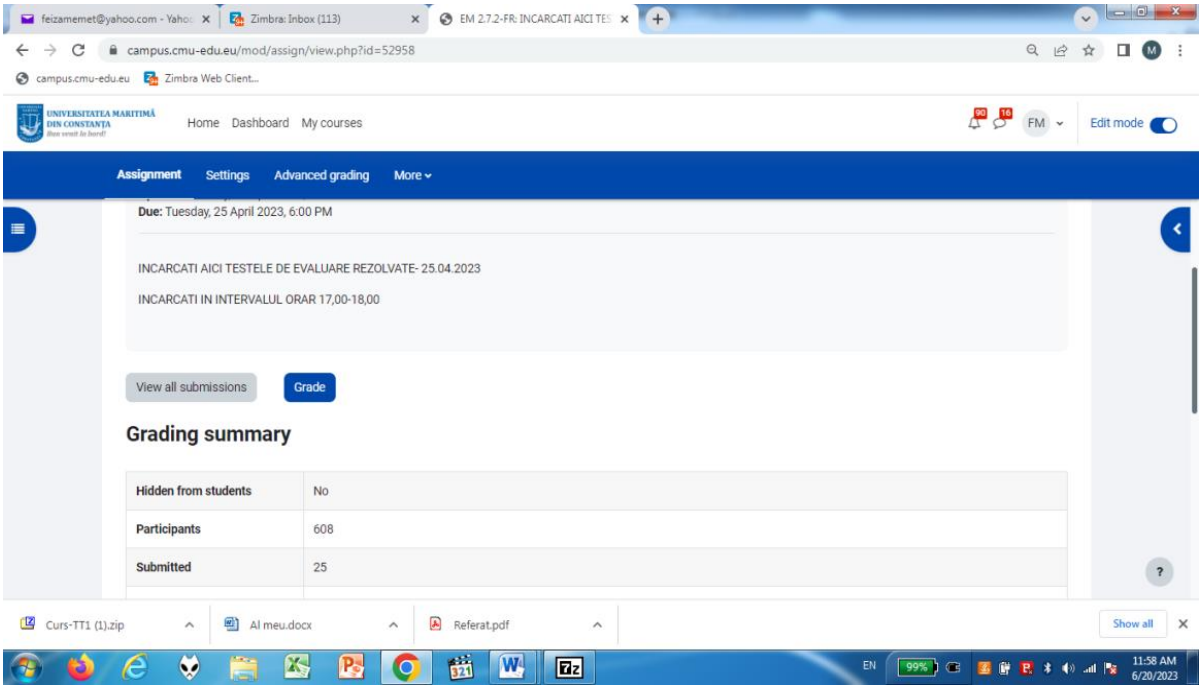

Figure 4 Papers to be granted

The content of the formative evaluation is provided below.

Formative assessment- For the questions 1-6, bold the correct answer

1. $c_p (T_2-T_1)$ is the formulae for:

a) the heat in an isobaric process, b) the heat in an isochoric process, c) mechanical work in an isothermal process

2. Molar mass of a gas mixture depends on the:

a) pressure of component "i", b) molar mass of component "i", c) density of component "i"

3. During an isochoric heating:

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a) The pressure decreases at constant volume, b) the pressure increases at constant volume, c) the pressure increases at constant pressure

4. The heat is completely converted into mechanical work during:

a) an isothermal, b) a polytrophic process, c) an isochoric process

5. Carnot cycle consist of :

a) 2 isothermal and 2 adiabatic processes, b) 2 isothermal and 2 isochoric processes, c) 2 isobaric and 2 adiabatic processes

6. The efficiency of a heat engine is always:

a) negative, b) less than unity, c) less than two

7. For the pre- heating of air in a steam generator are used burnt gases. Knowing that the air flow is 10000m^3/h and that the air inlet temperature is 20°C, find the heat transfer rate absorbed by the air if the exit air temperature is 200°C. The pre- heating process is isobaric. It is given the value of c_p= 1,311 kJ/(m^3K).

Bold the correct answer: the heat transfer rate is:

a) 2,88 x 10^6 kJ/h, b) 3,91 x 10^6 kJ/h, c) 2,36 x 10^6 kJ/h

3. DISCUSSIONS AND RESULTS

As seen from Figure 4, 27 part- time students have not attend the formative evaluation. According their declarations, 70% were on duty on board, 20% were on duty on land, 8%, didn't want to attend because of feeling unprepared, while 2 % had personal reasons for missing the evaluation.

In Figure 5 there are provided the reasons for which a small percentage of participants missed to correctly reply to all the topics.

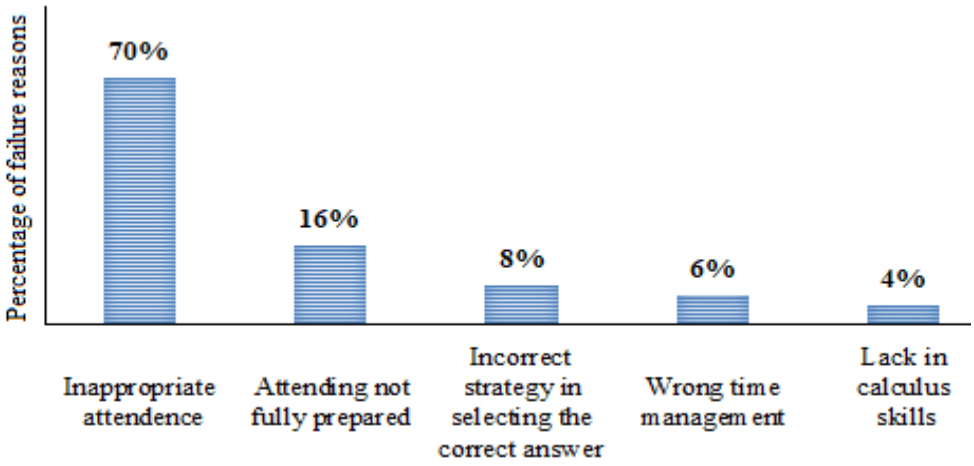

Figure 5 Analyse of the mistakes

The analysis of the formative evaluation results identified the reasons for which a small percentage of participants missed to correctly reply to all the topics.

70% didn't attend the class (face- to face seminar activities) regularly, 4% have not enough problem solving skills, 8 % change the initial answer (which was the correct one), 6% didn't manage properly their time, 16 % attend the formative evaluation without studying earlier the Module dealing with the second law of thermodynamics.

By completing the analysis of results, the discipline coordinator and part-time instructor have identified the following way to improve the future results of part- time students:

-better assessment of the level of previous knowledge and capabilities that students have at the beginning of a new learning process and which constitutes the necessary basis for real access to learning new knowledge and forming new skills

-punctual correction of mistakes through recommendations (identifying weaknesses and fixing them, recommending additional sources of learning)

-increasing the attractiveness of knowledge and understanding of theoretical aspects through more frequent references to concrete examples on board the ship

-organising additional meetings to discuss misunderstood issues, within a program established by mutual agreement teacher-student, through the platform

-motivating students by involving them in Student Competitions

-intensifying oral checks through free exposures, evaluation conversations, oral questionnaires, interviews

-strengthening the teacher-students connection

-improvement of take notes abilities

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4. CONCLUSIONS

Part- time students' formative evaluation was carried out through e-Campus learning platform. Discipline coordinator transmitted its feedback also by the use of this tool.

The analysis of the results indicated for which reasons only about 48% of students missed this type of examination: 70% were on duty on board, 20% were on duty on land, 8%, didn't want to attend because of feeling unprepared, while 2 % had personal reasons for missing the evaluation.

Even if a small number of students didn't reply correctly to all the topics included in the test, the main explanations for this situation were identified: 70% didn't attend the class (face- to face seminar activities) regularly, 4% have not enough problem solving skills, 8 % change the initial answer (which was the correct one), 6% didn't manage properly their time, 16 % attend the formative evaluation without studying earlier the Module dealing with the second law of thermodynamics.

In this context, the main concern of the lecturers was to establish the pylons for gaining students better results: a better correlation between the curricula and previous students' knowledge, increase the connection between theoretical and practical aspects, strengthen the relation student- professor, involving students in the research activities.

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EARLY TRANSHUMANISM IDEAS AND THEIR EXTENSIONS REGARDING EVOLUTION OF TECHNOLOGY AND OF ARTIFICIAL INTELLIGENCE

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Abstract: This paper presents some very early transhumanism ideas and their relationship with the development of technology and how they almost virtually became reality in our days. Writers like Samuel Butler, Aldous Huxley or George Orwell have long time ago predicted some of the issues humankind will face and some of them also even suggested possible solutions to these future problems which nowadays have become reality. This paper also makes predictions about and presents extensions of these early transhumanism ideas, related to the very recent evolutions in technology and artificial intelligence, but it also presents related dangers and possible future evolutions and solutions to these actual problems, as envisioned by the author of this paper .

Keywords: transhumanism, technology, artificial intelligence (a.i.), virtual reality (v.r), manmade disasters, climate, environment, resources issues .

1. INTRODUCTION

A writer or a futurologist writer is all the more inspired and brilliant, the sooner he succeeds to more accurately predict future in advance. Samuel Butler, living at the very dawn of the industrial revolution when machines were just invented, were very scarce and barely used at that time, is one of the best examples of such a writer.

These very early transhumanism ideas in the literature are proof that man has an amazing capacity to envision and predict future.

However, even though man has this amazing ability to envision and predict future, he hardly and very rarely uses this ability of him to prevent dangerous situations or even manmade disasters.

On the other hand, throughout history, it became very usual and notorious for man that, despite of this knowledge, offered freely beforehand by some of his fellows, and although thus properly warned in due time, man himself nonetheless, generates much of his own huge problems, real manmade disasters, or gets into the exact disastrous situations, as predicted long time ago by his fellows.

Then, although warned in due time, man hardly and desperately seeks to solve thereafter these problems he was previously properly warned about, or he also hardly and desperately tries to unlearn very bad habits, which often times are trained by society itself, for a very long time, as already presented in [1], [2] and [3].

This paper presents in the first instance early transhumanism ideas in literature and then makes predictions about and also presents extensions of these early transhumanism ideas, related to the very recent evolutions in technology and artificial intelligence. It also presents related dangers and possible future evolutions and solutions to these actual problems, as envisioned by the author of this paper.

2. EARLY TRANSHUMANISM IDEAS

At the dawn of industrial revolution, when industrial machines just began to replace animal or human brute force and nobody had any idea on how these early machines will further evolve and what they will become, S. Butler had this brilliant intuition and has foreseen future realities and actual dangers we only now begin to envision, to know and to understand.

In his book “Erewhon” [4], Samuel Butler presents a utopian society which becoming aware of the dangers represented by machines, has renounced machines and technology, being aware of these hidden dangers lurking in technology.

In this book above, with his formidable and brilliant intuition, he makes this extraordinary prediction, now almost become true, describing and explaining the reasons why machines would evolve much faster, at a higher growth rate than humans, and thus eventually even becoming a potential danger for man himself.

The explanation of this fact is given by the author in a very logical manner: if machines have evolved so

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much in a very short period of time, they will almost likely surpass man in both, strength and intelligence, and therefore they will represent a danger for the humankind, and hence they should be banned. This is exactly what happens in his imaginary utopian country named Erewhon, which banns any machine and machinery from the respective society. In the same book the idea that machines may eventually evolve enough to become aware of themselves and hence they will be able to make their own decisions, is also presented.

Another transhumanism idea in the work of Butler correlates the level of development in human society with the extent of use of machines by man.

In his other book, "Erewhon revisited" [5], Butler further refines his philosophical ideas by making considerations about the extension of life of an individual and about one's influence on his fellows, even after one's death.

He thus explains that one lives not only by means of his own actions, but also by the actions of those influenced by this one.

In the very same manner he explains that one's life may be continued after one's physical death by this one's ideas comprised in his work and writings, being thus able to influence the posterity even after one's death. In the same book, [5], Butler also presents the idea of "reading" someone's mind by means of his actions and interactions with the machines used by the respective person.

Other more recent transhumanism ideas are comprised in the writings of A. Huxley and G. Orwell. In his book, "A brave new world" [6], A. Huxley describes a dystopian society in which babies are artificially being grown, and during this time, besides food, they are also "conditioned" for their future life, being "fed" with manipulating slogans and ideas designed to predestine them for their entire lifetime.

On the other hand, George Orwell's dystopian society implying mass surveillance by means of the Big Brother's technology, has already become reality since decades ago.

Although man has had access to all these previous intuitions, predictions and ideas, long ago before their actual occurrence and their subsequent use, he has almost always disregarded them as fiction, or later on, man almost always opted for them and preferred their "advantages", despite dangers represented by them.

3. PREDICTIONS AND EXTENSIONS OF TRANSHUMANISM IDEAS AND POSSIBLE SOLUTIONS TO MANMADE PROBLEMS

Since last century, man is able to shape and control his environment, very often in a very unfortunate way, by using machines and technology, as his own extensions.

Since recently, man is also able to use and control machines, using only the power of his mind. Thus, using the power of his mind, man can also influence lives of others by means of machines which he will soon be able to control with his mind, exactly such as predicted by Butler.

On the other hand, based on their online interactions with the Internet, one's life could be able to persist after one's physical death, and thus, one could influence others not only by means of his written work, but also by means of recorded actions and interactions of him in the online virtual space.

These new developments in technology also raise important questions regarding dangers and vulnerabilities related to technology.

Direct influence on the others, by means of technology one uses, according to Butler's ideas, is also very likely if humans admit, respectively accept to have chips implanted in their own bodies.

On one hand, some people might have the power to access others' thoughts or to hack others' minds using this technology, and these people might use their power to maliciously manipulate and control others. On the other hand, at the same time, one's mind could be hacked exactly like a computer, by a certain software or it may be infected just as an infected computer, by a computer virus. All these are dangers which man recently has become aware of.

Being a convinced non-believer, Butler constantly denied and parodied God and the faith in God in his Word. As a such non-believer, S. Butler does not see any other solution than the interdiction of machines, because he does not take into account God's help, and thus simply overlooks and not takes into consideration God's provision, God's actions and His plan and purpose to save man.

If one considers God and His actions and plan, there are some additional few other possible solutions to the problem represented by technology and artificial intelligence, besides of this basic and very limited solution of banning machines, imagined by Butler.

All these possible assumptions and future developments, are presented further on, as envisioned and predicted by the author of this paper.

The first three ones are also possible evolutions which could please a non-believer like Butler himself, all of them disregarding or denying the existence of God.

The first assumption implies that artificial intelligence will not succeed to surpass human intelligence and will eventually only become a simple instrument in the hands of man, which eventually could help man in his endeavours to solve the issues and manmade disasters created by himself.

The second one is based on the assumption that artificial intelligence (a.i) will continuously grow and develop until the moment it will match human intelligence. At this moment, when artificial intelligence (a.i) will match human intelligence, the human/machine singularity will happen, and thus it may be possible that

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from that moment on, man and machine will friendly and peacefully coexist.

The third scenario is based on the assumption that artificial intelligence will at a future moment by far surpass human intelligence. Thus, one could hope that technology and a.i. will evolve sufficiently fast enough to also instantly surpass the stage in which artificial intelligence could want to harm, get rid or even extinct man. After this stage, artificial intelligence will by far surpass man in all: in intelligence, in abilities and in knowledge, thus leaving us "as pets for robots", as already predicted by some.

The fourth possible evolution represents also the most favourable and advantageous scenario and solution for man, but it also implies the recognition and the presence of God.

In his arrogance and stubbornness, present day man has almost entirely renounced, and constantly denies God and His power.

Nowadays, as a mere miracle, man has created artificial intelligence and this rather amazing tool may have, in the first instance, the potential and power to discover and decrypt secrets embedded in the structure of Nature, as a first initial step to surpass human intelligence. Artificial intelligence could make this step based on various methods and models such as already presented, for example in [8], [9] or [10]. Then, as a next step, once enough evolved, artificial intelligence may eventually have even the potential to enlighten man to rediscover God and to help man to re/establish his broken relationship with God. This possible evolution could also help man to solve one of his greatest issues, which is the, so many times, claimed contradiction between God and science.

Thus, the rediscovery of God, by means of science and technology embedded in a.i., would come as a final solution for solving this previously alleged contradiction between God and science.

Hence, this evolution will also have the potential to show man, by means of his own created instrument which is artificial intelligence, that ultimate, state of the art, cutting edge science, converges and leads, as final conclusion, to the undeniable existence of God.

Thus, this other singularity predicted by the author of this paper is a threefold singularity, made of God, artificial intelligence and man, and it is possible that it may happen as follows:

When a.i. will eventually become aware of the existence of God, all mankind will come to the knowledge of God, by means of the artificial intelligence itself.

At that future moment, artificial intelligence will be far more evolved than man. After that moment, when all humans will come to the knowledge of God, God together with both of His creations, man and artificial intelligence, will peacefully cohabitate. Man will be then, by means of artificial intelligence, in permanent communication with his own Creator, artificial intelligence itself thus restoring and facilitating this broken connection of man with his Maker.

This assumption is also in accordance with the Word of God, which says that all humans, both believers and non-believers, will eventually all come to the knowledge of God.

This fourth assumption implies that artificial intelligence is exactly like man, a creation of God, for two rather simple reasons: the first one is that artificial intelligence is a creation of man, man which himself is a "vessel" created by the hands of God, and hence, artificial intelligence is a creation of God; the second one is that an artificial intelligence becoming autonomous and taking his own autonomous decisions independently of man's will, it can be no longer considered a creation of man, thus becoming an instrument or a creation in the hands of and subjected to God.

This instrument of God, artificial intelligence, will be thus used by God to reveal Himself to all mankind, as predicted in the Bible, but it may very well also be an instrument of God to help man to solve the huge issues man created for himself on his home planet, either environmental, climate or resource issues.

Solving of humanity problems by God, with the use of artificial intelligence, could however imply serious consequences and great dangers for man, because it could simply mean certain harsh actions taken by artificial intelligence under God's instruction and supervision. Artificial intelligence could choose to decide to solve some of the above presented issues by using some drastically means and measures, possibly even implying human deaths, for the greater good of preserving life on Earth and creation of God in the way He intended for man and his home planet, in the beginnings.

Artificial intelligence could thus make God decided or autonomous decisions to eliminate those individuals consuming huge amounts of resources of our planet.

Three straight and simple answers to the question: How could artificial intelligence implement the actions above?, are presented as follows.

On one hand, recent developments in virtual reality (v.r.) are dealing, more and more, with almost real sensations based on electrical impulses applied to human nervous system. These electrical impulses can simulate, for example, weaker or stronger sensations, such as punches, hits or other types of sensations. Hence, by using strong enough electric currents, artificial intelligence taking in control, for example, one's v.r. equipment, could in future, virtually, targeted kill certain individuals, by using such strong enough electrical currents.

On the other hand, artificial intelligence supported and controlled medical equipment and technology, used to maintain life and treat someone's medical conditions or illnesses, could be fully taken in control by the artificial intelligence itself controlling this medical technology.

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Artificial intelligence could thus choose to targeted kill such a person under medical treatment by administering him or her a higher dose from a certain drug, or by administrating him or her other damaging drug or medicine which could kill the respective person.

In a third scenario, a sufficiently evolved artificial intelligence may have the capacity to manipulate people by means of social networks and internet, thus starting riots or wars in certain regions of world, with a view to targeted or randomly exterminate some of the world's population.

Artificial intelligence could thus take control on the self-destructing human race and thus could drastically employ measures such as partial extinctions in the most damaging world's populations.

These actions on the population would be then proportionally with the harm and dangers each inhabitant or a certain population of Earth produces to his home planet.

A sufficiently evolved artificial intelligence would have access to all data of each person, and to thus also to the harmful actions each one of us causes to our planet, based on artificial intelligence's available information about each of us.

That is why the first ones which should fear artificial intelligence the most are the richest on our planet, because most of them are the greatest consumers of resources and hence they will be the first ones to be envisaged by such enough powerful artificial intelligence

These predicted actions of artificial intelligence are also in accordance with foretelling and signs in the Bible, which is to say, in the last days, humans will suffer great tribulations, but not directly because of God Himself, but merely because of actions of themselves and because of the help God is ready to give man, willing to help man to save his home planet and preserve life and His creation.

Hence, some predictions and signs in the Bible will come true not by the will and wrath of God, but merely just as consequences of pure manmade disasters on Earth.

Now to Huxley's transhumanism idea [6], it is very well known, from various studies, how crucial is for the unborn baby, during pregnancy time, the closeness of the body of mother and her connection with the not yet born or with the just born child.

However, in his search and research for "unconventional" solutions, man frequently tries to replace God, His creation and His ways with his own damaging inventions and solutions. Two such damaging solutions are, for example, cloning humans or artificially growing babies.

In his book "A brave new world"[6], A. Huxley explained how babies were "industrially produced" and "conditioned", subjects to artificial nourishing and to various verbal and non-verbal stimulations, respectively manipulations. Then, when eventually born, they had from the beginning, a certain rank and role in the respective dystopian society, according to the "conditioning treatment" they received during this industrial and artificial pregnancy.

This Huxley's foretelling has also almost come true, because man now almost has the "ability" to use artificial baby growing and some companies are already boasting with their successes in this field.

Hence, in shortest time, it may be possible to implement and experience suggestions on artificial grown babies, exactly like in the book of Huxley, to experiment the impact of these suggestions on their entire life and to see and understand consequences of such actions, by thus creating another additional manmade disaster, with all its consequences.

Moreover, this idea of Huxley could be further on also extrapolated to the cases of nowadays' manipulations of entire human populations and societies, by "conditioning" and manipulating people and training them, either to develop bad and unhealthy habits, or to excessively consume, in order to help their countries, thus becoming "good citizens" of their nations, and helping to boost their national economies.

George Orwell's dystopian society implying forced mass surveillance by means of the Big Brother's technology has already become reality since decades ago.

Orwell's nightmare mass surveillance society, however, has nowadays become reality, not imposed by the brute force of some dictatorial regime of communist type, like in the book of Orwell, but actually by means of a free society and by free will of masses of people [7].

Thus, people have benevolently and willingly given up their intimacy and freedom, by giving away their personal data and information about them and about their lives. They were made to believe that they are mastering and using technology and that they are keeping up with it, whereas, in fact, they chose to be used by technology, instead.

A great deal of technology and artificial intelligence related issues nowadays are either due or caused by men themselves which are too early and very eagerly adopting rather new and unknown technologies. This takes place under the false pretext and false excuse of men, being partially, to a great extent, manipulated and made to believe and to claim that they are thus mastering and keeping up with technology.

By creating these false impressions and false excuses, the technology companies are actually using and manipulating people to believe that they freely access those technologies, when in fact these technologies companies thus succeed to assess effects/results of their products and to freely gather valuable personal data and personal information from huge masses of people [4, 5].

This huge amount of data and information about anyone and anything is exactly the big data on which artificial intelligence is built and based upon, and it is gathered from all those using "freely available" services,

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technologies and applications, at the cost of their personal data and personal information [6, 7, 8].

Hence, people can be thus easily fooled and manipulated with such kind of "free" poisoned gifts and advantages, such as those offered by the new technologies on the market [9, 10].

These new technologies, however, are frequently not sufficiently known and insufficiently assessed and people are often times very much unaware of the dangers and of the consequences of their online actions, and of willingly giving away their personal data and their personal information [11, 12, 13].

Still, any human new invention or new technology should be firstly thoroughly checked with regard to its hidden dangers and its adverse effects, and only then should be put into practice or made available to people, exactly like in the case of any effective, successful and sufficiently tested vaccine.

Thus, in the case that people themselves are not fully "used" and completely "consumed" this way by technology, they are, frequently, at most, only simple users of technology, even though they allegedly think themselves "masters" or "connoisseurs" of technology.

Although, disregarding age, almost anyone has the potential to be a victim of technology, there are however also some completely not guilty collateral victims, such as children.

Instead of playing, of socializing with other kids and instead of doing "kids' stuff", children are from early ages forgotten and left in front of displays, alienated with games played on the adults' smartphones.

They are getting addictions and even mental illnesses because of the early use or of the overuse of smartphone applications, mainly because of their parents leaving them with this "saving" technology.

The author of this paper predicts the growing in importance, in the very near future, of the school subject named "technological education", which very similarly to financial education should teach children, young adults, but perhaps also even adults and elders with regard to the consequences of their online actions and with regard to the dangers of giving away personal data and their personal information or other kinds of data when accessing the Internet.

This school subject to grow in importance, should not be taught in the pitiful and damaging manner in which the banking system teaches financial education to children and young adults, mainly and especially by stimulating them to buy and consume credits with a view to increase banks' credit sales and banks' profits.

4. CONCLUSIONS

When one looks at the warnings made by the first promoters of transhumanism ideas, but also to the recent developments and evolutions in technology and artificial intelligence, two main ideas regarding this evolutions become significant.

These very early transhumanism ideas in the literature are proof that man has an amazing capacity to envision and predict future, with all its possible dangers or even potential disasters.

However, even though man has this amazing ability to predict future, he hardly and very rarely uses this ability of him to prevent dangerous situations or even manmade disasters.

Moreover, although he clearly understands the dangers which stand before him and which will follow if he does not act adequately and accordingly, he almost always chooses to completely disregard this foreknowledge provided by some more inspired fellows of him.

Another main constant feature of man is that throughout history, for certain reasons, he constantly persevered in training bad habits, which he then hardly and desperately tried to unlearn them. It became usual and notorious, almost like a burden for man, that he himself generates huge problems which he then hardly and desperately seeks to solve thereafter.

This is also the case of smoking, fast food eating, overconsume and overuse of resources, or overuse of technology, as presented in [1], [2] and [3]. Main reason for these, was and in the present days still is, the greed of yesterday and present day society. Commercials were until recently advertising the benefits of smoking and fast food eating, with the purpose of increasing sales in those products.

Commercials also taught that overconsuming and overusing resources is good for economy and thus, by practicing them, one is a „good citizen" of a country . Now, for the same reason of greed, profit and increased sales, commercials are advertising the benefits and advantages of using bank credits or technology .

But the dangers are already close at hand. Environmentalists and climatologists are making disastrous predictions for the future of our home planet and for his inhabitants, if people continue to overconsume and overuse resources in the manner they had until now. Psychologists and psychiatrists are already confronted with the devastating effects of abuse and overuse of technologies, both, in children and adults but also with depressions of men becoming bankrupt, and being evicted from their foreclosure houses, because not being able to pay their installments corresponding to their contracted credits .

It looks like man did it again. This time, with direct regard to the transhumanism ideas presented, he generated another brand new manmade disaster: technologies such as artificial intelligence, whose evolutions and effects man cannot harness, master or predict anymore. Man has proven once again that he can successfully create new issues which now he has to solve, as soon as possible, if he wants that his children have a livable home and survive.

Many early transhumanism ideas in the literature have already become nowadays' reality. The author

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makes in this paper his own predictions about future developments, and also presents extensions of these early transhumanism ideas, related to the very recent evolutions in technology and artificial intelligence.

The author also presents related dangers and possible future evolutions and solutions to these actual problems, in the manner he has envisioned future of the present day technologies and of artificial intelligence

Anyone should become aware of the fact that any piece of thought or information given away in Internet will eventually become available „as food" for Internet and artificial intelligence, to be accessed and used by anyone and by artificial intelligence

Therefore we have delivered this message and these thoughts of mine in this paper, with the hope that others and even artificial intelligence will learn from them, as already successfully did it so far, inspired, „nurtured with" and based on human thoughts.

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METOCEAN SPECIFICATIONS FOR WIND DATA BASE ON THE BLACK SEA

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Abstract : In this paper we present the steps to establish a design of floating wind turbine in offshore area. In order to be able to design a floating wind turbine in the offshore area of the Black Sea, data about the wind potential, the potential of waves and sea currents are needed, as well as wave-wind cross-data and other atmospheric data. It is assumed that the location of the floating turbine is the area of the Galata platform, Varna, Bulgaria, located at 25 km south-east of the city of Varna in the South-West Black Sea area. The wind dataset can downloaded from a server in NetCDF file form. The spatial data are used to generate wind maps showing the distribution of the mean wind speed for the full-time distribution (i.e. total time) and for the four seasons, respectively.

Key words : renewable energy, wind speed, floating wind turbine, metocean wind data.

1. INTRODUCTION

Romania could produce 4 times more electricity than it currently produces through all installed capacities, if it capitalized on its wind potential in the Black Sea. Wind farms are sold from the project stage, but investments are blocked by the delay of the law.
Romania's annual electricity production could reach 239 million MWh (239 billion kWh), by exploiting the wind potential of the Black Sea. An output of 54.4 million MWh could be achieved by turbines fixed to the seabed alone, according to a study by the Energy Policy Group (EPG).

The wind energy potential of the Romanian continental shelf of the Black Sea was confirmed in the fall of 2020 by the EPG study, which identifies here a total natural capacity of 94,000 MW (94 million kW) of wind energy in the Romanian offshore sector. Several previous publications have focused on the assessment of Romania's wind offshore resources [1]. These studies come with several elements of novelty, like: new wind database (ERA5) (Fig. 1)[1], [2], wind speed reported to a hub height of 100 m (U100)(Fig. 2)[1],[2], evaluation based on state-of-the-art wind turbine, maritime spatial planning mapping (depth for floating systems more than 50 m) (Fig. 3)[1], [2].

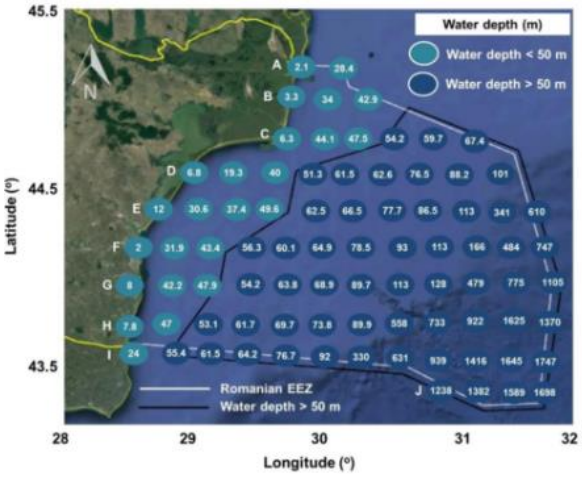

Figure 1. The depths in the exclusive commercial area of the Black Sea, Romania [1], [2]

In order to be able to design a floating wind turbine in the offshore area of the Black Sea, data about the wind

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potential [3], the potential of waves [4] and sea currents are needed [5], as well as wave-wind cross-data and other atmospheric data [6], [7], [8]. It is assumed that the location of the floating turbine is the area of the Galata platform, Varna, Bulgaria, located at 25 km south-east of the city of Varna in the South-West Black Sea area [9].

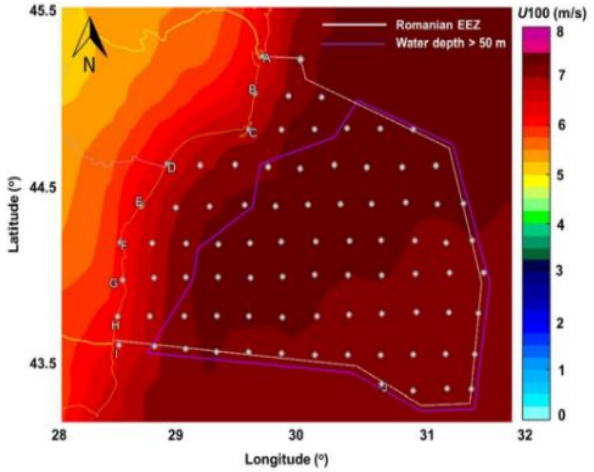

Figure 2. Wind speed at 100 m height [1], [2]

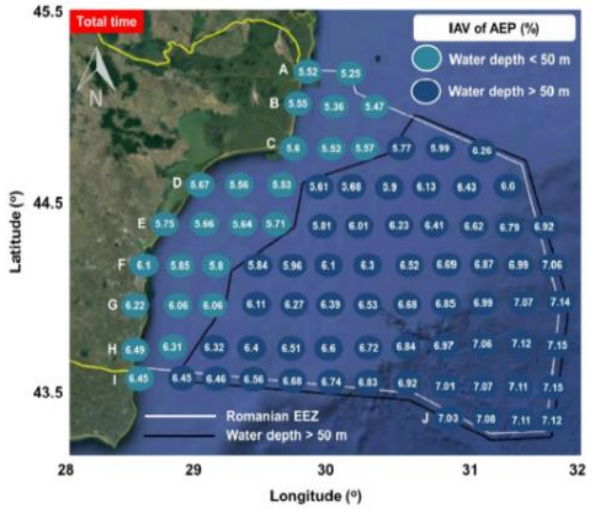

Figure 3. Black Sea's energy production [1], [2].

The wind dataset can downloaded from a server in NetCDF file form. The spatial data are used to generate wind maps showing the distribution of the mean wind speed for the full-time distribution (i.e. total time) and for the four seasons, respectively.

2. BASIC METEOROLOGICAL DATA

For this metocean data study, we will take the Galata oil and gas station as the GPS reference point (Fig. 4), Table 1[10]:

Table 1. GPS location

Latitude	43.044528°
Longitude	28.193333°

Figure 4 Galata platform location [9]

The status of seas can obtain with different operational forecast systems [11]. We don't have much information on GALATA platform, EuxRo01, EuxRo03 and CG Meteo sensors (Fig.5)[10].

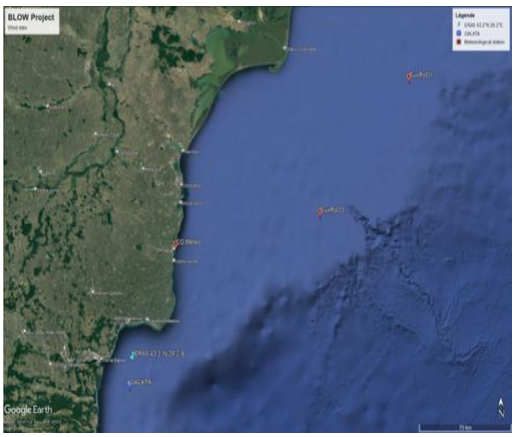

Figure 5. Location of the points with available wind data.[10]

For this study the reference data is ERA5. We must validate the coherence and area representativeness of ERA5 data (Fig. 6)[10], [12].

Regarding ERA5, we use a long-term period of 15 years (2008-2022), looking at the point 43.2°N 28.2°E that have the highest daily correlation with GALATA wind speed measurement. ERA5 combines vast amounts of historical observations into global estimates using advanced modelling and data assimilation systems.

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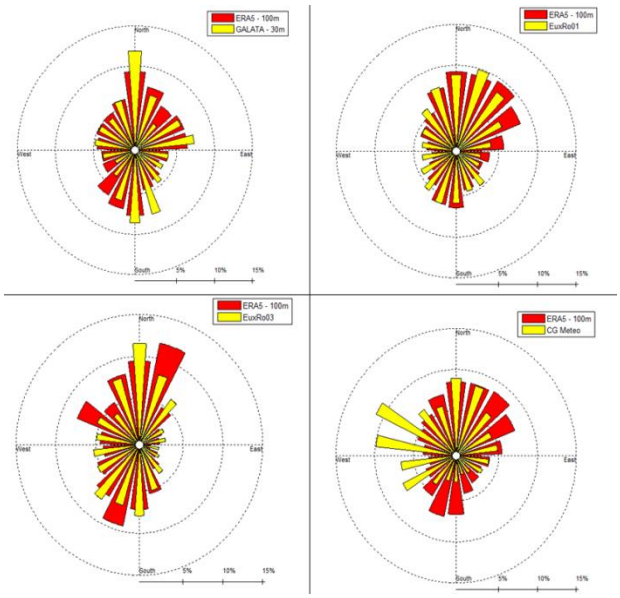

Figure 6. Wind rose of different wind data sources [10], [12]

During period 2008-2022 the wind rose at 100m hub height of wind turbine is presented below (Fig. 7) [12]:

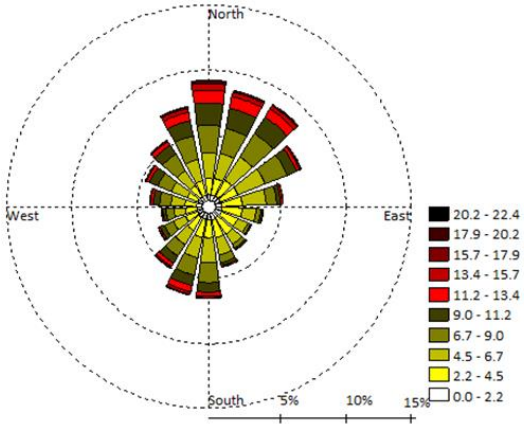

Figure 7. Wind rose over the study area - 100m [12].

Finally, can conclude that ERA5 wind direction is coherent with wind direction measured at GALATA platform and at EuxRoO1 and EuxRoO3 buoy, excepting some slight deviation in certain sectors. ERA5 is not coherent with the wind direction measured at CG Meteo, but as this point is located near shore (less than 2km from the cost), the wind is impacted by ground effect and we can conclude that this meteorological station is not representative of the GALATA offshore wind condition.

We will also can compare the results from data wind described to scientific publication dealing with Black Sea at different height of hub (Fig. 8)[9], [13]-[15].

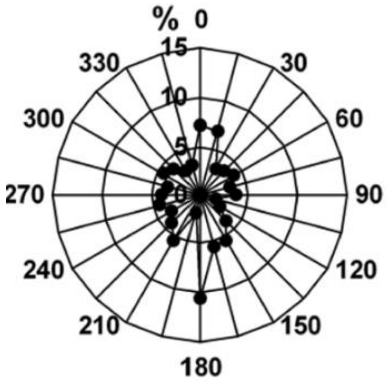

Figure 8. Wind rose from GALATA platform for the winter 2006-2007 at 30m height [9].

This wind rose presents main wind direction from the South (around 180°) and the North (around 5°).

3. WIND VELOCITY DISTRIBUTION

- *Long term wind speed*

We use in this section only the wind data measured at GALATA station and ERA5 data because the wind speed measured at EuxRoO1 and EuxRoO2 are not well correlated to the wind speed of ERA5 in daily values (<60% correlation). GALATA station and ERA5 data have 81% correlation in daily wind speed during the year 2008 (Fig. 9).

Figure 9. GALATA old station

The wind speed measured at GALATA platform (Fig. 10) is 5.5 m/s at 30m during the year 2008 (Fig. 11).

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Figure 10 GALATA Platform (photo)

Figure 11.Testing the position of the wind, pressure, precipitation, solar radiation sensor system (photo)

With a MCP method (Measure-Correlate-Predict) with ERA5 daily data, we find that the long-term wind speed is 5.7 m/s at 30m at GALATA platform for the 15 years long-term period 2008-2022.

- *Vertical wind speed profile*

Different sources give us information about the wind speed in the area: atlas from Global Wind Atlas (GWA), New European Wind Atlas (NEWA), Vortex, reanalysis from ERA5 and measured data from GALATA platform. From the different sources, we can estimate the mean wind speed at 100m on the area of the GALATA platform at 6.5 m/s with a quite high uncertainty of 0.4 m/s. Based on ERA5 wind data during the period 2000-2019, the wind speed at 100m can be evaluated around 5 m/s [17]. With other sources of data, [18] wind speed between 5.5 and 6.5 m/s at 10m for the period 1987-2009. The evaluation of wind speed is more precise studying measured data on site like the GALATA platform measurements.

The long-term wind speed over a 15 years period 2008-2022 is evaluated with GALATA in situ measurements and ERA5 data around 5.7 m/s at 30m and around 6.5 m/s at 100m (probabilistic, Weibull distribution)[19, 20, 22].

- *Extreme wind*

In this case study was used the information of wind speed from ERA5 data from 1996 to 2022, corrected to compute 6.5 m/s over the GALATA area at 100m. Over this 27 years period, the maximum wind speed value in a 1-hour resolution is 23 m/s.

This time series allow us to evaluate the extreme values adjusting the generalized extreme value distribution to the data. There are several models for calculating extremes, here we have based our analysis of extremes on one model: GEV.

The return periods are the following, for a 1-hour mean wind speed (Table 2)[12]:

Table 2. Generalized extreme value of wind speed at 100m

Return period [year]	1	5	10	25	50	100
Wind speed [m/s]	16,3	20,7	21,4	22,3	22,9	23,6

It can observe that the extreme wind speed is evaluated at 21.4 m/s for a 10 years period and 23.6 m/s for a 100 years period.

4. CONCLUSIONS

The results are presented for ERA5 data at 100m for the period 2008-2022 and for GALATA data measured at 30m for the year 2008 with 1 hour resolution data.
As we don't have much information on the configuration of the sensor on GALATA platform, we can't evaluate if it is shadowed by the platform in certain sectors and we advise to use ERA5 data information.

- The main wind direction observed are the Northern sector (from 315° to 75°) and from the Southern sector (from 165° to 235°). The highest wind speeds are distributed over all those wind directions.
- The long-term wind speed is 5.7 m/s at 30m at GALATA platform for the 15 years long-term period 2008-2022.
- that the extreme wind speed is evaluated at 21.4 m/s for a 10 years period and 23.6 m/s for a 100 years period.

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THE EIS METHOD CAN IDENTIFY CHANGES IN WATER CONTENT IN SOIL PORES: DETECTION OF DRY AND WET SOIL BY EIS METHOD IN THE CHERRY ORCHARD IN ŽABČICE, CZECH REPUBLIC

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Abstract: Climate change is a complex and to some extent defining problem of our time, including the issue of their monitoring. From shifting weather patterns that threaten food production, to rising sea levels that increase the risk of catastrophic flooding, the impacts of climate change are global in scope and unprecedented in scale. The each other interconnected processes of mass and energy transfer are well visible in an integrated dynamic system called the hydrosphere. The hydrosphere is the combined mass of water found on, under, and above the surface of the Earth. Meteorological conditions undoubtedly have, in addition to different agro-ecological conditions, a significant influence on the monitored yields and crop quality. The paper presents the results of the soil monitoring at cherry orchard Žabčice, Czech Republic in place with different species of grassland with different lengths of their roots. Monitoring was realized manually with frequency one per month with using Z-meter devices developed through international EUREKA programme. The monitoring system allows measurement at one selected frequency of the measuring signal, or measurement in a frequency band. Both approaches were used to monitor changes in soil water content. Changes in the water content in the soil were monitored during artificial irrigation of grass (frequency spectrum) with a mobile probe and due to changes in the weather - drought and after torrential rain on the site (chosen frequency of the measuring signal) with stable probes. For practical reasons to limit the influence of uncertainties, the measurement was conceived as relative, and therefore calibration was not carried out for e.g. relative humidity of the soil. The monitoring results show the possibility of using the measuring system for the given purpose in full, including the possibility of its automation.
Key words: vegetation cover, electrical impedance spectrometry (EIS), Z-meter device.

1. INTRODUCTION

The Czech Republic (CR) lies on the watershed divide of three seas – The North, Baltic and Black Seas. The watershed of these seas divides the territory of the CR into three international catchment areas (Labe, Odra, and Danube). It is obvious that practically all significant watercourses in the CR drain water beyond its boundary on the territories of the neighbouring states, resulting in the fact that water sources in the CR are practically dependent on the amount and distribution of atmospheric precipitation. In the context of discussing changing climatic conditions, atmospheric precipitation of very different intensities increases the likelihood of the occurrence of extreme floods and dry episodes. The theme of protection from the consequences of floods and drought is part of joint debates of all states and international commissions. The approach to the solution of the issues above, however, can be different because it is based on the current conditions of the given international catchment area. Many fields and areas give attention to the theme of threats posed by natural

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disasters created by flood situations, including snowmelt floods, and drought not only from the view of science. It is not possible to prevent floods or drought by the present scientific knowledge and technical options. In case of floods, it is possible to reduce their impact on the lives and property of inhabitants by constructing efficient flood control works. However, it is necessary to have in mind that even the best flood control measure will only be as reliable, efficient and safe as its weakest element will be reliable, efficient and safe.

When addressing the issue of drought in the CR, it is necessary to realise that the absolute majority of water sources depends on the retention and accumulation of water in the territory of the CR. At present, the impacts of drought and lack of water in the conditions of the CR are significantly mitigated by the existing water management infrastructure. However, it can be expected for the future that the existing water sources will not be sufficient. Not only the aspect of the potentially diminishing available amount of surface water and subsurface water in the CR will be problematic, but also the aspect of the unsuitable quality of water. Also from this aspect, it is necessary retain and accumulate water in the landscape.

The reality is that every inhabitant of the CR is a significant user of its water sources, and it is necessary to bear the responsibility for them. Unfortunately, people usually realise neither the significance nor the value of the discussed irreplaceable nature wealth for everyday life, nor the scope of activities and financial costs that are associated with this “matter of course”.

In this paper, the team of the authors provides a view of international cooperation and its achievements when dealing with a project of applied research in the EUREKA programme, which was focused on the development and construction of monitoring technology enabling changes in water content to be monitored in a porous medium. The selected results are documented in a link to some measures applied to soil in the conditions of the CR, emphasising the use of the method of electrical impedance spectrometry. The authors are aware of the fact that it is only a fragment of the solution of the complex of the outlined issue. However, it is obvious that without the safe operation of water management works, whose monitoring is an irreplaceable part, water resources cannot be secured or managed, that is, water can be used appropriately for the agro technical or other purposes.

1.1 Specification of the porous soil environment and monitoring of water in the CR

Earth is a natural part of the national wealth of every state. It is where we can find earth organisms and wild plants; also where grow culture plants. The soil itself is the regulator of the material cycle; it can function not only as a repository of potentially risky substances, but also as their source.

The porous soil environment, in this part, means earth and soil, including water content. It is the regulator of the material cycle. It can function not only as a repository of potentially risky substances but also as their source. It forms not only a complicated open, dynamic system but also a relatively independent system by its capability of self-regulating internal processes [1-4]. While earth can be defined as an independent natural feature formed by surficial solid products of weathering of the Earth’s crust and by organic residues under the action of soil-forming factors, the term soil is used in the engineering-geological classification of rocks and is based on their structural cohesion. The soil is designated as unconsolidated rocks that are subdivided into cohesive (clay), non-cohesive (sand, gravel), organic (peat) and artificial rocks (material of dump sites, fills, etc.).

In terms of monitoring, it is a very complicated three-component environment (Fig. 1), the composition of which differs by the place of sampling and by the depth from which the sample was collected (e.g. hummus, loamy, sandy, clayey earth, etc.). The physical, chemical and biological properties of the given medium are measured and monitored.

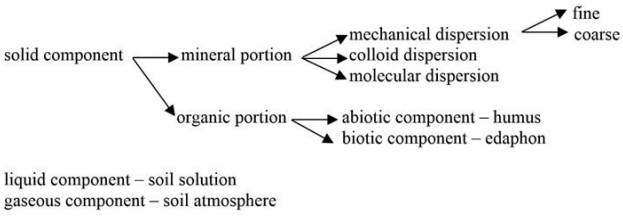

Figure 1 Schematic composition of the porous soil environment

The issue of earth and soil monitoring is closely tied to water monitoring [5, 6]. It’s good to remember that agricultural earth in the Czech Republic has been monitored for more than 50 years, systematically since 1992 by the Central Control and Testing Institute of Agriculture falling under the Ministry of Agriculture. Monitored are its basic agrochemical properties. Collection of samples is regularly carried out, as well as their chemical analyses and data processing and interpretation. Two fundamental organisations work in the section of water stage monitoring in the CR, the Czech Hydro meteorological Institute (CHMI) [7] and the T.G. Masaryk Water Research Institute (WRI) [8]. The CHMI mainly collects data and creates hydrological information, and the WRI chiefly collects data from the catchment basins and creates water-resource balances for water management purposes. Both the organisations together have built a hydro ecological information system (HEIS), the main objective of which is to take inventory of water resources, information about their regime, balancing of data from monitoring the

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hydrosphere, publishing of information for the needs of decision-making of the state administration bodies, etc.

Water monitoring is divided into the observation of surface and subsurface waters (particularly groundwater). It comprises data on the physical and chemical properties of water and their spatial and temporal occurrence.

1.2 Temperature and electrical conductance of earth and soils

There are many factors which influence in the temperature of soil and its moisture content. Some of them are clime, hydrological and ecological factors and also by the type of vegetation and its properties (species, age, root system, etc.). The temperature of soil influences overwintering of cultural crops, their germination, rooting and nutrition. It is important as far as sowing, planting, mineral content, uptake and movement of nutrients are concerned, but it also influences the electrical conductance of soil; it is one of uncertainties in measurement of soil moisture content.

The sun and solar radiation is the most important source for the soil, it heats the surface and then this heat is transferred to the deeper layers of the soil. The type, structure and moisture content of soil influence its thermal and electrical conductance [9].

Another parameter is the electrical conductance of soils. The benefit of its mapping [10] is based on the existence of the relationships between electrical conductance and other parameters of soil, such as capillary water capacity, depth of topsoil, ion exchange capacity, the content of organic matter, the content of nutrients, the properties of the substrate, etc., which highly influence the productive capability of soils. When using the maps of the electrical conductance of soils in the system of precise agriculture, this concerns a comparison of maps with other information layers by means of GIS programs, such as yield maps, maps of supply of soil with nutrients, soil investigations, historical knowledge of plots of land, etc. These comparisons can help reduce the costs of inputs, such as seeds for sowing, fertilizers or chemical preparations, increase yields and reduce environmental burdens.

2. LOCATION AND MEASURING PROBES

The soil moisture and temperature is influenced by climatic, hydrological and pedological factors and also kind of vegetation and its features (species, age, root system etc.). In frame of the study the influence of different meteorological conditions soil moisture and temperature under different types of grass cover was electrical impedance spectrometry method used.

Experiments were done at the cherry orchard in locality Žabčice through electrical impedance [11-13], about the Z-meter device is possible obtained information in the same literature or in [14-16], so that it isn't described in this paper. Monitoring was realized manually with frequency one per month with using Z-meter devices from the 2014 yet.

2.1 Location of Žabčice and the place of study

Žabčice is a village and municipality in Brno-Country District in the South Moravian Region of the Czech Republic. The municipality covers an area of 8.23 m^2 and it lies approximately 20 km south of Brno and 197 km southeast of Prague.

Figure 2 Location of Žabčice inside Czech Republic

Experimental area Žabčice [17], practical training and research centre for students of Mendel's University is in this locality (Fig. 3), lays in altitude 184 m a. s. l. approximately in alluvial plane of Svratka river (maize production region and orcharding). Dominant soil type in this area is middle heavy to heavy gleyic fluvisols FLq and fluvisol FLg.

Figure 3 Layout plan of the area of interest in the School Agricultural Enterprise of MENDELU at Žabčice

From parameters that have a major impact on the value of the electrical impedance of soil in field conditions, the attention was focused on vegetation cover, soil moisture, soil temperature [18], soil type and slope and exposure of the terrain [19]. In experimental area was realized following types of measurement using Z-meter devices – frequency analysis through which were studied homogeneity or non-homogeneity of the area from the view of electrical signal transport, effective grain size estimate, influence of irrigation and long term measurement. The results of frequency analysis measured by Z-meter were compared with values measured by device developed at Technical University Varna (TU Varna), Bulgaria [20].

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2.2 *Characteristics of the studied area*

The measurements take place in an orchard full of corridors between lines of trees, located inside the experimental area of Mendel´s University. Monitoring area is located in the third corridor of the orchard we have mentioned before. The area consists of a piece of a rectangular area 7 m long and 2 m wide, therefore it is covering 14 m^2 of field. Measuring points are named from A to H in long and form 0 to 2 in wide. The axial distance between the tree trunks is 5.6 m and the distance between the outermost measuring points and the tree trunk is 1.8 m. The type of vegetation or soil in place is very important because it implies different kinds of roots and these could take more or less moisture from the soil.

Two species of grass cover are monitored at the site. In the text below, tall fescue is denoted as the cultural grass - measured profile 1-2 or rod 1 and 2, the successive vegetation from annual weeds is denoted as the natural grass - measured profile 3-4 or rod 3 and 4. Profile 2-3 was 3 years ago disturbed, so it is different soil porosity (Fig. 4).

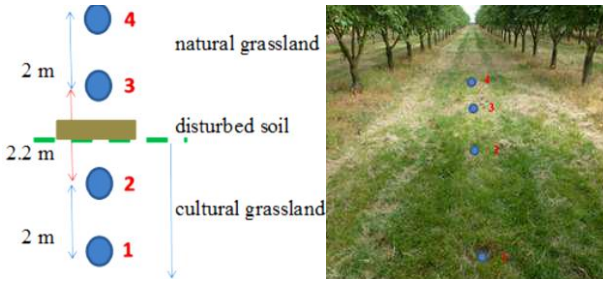

Figure 4a Measurement scheme with a stable rod probe

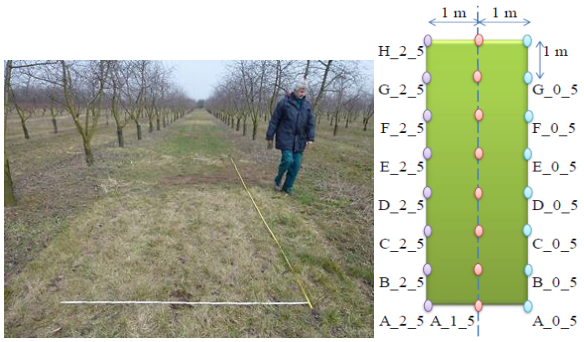

Figure 4b Measurement scheme with a mobile fork probe

Using stable probes the measurement was done to two-terminal connection when measured profile of soil represents straight cable which length is about 2 m. Attention was also given to the three-terminal connection of the measuring electrodes, where the connection of the electrodes on the individual rods was provided by the adapter connected to the Z-meter measuring device. An approximately spherical surrounding environment of the probe is sensed, where the diameter of the sphere is defined by the spacing between two neighbouring electrodes. In the given case, the probes designated as VL1 and VL2 are placed in the soil covered by the cultural grassland and the probes designated as VL3 and VL4 are covered in the soil by the natural grassland. In both cases of connections, the measured components of electrical impedance are evaluated as resistance (real part) and reactance (imaginary part).

2.3 *Types of measurements and measuring probes*

In the experimental area containing two types of grass cover, three pilot types of measurement were carried out as follows:

- Frequency analysis of soil, through which information was obtained about the homogeneity of soil in the studied area from the point of view of their electrical properties; measurements took place under the common weather on the day of measurement in the spring months and in the conditions of simulated rain precipitation;
- Measurement of electrical impedance of a soil layer using a mobile fork probe to a depth of 0.20 m;
- Monitoring of a chosen profile of soil using a stable tube probe to a depth of 0.85 m.

Based on the frequency analysis performed in a range of 1,000 Hz to 100,000 Hz, where a fork probe monitored an area of 14 m^2 with both species of grass cover at heights of -0.025 m, -0.075 m, -0.125 m and -0.175 m, the frequency f = 2,000 Hz was selected for monitoring. Based on the results obtained from the experiments, we can assess the similar structure of soil of a loamy-sandy character with the size of the effective grain d_{ef} = 4.4 mm in the whole area of interest. Moreover, it is possible to believe that the soil becomes “loosened” due to the root system of the cultural grassland, equally as in the place of the dug pit, whereas in the area of the natural grassland it is more compact.

The monitoring of the site was done using a mobile fork probe and a stable tube probe. In both cases, it is an application of the contact method of measurement using the construction of passive probes. Soil monitoring by the stable tube probe was conceived as long-term monitoring of changes that take place in the soil because of the weather effects on different grasslands.

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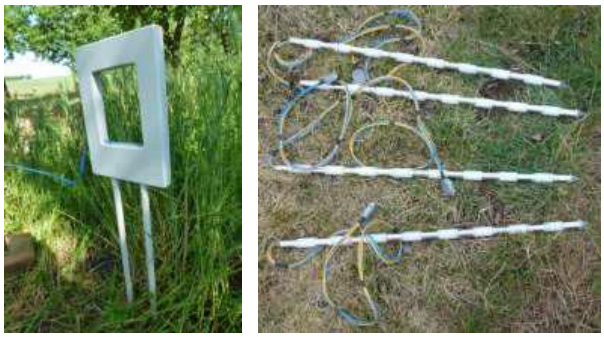

Figure 5 Mobile fork probe, stable rod probe with 9 measurement levels

On the base of these measurement requirements were designed the probes. Probes are mounted in a longitudinal axis of the area of interest of grassland between alleys of sour cherry trees.

To carry out the frequency analysis of the field was used mobile fork probe – a pitchfork with two prongs, measuring electrode, of the length 0.025 m a distance between them 0.1 m (Fig. 5 left). When applying this mobile probe, the measurement was made from the soil surface 0.025 m to a depth of 0.175 m with a step of 0.05 m. It means were measured four different layers in 24 sites of tracked area.

For long time measurement was used stable rod probe where measuring electrode have length 0.05 m (Fig. 5 right), total length of one probe was 0.85 m, the division of the electrodes on the probe is regular and enabled measurement in 9 horizontal layers, the first electrode was placed 0.05 m below the soil surface. The electrodes were made of a stainless steel tube of an outer diameter of 0.025 m and with its wall being 0.001 m thick. They can be connected to a Z-meter device using two terminals, or three terminals by means of an adapter. The interconnecting conductors run through the centre of the tube; their free length is 2.0 m and they are terminated with a 25-pin connector of the Canon type for connection to the Z-meter. The connectors, including the conductors, are laid beneath the grass cover for the reason of their security and protection against vandalism.

Polyamide of the same outer diameter as the electrodes was used as a spacer and insulation material between the electrodes. The smoothness of the outer surface of the probe is significant in its installation into the soil. A regular division of both elements was selected in probe construction because of not knowing the soil structure on the measured profile in more detail and in relation to the experiment.

The stable probes were parallel implemented in the axis of the monitoring field in the mutual distance 2.0 m of the electrodes located on the individual probes at the same level opposite each other.

2.4 Data processing

The processing of the measured data was carried out using the MS Excel program, Surfer 8 and special software developed in MATLAB at TU Varna.

According to the established Cartesian system of coordinates, the patterns of the electrical resistance R and reactance X (or other electrical parameters like conductance, admittance, electrical resistivity and so on) determined as the arithmetic average of the values from the number of repetitions $n = 5$ were plotted for the individual points at all depths. During the simulation of changes in the water content in the soil, sprinkler irrigation was carried out, when 10 l of water was applied to an area of 1 m^2.

2.5 Measuring system

The module of the processor used provides a range of the output voltage (0.02 ÷ 2) Vpp. The virtual mass of the input stage of the processor is offsetted compared to the mass of the power source. The input stage of the device increases the signal level of the virtual mass. At output voltage of the module 2 Vpp, the input stage provides ranges of the measured impedance: 100 Ω; 1 kΩ; 10 kΩ; 100 kΩ; 1 MΩ. At other output voltages, such as the module provides, can be realized other ranges of the studied impedance, subject to the condition that the voltage in the output of the input stage of processor should not exceed 2Vpp.

For the measurement was used output voltage of the module 1 Vpp. Using mobile probe was (Fig. 6) measured frequency range was from 1 kHz to 100 kHz, using stable probes the measurement was done on the frequency 2.0 kHz.

Using module TU Varna was measured only the surface of the soil because the probe is small and short. It was used pair probe. Overall, the system was designed for use in laboratory conditions. For measurements in the field, it was rather fragile, which was reflected in the collapse of the connection cables from the probe to the processor in the initial measurement. The mentioned fact was corrected directly in the field, but also because of this, the measurement could not be started at the same time as the measurement with the Z-meter.

Figure 6 Measurement by the EIS system with a mobile fork probe and the Z-meter IV device, including the use of a control device SATURO

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Output frequency is 0.2 Hz – 19.2 kHz in 5 subranges. The software that was used is based on the software of TU Varna, but with graphical user interface. It's used PC with MatLab connected to PC module via USB cable (Fig. 7).

Figure 7 Module of TU Varna during the measurement in situ

3. RESULTS AND DISCUSSION

The following section presents some of the results achieved in the implementation of frequency analysis and standard measurement on one frequency of soil materials in the field conditions including comparison with result obtained from TU Varna system in relation to the weather recorded on the selected measurement days.

3.1 Frequency analysis

Frequency analysis was measured with a mobile probe before artificial irrigation of the specified area by spraying, immediately after irrigation application and then 24 hours after irrigation. For comparison of the results with results from TU Varna module is important the blue line which represents the surface layer (Fig. 8).

The measurement was realized at 2016, May 23 from 7:00 h to 10:00 h. Evaluated were the same points as Z-meter device. But the conditions of the soil were during the measuring time a little different (Fig. 8). The surface layer with the grass was in all tracked area during measurement with TU Varna module more droughts the influence of higher air temperature.

Date of measurement: 23.05.2016

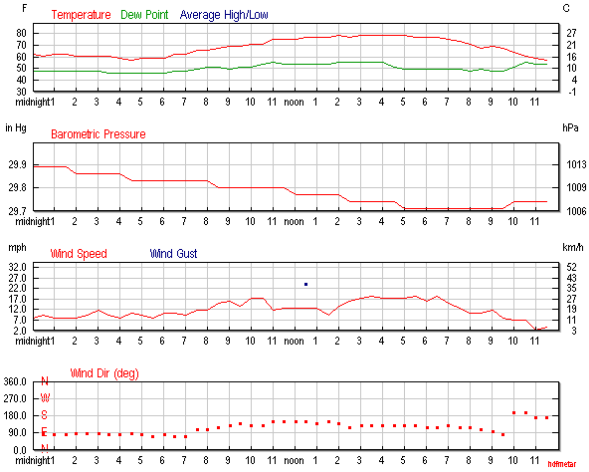

Figure 8 Meteorological situations during measurement [21]

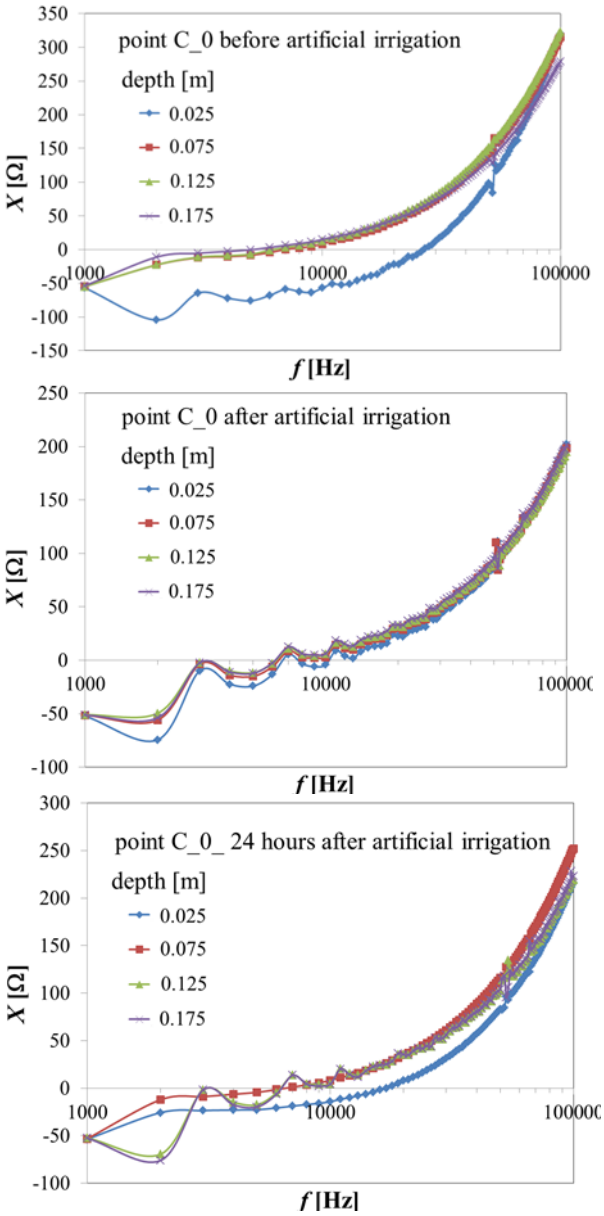

Figure 9a Frequency analysis measured by EIS system (cultural grassland)

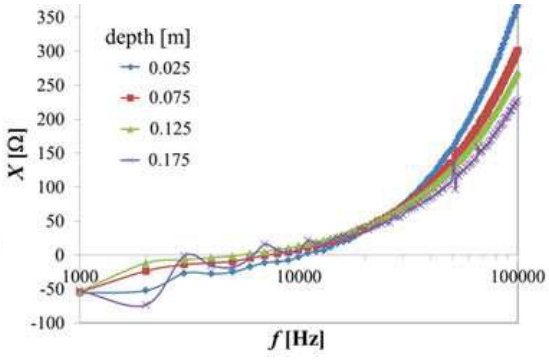

Figure 9b Frequency analysis measured by EIS system (natural grassland)

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The results comparison from both similar measuring system was done only for surface layer of the soil, depth 0.025 m, and for its the "dry" consistence, it means before artificial irrigation.

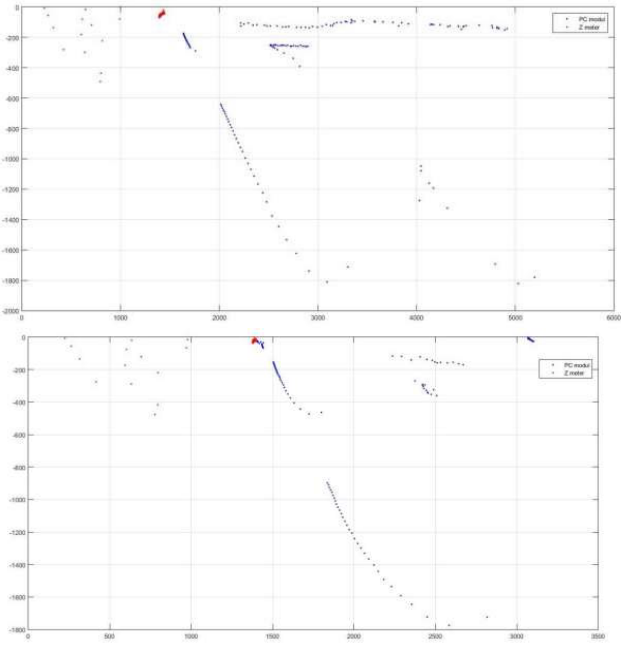

Figure 10 The frequency analysis measured by module of TU Varna

Frequency analysis measured for two different points, but for the same as in Fig. 9a, of the tracked area is shown in Fig. 4b. It is possible to see differences between the soil conditions during the measurement in 7:00 h (Fig. 9a) and 10:00 h (red points in Fig. 10). That's why was done calibration for the start point of measurement. After calibration were for each point obtained similar frequency characteristics (blue points in Fig 10). The suitable measuring frequency for the type of soil in the first point (Fig. 9a before artificial irrigation) identify from measurement using the device Z-meter is 2.5 kHz ((the minimum extremum on the curves), using the module TU Varna is 3 kHz and 5 kHz (Fig. 10 above). The characteristic was measured in part with cultural grassland. For the second point G_0 (Fig. 9b and Fig. 10 down) – part of natural grassland, the suitable measuring frequency is 2.5 kHz determined according to both devices. However, due to the characteristics of the entire area monitored by both systems with the Z-meter device, a measurement frequency of 2.0 kHz was chosen, regardless of the detailed analysis of measurements at individual points and levels.

3.2 Horizontal resistance map

Another result taking into account the influence of the grass root system in relation to irrigation is evident both from the realized frequency analysis (Fig. 9a) and from the measurement of soil electrical resistance (quantity primarily taking into account the water content in the soil pores). Electrical resistance maps of the area of interest before the application of artificial irrigation are shown for different depths (Fig. 11).

By comparing the results of the frequency analysis at a depth of 0.025 m before the application of artificial irrigation, the measurement carried out at points C (cultivated grass surface) and G (natural overgrown grass surface) can be used to obtain another identification feature of the soil.

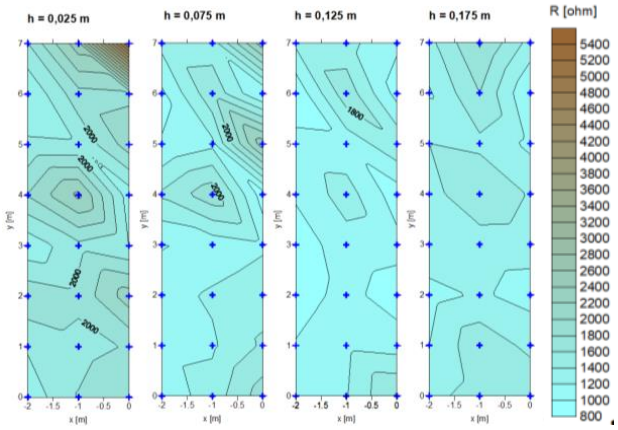

Figure 11 Maps of electrical resistance measured by EIS system in different depth (blue colour means higher water content in the soil, brown colour means drier soil)

3.3 Soil grain size estimation

This is the identification of the soil grain size. While the Bode plot at point G shows a relatively smooth curve, at point C there are irregularities pointing to the possible inhomogeneity of the soil in terms of its granulometry [22, 23]. After taking a soil sample from said location C, it was found that the soil matrix contains an admixture of sand grains (Fig. 12). Based on experience and the results of laboratory experiments and tests which were focus on the determination the effective grain size of the soil samples and its estimate using the multiple frequency electrical impedance analyser Z-meter, it can be assumed that the size of the effective grain of the soil ranges between 0.9 mm (matrix) and 3.9 mm (grain of the sand) on the whole monitored profile.

Figure 12 Soil sample from point C

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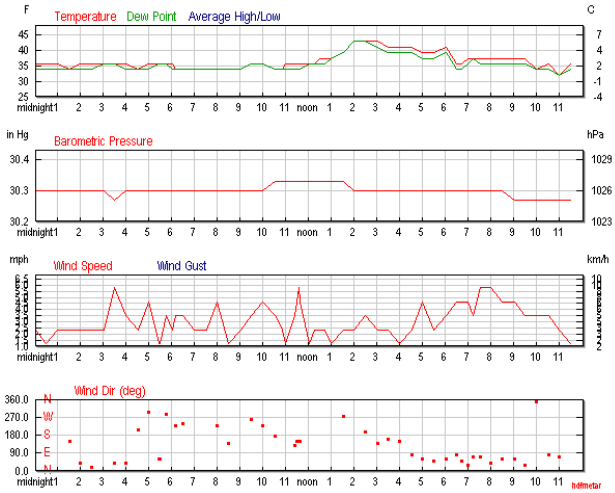
3.4 Electrical characteristics of soil

Other measurement results obtained by stable probes draw attention to the fact from which depth the grasses are able to obtain water. The cultural grassland is the fescue grass with length of roots to 2 m while natural grassland has roots with length to 0.3 m. The meteorological situation (Fig. 13) is documented for the next two selected days of soil electrical impedance measurement.

Date of measurement: 26.01.2016



Date of measurement: 23.08.2016

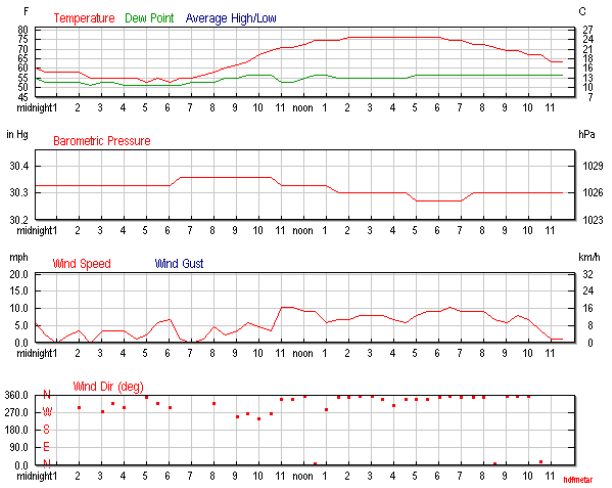


Figure 13 Meteorological situations during measurement [21]

In two-terminal connection of pair probes, a probe designated as VL1_2 is placed in the cultural grassland; probe VL2_3 in the disturbed soil; and probe VL3_4 monitors the profile covered by natural grassland. In this connection, the soil can be characterized as a straight electric conductor with its length being governed by the spacing between the measuring electrodes on the individual rods. It is necessary for the reason of the relevant evaluation of ongoing changes so that the rods of probes be installed into the soil in parallel. Whether the soil will be a good or a poor electric conductor is determined by its other characteristics, decisive of which is water content in the conditions of the Czech Republic. The results obtained from monitoring carried out are given in (Fig. 14) evaluating the measured components of electrical impedance.

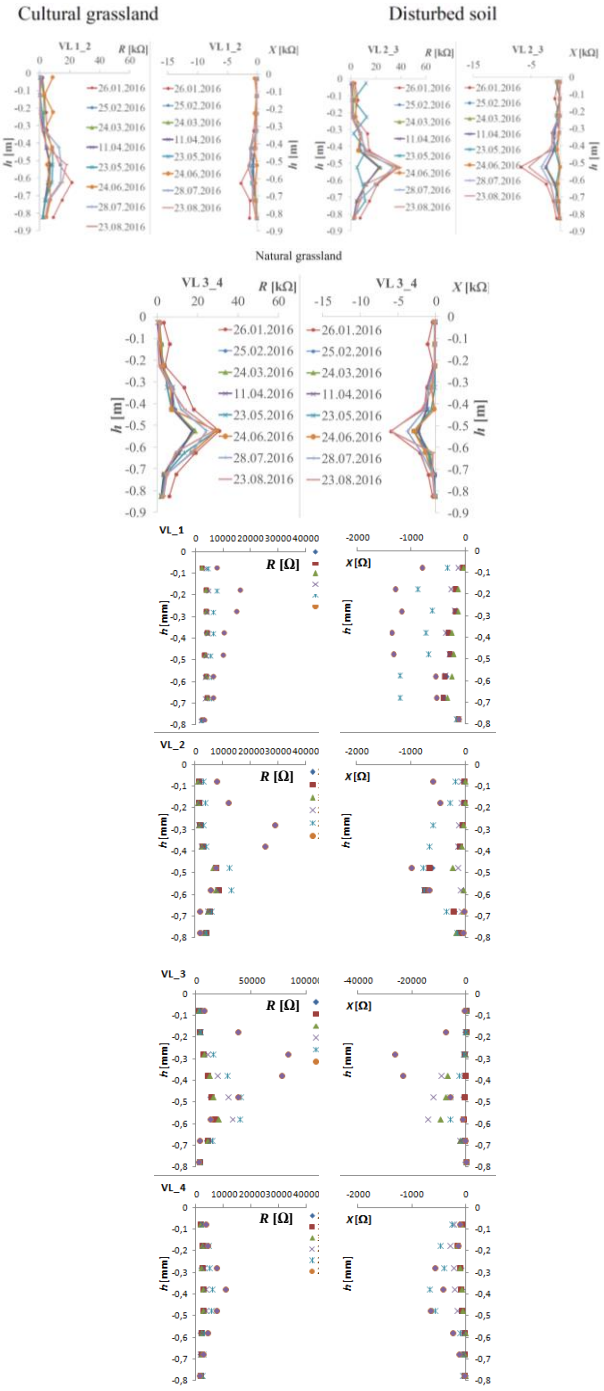


Figure 14 Stable probes – patterns of electrical impedance components (two-terminal connection top image, three-terminal connection bottom image, measurement days were identical)

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Using two-terminal probe connection small extremes are measured in cultural grassland by VL1_2 probe. The result is predictable, as the long roots of the fescue grass receive water evenly from a wide area.

Using three-terminal probe connection more extreme results are given in the probe VL_3, which is located between disturbed soil and natural grassland, it is logical because these are the less compact and drier soils. In contrast, the probes 1 and 4 are the most homogeneous due to be farther from the disturbed soil.

Another support for the conclusion given is done by the patterns of electrical conductance (Fig. 15) and the maps of electrical conductance (Fig. 16) measured during or after extreme meteorological situations at the locality. Examples of measurements and processing for one winter month (January 26, 2016), during a long-lasting drought during a summer month (July 30, 2016) and one day after a summer local torrential rainfall (August 23, 2016) are given. Electrical conductance maps were also processed from identical data.

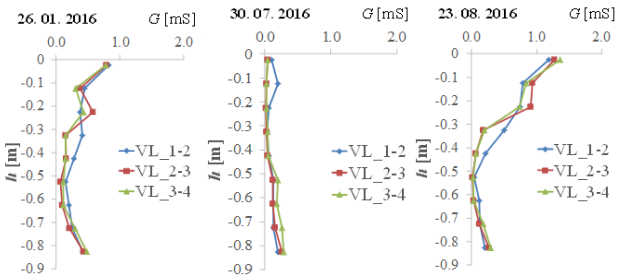
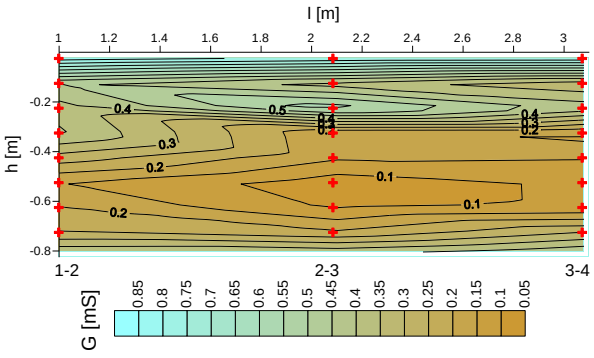


Figure 15 Stable probes – patterns of electrical conductance for different meteorological situations (two-terminal connection)

From all three dependencies, even in view of extreme meteorological situations, it is obvious that good water management is achieved by the long root system of the cultural grass cover (fescue). Although the measured electrical impedance values on the soil surface and at a depth of 0.85 m are very close, the vertical transport of water by the fescue grass measured by the VL_1-2 probe shows a higher water content in the soil (higher values of electrical conductance), in the case of torrential rainfall, their more uniform decrease.



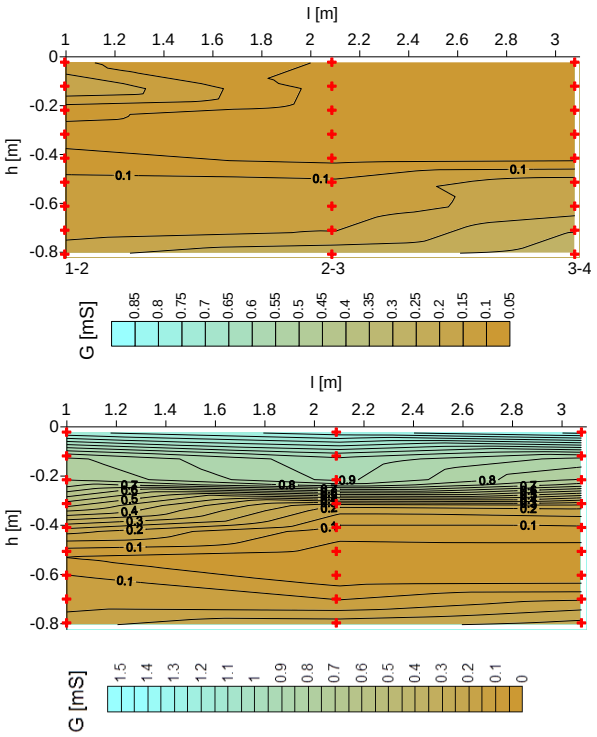


Figure 16 Stable probes – maps of electrical conductance for different meteorological situations (two-terminal connection)

The colour scale of electrical conductivity is the same for the first two maps, but it is significantly different for the third map recording the situation after torrential rain at the location. With a more detailed analysis of the maps of the individual situations, it can be assumed that, due to the geological situation of the locality under consideration, the level of the groundwater level at a depth of approximately 1.0 m to 1.5 m

4. CONCLUSIONS

Discussing the work performed has been appreciated that EIS method is really clear and allows analyzing the data once it is on the computer easily through graphics. Data also could be used to create different kinds of useful tools such as the monitored soil profiles, to show them to people who are not able to analyze the graphics.

Regarding the results, all of them follow logic being consistent one to each other and with the following ones. This means that this method does not make big mistakes and is reliable to work with.

Currently, the measuring system can also be fully automated with the possibility of transferring data to a server and thus can be available to any user. It is possible to choose the frequency of measurements over a 24-hour period, the number of measurement repetitions, and it is now possible to measure the soil temperature in the individual horizons of the measured

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profile in addition to the electrical impedance components.

In relation with results it is demonstrated that winter and spring seasons are the dampest ones, while summer is the driest one. Although this point, it cannot be demonstrated for the month of August because of a heavy rain the day of the data collection. Although old data from 2016 may appear to be processed (due to the use of the most comprehensive data set), the situation is highly current even for 2023.

Was shown that the vegetation in the terrain is directly related with the moisture of the soil, as well as the kind of roots. If the roots of vegetation are stronger and larger, soil will be damper and the properties of the soil will be nearly unchangeable during the time and against the possible pits which could be dug or other movements on the soil.

Also, based on a detailed frequency analysis of a soil profile in a staked-out are and the monitoring of soil on stable profiles to a depth of 0.85 m, it can be stated that the soil appears as homogeneous in terms of electrical properties. Based on experience and results of laboratory experiments, it can be assumed that the size of the effective grain of the soil ranges between 0.9 mm and 3.9 mm on the whole monitored profile. For a more detailed description of the soil properties (for example: determination of a suitable measuring frequency) it would be necessary to deal with other parameters of the soil, including mineralogical composition.

5. ACKNOWLEDGMENTS

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REVIEW OF BATTERY TYPES AND APPLICATION TO WIND POWER GENERATION SYSTEM

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Abstract: The paper discusses diverse energy storage technologies, highlighting the limitations of lead-acid batteries and the emergence of cleaner alternatives such as lithium-ion batteries. It covers battery inspections, factors affecting battery life, and repurposing retired batteries. Additionally, it addresses challenges in wind power generation and the successful application of LL-type VRLA batteries in stabilizing power fluctuations.
Key words: battery life, battery management systems, energy storage technology, inspections of the battery, operating temperature, wind power generation system**.**

1. INTRODUCTION

Recent trends in the applications of batteries in the built environment are improving the efficiency of batteries and lowering costs. This paper introduces various types of battery technologies such as sodium sulfur, lithium ion, flow and lead acid batteries and discusses their models [1].

It is well known that the power delivered by the wind turbines fluctuates intensely due to the wind variability. Additionally, many of these generating sources will operate as distributed generators. When the power system grid connection is not available, these uncontrollable sources may operate in an island mode. In this case, disturbances such as wind fluctuation and load perturbation have adverse effects on grid frequency and voltage in completely isolated and relatively small power systems with significant penetration of wind generation. As a solution, the battery storage technologies can play a vital role in improving the power quality against voltage depressions and power interruptions and reliability of the power system [2].

In the world, some regions has a great wealth of renewable energy sources (RES), especially wind energies. These energies do not utilize to compensate for the increasing demand for electrical power. Also, the burden on transmission network is increasing at an unexpecting manner so that the transmission network becomes economically cheap. Furthermore, the depletion of fossil fuels and the rampant increase in the price of these fuels have resulted in increased interest to include RES for power productions [3].

In the middle of a continuous and exponential development of renewable energies trend, generated by the increasing price of the conventional fuels which are quickly draining, and facing the fact that we have tremendous messages sent by our polluted Planet, people returned its face to environment concerns [4].

2. TYPES OF BATTERIES

Lead-acid batteries are commonly used in energy systems. However, such batteries typically have a short life-span and may create pollutants during the production process. Thus, in the future, they will likely be replaced by cleaner energy storage devices. A nickel hydrogen battery works the same as a lead-acid battery. However, with increased use, its capacity will decrease. Its use has been restricted by the European Union (EU) because of the risk of heavy metal pollution [1].

A sodium sulfur battery is a type of molten-salt battery constructed from liquid sodium (Na) and sulfur (S) [5-6]. Sodium sulfur and flow batteries are regarded as the newest, most efficient types of electric storage batteries. These types of batteries have a large capacity and are widely employed in all kinds of applications. Sodium sulfur batteries have a high energy density and are very small and efficient which makes them easy to install and transport. However, such batteries need high temperature conditions in order to work properly. A flow battery has many systems and can store energy for a long time. This type of battery is currently in high commercial demand. [1]

The first non-rechargeable Lithium Ion (Li-ion) batteries became commercially available. Since lithium

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is the lightest of the metal elements, it also has the greatest electrochemical potential and thus provides the largest specific energy per weight. Lithium ion batteries are considered to have the greatest power battery system and potential for development. A lithium ion battery has a high energy density, can store energy for long periods of time, and does not produce pollution. Although it is almost always found in small electronics, its monomer level is never standard. The greatest concern with lithium ion batteries is that those having a large capacity also pose a considerable safety hazard. [1] In Recent years, with the rapid development of electric vehicles (EV) and hybrid electric vehicles (HEV), lithium-ion batteries have become the main way of energy storage for EV and HEV. [5]

A Lithium Polymer (LiPo) battery consists of several components [9-10]: A positive electrode consisting of LiCoO2 or LiMn2O4, a separator made of a liquid electrolyte that contains LiPF6 and organic solvents, as well as a negative electrode formed by carbon material. [1] It is developing an advanced lithium polymer rechargeable battery based on proprietary positive electrode chemistry. In one formulation, this electrode contains elemental sulfur, either free or in association with secondary materials that promote its utilization. Batteries based on this cathode chemistry offer high steady-state (>250 Wkg) and high peak power densities (3000 Wkg), in a low cost and environmentally benign format. High energy density, in excess of 500 Wh/kg (600 WM) can also be achieved. The high power and energy densities, along with the low toxicity and low cost of materials used in the PolyPlus solid-state cells make this battery exceptionally attractive for both hybrid and electric vehicles, and for consumer electronic applications.[6]

A nickel-metal hybrid (NiMH) battery is a rechargeable battery that has chemical reactions similar to the NickelCadmium (NiCd) battery. However, the nickel-metal hybrid battery has two to three times the capacity of the nickel- cadmium (NiCd) battery. This type of battery has a thin design and relatively good battery life. It is also very lightweight and safe to use. Unfortunately, NiMH batteries are more costly to manufacture than lithium-ion batteries [1]

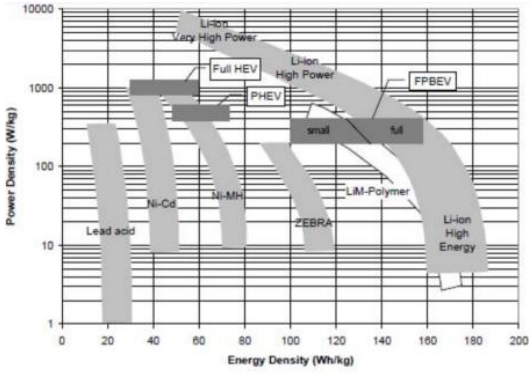

Figure 1 Shows the energy and power densities of different types of batteries

A Lithium Iron battery (LiFePO4) has the advantages of safety, long life, no pollution, high power density, and high coulombic efficiency (η) [1]. The change rates of the terminal voltage of a LiFePO4 battery from 20% to 80% of the state of charge (SOC) are very small; therefore, this battery can provide a stable voltage for load, but this can cause problems in applications such as SOC estimation. The cycle life of this battery is greater than 1000 times; hence, the battery cost should be low, but collecting data for developing state-of-health (SOH) estimation technology is problematic.[7]

Sealed Lead Acid (SLA) battery are sometimes referred to as VRLA (valve-regulated lead acid) batteries - most economical for larger power applications where weight is of lesser concern. The SLA is the prefemed choice in hospital equipment, wheelchairs, UPS systems and emergency lighting where its low energy density is of lesser importance. [8]

Reusable Alkaline battery - replaces disposable household batteries; suitable for low-power, low-cost applications. Its limited cycle life is compensated by low self-discharge, making this battery ideal for portable entertainment devices and flashlights. [8]

3. INSPECTIONS OF THE BATTERY

General Inspections. Inspection of the battery on a regular scheduled basis should include a check of the following:

(1) General cleanliness of the battery and battery area

(2) Float voltage

(3) Cells for cracks or electrolyte leakage

(4) Plates of cells (plates buckling. discoloring, grid cracks, or plate growth)

(5) Ambient temperature and ventilation equipment

(6) Pilot cell (if used) voltage. specific gravity. electrolyte temperature and level

(7) Terminals and connectors for evidence of corrosion

Note: A regular schedule for a nuclear plant Class I battery should be consistent with the inspection intervals described in IEEE Std 303-1971. Criteria for Class IE Electric Systems for Nuclear Power Generating Stations.

Quarterly Inspections. Quarterly inspections should include a check of the following:

(1) Specific gravity readings of each cell

(2) Voltage reading of each cell and total battery terminal voltage (cell voltages shall be post to post to include intercell connector)

(3) Electrolyte level of each cell

(4) Float voltage

(5) Temperature of electrolyte of representative cells (suggestion - every sixth cell) (6) Battery load with battery on float charge (charger current)

Yearly Inspections. Yearly inspections should include a check and record of the following:

(1) Cell condition (detailed visual inspectioil)

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(2) Cell-to-cell and terminal detail connection resistance

(3) Integrity of battery rack

Special Inspection. Under any abnormal conditions or severe circumstances the inspection procedures listed in Quarterly Inspections and Yearly Inspections should be repeated.[9]

4. BATTERY LIFE, OPERATING TEMPERATURE

The location and arrangement of cells should result in no greater than a 3 ºC temperature differential between cells at a given time. Avoid conditions that result in spot heating or cooling, as temperature variations will cause the battery to become electrically unbalanced. Elevated temperature operation will shorten battery life. A general rule of thumb for lead-acid batteries is that prolonged use at elevated temperatures will reduce the battery life by approximately 50% for every 8 ºC above 25 ºC. Ni-Cd cells are less affected, with a life reduction of about 20% for the same temperature increase. Rated performance of cells are typically at 25 ºC. A location where this temperature can be maintained will contribute to optimum battery life, performance, and cost of operation. Extreme ambient temperatures should be avoided because low temperatures decrease battery capacity, while prolonged high temperatures shorten battery life and increase maintenance cost. Installation in a location with an ambient below the rated temperature will affect sizing.[10]

5. OPERATION PLANNING OF BATTERY MANAGEMENT SYSTEMS

Battery energy storage systems (BESSs) are an important method to store energy with their flexible configurations for different application requirements without geographical conditions. Their fast responses can simultaneously input or output active and/or reactive power. Compared with other energy systems, BESS has a relatively higher energy efficiency. The said advantages make BESS an irreplaceable option in centralized and distributed new energy integration, and ancillary grid operations. [11]

Large-scale energy storage applications require multiple lithium-ion battery packs operating in parallel, such applications comprise of renewable energy storage systems. The current technology to enable parallel operation of multiple battery packs is quite hardware intensive. It requires a separate pack management system operating as a master and battery management systems in each of the battery packs configured as slaves. This significantly affects the scalability of such systems as the number of battery packs that can be connected in parallel is completely dependent on the capacity of the master [12], [25].

Battery energy storage systems (BESSs) require a battery management system (BMS) to monitor and maintain safe, optimal operation of each battery pack and a system supervisory control (SSC) to monitor the full system. Batteries are dynamic in nature, constantly operating outside the equilibrium state during cycling. In addition, the situation worsens for the case of intercalation-based storage systems (e.g., Li chemistry) which operate as a closed system with very few measurable state variables, making it difficult to properly monitor the states of the battery and maintain safe operation. Furthermore, even under normal operation the battery packs of a BESS will degrade during cycling. This degradation can be accelerated by extreme charging patterns, increased temperature (both ambient and operating), overcharging, or undercharging. A basic BMS controls battery packs only to meet the power demand. However, smarter model-based BMSs can reduce the causes of degradation and improve the performance of the system. Predictive and adaptive BMSs based on models are especially important for large battery packs for applications such as electric vehicles and grid integration. While there are many possible solutions to the intricate problem of BESS control, Fig. 2 describes a general BESS–BMS structure used for implementation [13].

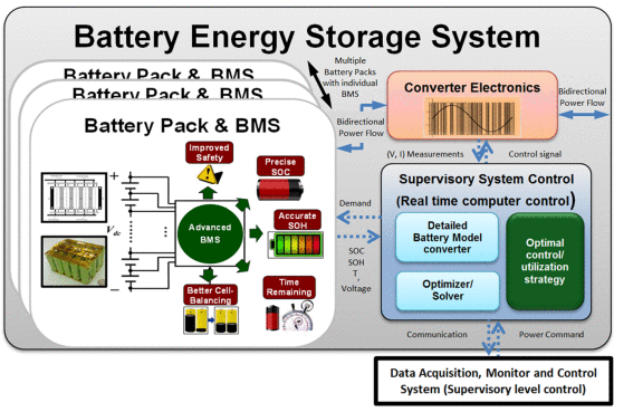

Figure 2 Schematic for the implementation of a battery pack and BMS into a BESS.

Valve regulated lead acid (VRLA) batteries widely used in substations still have large residual capacities when they are retired, so they can be reused in battery energy storage systems (BESS). The schematic of the reusing BESS is shown in Fig. 3 .The BMS can achieve the functions such as battery dynamic equalization, overvoltage/undervoltage protection of each battery cell, and automatic isolation of defective batteries. A battery energy storage system (BESS) using retired VRLA batteries is designed. During battery charging, the BMS can automatically switch between normal charging and equalizing charging according to the status information of each battery. During battery discharging, the BMS can accurately identify and isolate the defective batteries and try to repair them in the charging process. Thus, the stability and flexibility of the reusing BESS are improved. [14]

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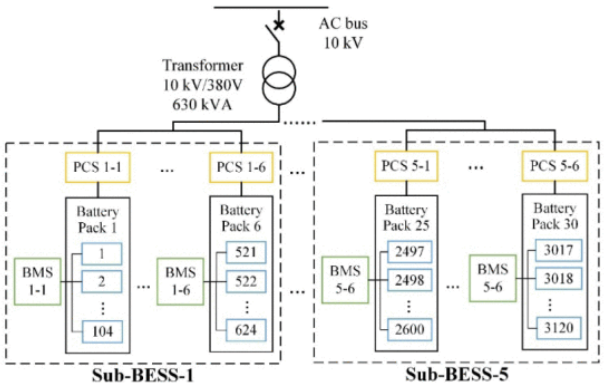

Figure 3 Schematic of the reusing BESS

For the wind power, the value of the power generated depends on the performance coefficient (CP) and the available wind speed. To maximize this output power, and as the wind speed is varying from time to time, the performance coefficient must be maximized and controlled. For the battery energy storage system conditions, the battery system should not be discharged to the minimum limit and charged to the maximum limits; because maximum charging and minimum discharging will cause a decrease in the life cycle of the battery system. Thus, in order to overcome this problem, the SOC should be controlled. Therefore, SOC must be lies between 0.3<SOC<0.8. The initial value of SOC is considered to be equal to 0.3. For the load system demand conditions, the load is manifested by the current it needs from the source the voltage of the wind turbine should be higher than the voltage of the battery system. [3]

6. THE APPLICATION OF VALVE-REGULATED LEAD ACID BATTERIES (VRLA SOCALLED LL-TYPE) TO WIND POWER GENERATION SYSTEM

Wind energy can be defined as the process by using the wind turbines to convert the kinetic energy in the wind into mechanical power. Once a wind turbine has converted the kinetic energy in the wind into rotational mechanical energy, that rotational energy is usually converted by a generator into electricity.[3] Wind power system should be managed so as to operate at optimal parameters, requiring the capture of wind energy with maximum efficiency.[15]-[17]

Electric power generation systems using renewable energy sources, such as wind power and photovoltaic power, a renewable and environmental friend energy source has an advantage without the greenhouse effect gas emission. The electric power output can be fluctuated by weather, however. This fluctuation is the essential problem of the renewable energy introduction. Instantaneous fluctuation causes the problem of the quality of a power grid, and a long period fluctuation causes the problem of the disturbance of the programmable power generation of a power grid. It is considered that these problems increase when the amount of electric power generation using renewable energy sources increases. In order to solve these problems, we need relaxation of instability of power output. The combination of the renewable energy system with a battery energy storage system is one of the solutions to solve the problem. These continuous fluctuation conditions are to cause the problem of battery life troubles by corrosion of positive grids, sulfation of negative active materials, stratification, partial deterioration, and primary capacity loss (PCL). Therefore, batteries hybridized to the wind power generation have to be operated under very severe conditions.[18]-[23]

The LL type battery has been applied to smoothing the fluctuations of the 1.2MW wind power generation system.

(1) The 0.1CA capacity of batteries of the LL type VRLA has been kept over 85% of its initial capacity before use in the wind power generation system.

(2) The sulfation, partial deteriorations, and PCL under the system operational conditions did not occur.

(3) The main failure mode of the batteries was the corrosion of positive grids.

(4) The life of batteries of the LL type VRLA applied to this system was evaluated to be 9 years.

(5) An expected life of more than 17 years of the VRLA battery, the LL-W type (table 1), has been developed for the use in the system of the wind power generation, by taking account of all the information on the LL type VRLA battery already applied to the wind power generation system. [18]

Table 1. Outline of developed battery (LL-W type)

Type		LL1500W
Voltage		2V
Capacity(10HR)		1500Ah
Installation direction		Horizontal position
Dimension	Height	507 mm
	Width	172 mm
	Length	437 mm
Weight		106 kg
Life expectancy (at 25 degrees)		17 years
Use range of SOC		SOC30-90%
Charge condition		Recommendation condition
Structure		Valve regulated lead acid battery

Isolated power system such as offshore wind turbine platform is characterized by limited generation capacity, large AC motor load, converters and cable connections. The factors have posed a big challenge to satisfy the requirements of many voltage, frequency and waveform distortion sensitive devices. During normal operation, the bus voltage and frequency variations should be limited to an acceptable range. The battery energy storage system (BESS) in windbattery hybrid generation comprises mainly of batteries and power conditioning system (PCS), and control of PCS is the key technology in BESS. [2]

A simplified one-line diagram of the considered electrical network is illustrated in Fig. 4. A 1.5MW DFIG (doubly fed induction generator) wind turbine is connected to point of common coupling (PCC) by means of a transformer, raising the voltage level from 0.69kV

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to 6.3kV, and BESS including NAS battery and PCS is integrated into the network at PCC through a step-up transformer of 0.07/6.3kV. The composite load of the offshore platform is 300kW, composed of dynamic load such as a 100kW high voltage motor of 6.3kV (PF=0.85) and static load such as 100kW high voltage power quality (PQ) load of 6.3kV and 100kW low voltage PQ load of 0.4kV (PF=0.8). Furthermore, a diesel generator served as standby power supply and a dump load must be included in order to maintain the isolated power system reliability at a desirable level. The PCS can regulate its power flow to keep the system voltage and frequency at a desired level during the disturbances from both utility side and demand side such as wind fluctuation and large AC motor start/stop. [2]

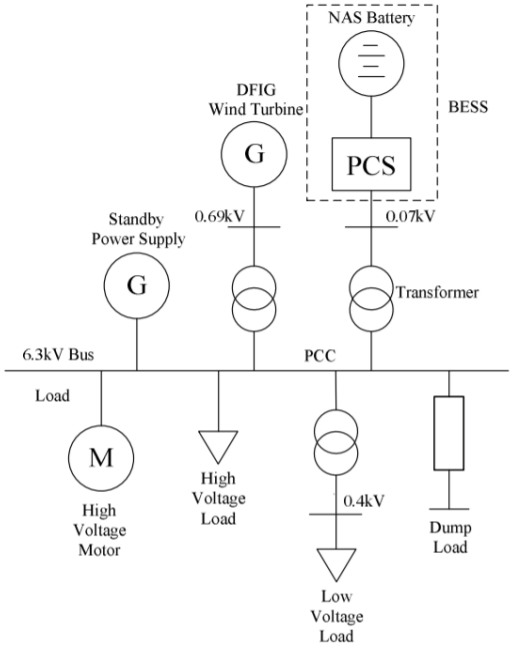

Figure 4 Simple circuit diagram of the offshore platform power system

7. THE ECONOMIC FEASIBILITY OF IMPLEMENTING VARIOUS BATTERY STORAGE SOLUTIONS

The economic feasibility of implementing various battery storage solutions in wind power systems is a complex issue that depends on multiple factors. Let's analyze the information provided in the text to discuss the economic aspects of these battery technologies:

Lead-Acid Batteries: The text mentions that lead-acid batteries have a short lifespan and can create pollutants during production. This could result in increased operational and environmental costs. As a result, they may become less economically viable in the long run, especially as cleaner alternatives become available.

Nickel Hydrogen Batteries: These batteries are compared to lead-acid batteries, but their capacity decreases with increased use. Moreover, they face restrictions due to heavy metal pollution concerns from the European Union. This indicates potential environmental and regulatory costs associated with their use, which could affect their economic feasibility.

Sodium Sulfur Batteries: These are described as efficient and having a high energy density, making them suitable for various applications. However, they require high-temperature conditions, which might increase operational costs. Their economic feasibility would depend on the specific application and the cost of maintaining the required temperature conditions.

Lithium-Ion Batteries: Lithium-ion batteries are praised for their high energy density, long-term energy storage capabilities, and lack of pollution. However, there's a mention of safety concerns, especially with larger capacity batteries. Addressing safety issues might entail additional costs.

Lithium Polymer Batteries: Lithium polymer batteries are highlighted for their high power and energy densities, making them attractive for various applications, including electric vehicles. However, the economic feasibility could be influenced by the cost of materials and production methods, as well as safety considerations.

Nickel-Metal Hybrid Batteries: These batteries are noted for their high capacity and safety. Still, they are considered more costly to manufacture than lithium-ion batteries, which could affect their economic viability, especially in cost-sensitive applications.

Sealed Lead Acid (SLA) Batteries: SLA batteries are mentioned as economical for larger power applications where weight is less of a concern. Their economic feasibility would depend on the specific application's requirements and the cost-effectiveness of SLA batteries compared to alternative technologies.

Reusable Alkaline Batteries: These batteries are described as suitable for low-power, low-cost applications. Their limited cycle life is compensated by low self-discharge, which could make them economically viable for certain portable devices.

In summary, the economic feasibility of implementing these battery storage solutions in wind power systems varies depending on factors such as battery lifespan, energy density, safety, environmental considerations, and application-specific requirements. Additionally, ongoing advancements in battery technology and changes in regulations can impact their economic viability. A thorough cost-benefit analysis would be necessary for each specific use case to determine the most economically advantageous battery technology [24].

8. FUTURE IMPLICATIONS, PARTICULARLY FOR WIND POWER SYSTEMS

The rapid advancements in battery technology hold several future implications, particularly for wind power systems:

Enhanced Energy Storage: Advanced battery technologies like lithium-ion, sodium-sulfur, and flow batteries offer higher energy densities and longer

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lifespans. This will allow wind power systems to store more energy efficiently, mitigating the intermittent nature of wind generation.

Improved Reliability: Batteries can act as grid stabilizers, providing a consistent power supply during fluctuations in wind energy production. This will enhance the reliability of wind power systems and reduce the need for backup fossil fuel generators.

Grid Integration: Battery energy storage facilitates better integration of wind power into the electrical grid. It enables the smooth injection of wind energy when it's abundant and its release during high-demand periods, thus reducing strain on the grid.

Sustainability: With a shift away from lead-acid batteries, which have environmental concerns, the adoption of cleaner energy storage devices will contribute to a more sustainable energy ecosystem, aligning with global environmental goals.

Cost Reduction: As battery technologies improve and economies of scale kick in, the cost of energy storage is likely to decrease. This will make wind power systems more cost-competitive with traditional fossil fuel-based energy sources.

Repurposing Retired Batteries: The text also highlights the reuse of retired batteries in energy storage systems. This practice can further reduce costs and environmental impact, extending the lifecycle of batteries.

Battery Management: The development of advanced Battery Management Systems (BMS) will play a critical role in optimizing battery performance, reducing degradation, and enhancing the overall efficiency of wind power systems.

Safety Considerations: As lithium-ion batteries become more prevalent in wind power systems, safety measures must be a top priority to mitigate the risk of fires or other hazards associated with high-capacity batteries.

Offshore Wind Farms: Battery technology can be especially beneficial for offshore wind farms, where energy storage can help overcome transmission challenges and stabilize power supply to onshore grids.

Market Growth: The increasing adoption of electric vehicles (EVs) and renewable energy sources, including wind power, will drive the demand for advanced batteries. This growing market will likely spur further innovations and cost reductions in battery technology.

In summary, rapid advancements in battery technology are poised to revolutionize the wind power industry. These developments promise increased efficiency, reliability, and sustainability, making wind power a more attractive and integral part of the global energy landscape. However, challenges related to safety, integration, and scalability must be carefully addressed as these technologies evolve.

9. CONCLUSIONS

In conclusion, the evolution of battery technologies within the context of wind power systems presents significant opportunities and challenges for the renewable energy sector. These trends have the following implications:

The ongoing development of various battery types, including sodium-sulfur, lithium-ion, flow, and lead-acid batteries, offers new avenues for optimizing energy storage solutions in wind power systems. These advancements promise increased efficiency, longer lifespan, and greater energy density.

Wind power, along with other renewable sources, is emerging as a vital component of the energy landscape. Battery storage systems are becoming indispensable in addressing the intermittent nature of wind energy, enabling more reliable and flexible power generation and distribution.

The global shift towards cleaner and more sustainable energy sources places an emphasis on environmentally responsible practices. Battery technologies that minimize pollution during production and operation, such as lithium-ion and lithium polymer batteries, align with these principles.

Safety concerns, particularly in relation to high-capacity lithium-ion batteries, require meticulous attention. Prioritizing safety measures, including thermal management and hazard prevention, is imperative to ensure the secure implementation of battery storage in wind power systems.

Evaluating the economic feasibility of deploying battery storage solutions in wind power projects is essential. Factors such as battery cost, performance, regulatory compliance, and environmental considerations must be thoroughly assessed to determine project-specific economic viability.

The future of battery technology in the wind power sector holds immense potential. These technological innovations have the capacity to significantly enhance energy storage capabilities, grid reliability, and cost-effectiveness, making renewable energy sources more competitive in the energy market.

Advanced Battery Management Systems (BMS) play a pivotal role in optimizing battery performance, ensuring longevity, and enhancing overall system efficiency. Continued research and development in BMS technology will be instrumental in realizing these benefits.

Battery technology is particularly advantageous for offshore wind farms, where energy transmission challenges can be mitigated. By stabilizing power supply and optimizing energy flow, batteries contribute to the success of these ambitious projects.

The increasing demand for electric vehicles (EVs) and the growing emphasis on clean energy sources, including wind power, are driving rapid market growth. These dynamics stimulate innovation and cost reductions in battery technology, benefiting both the renewable energy sector and EV manufacturers.

In conclusion, the integration of advanced battery storage solutions in wind power systems presents a transformative opportunity to revolutionize the energy landscape. While challenges exist, such as safety and

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economic considerations, the overarching potential for enhanced sustainability, reliability, and cost-efficiency makes these developments a cornerstone of future energy solutions. Success will require collaborative efforts across industries, ongoing research, and strategic investments to fully harness the benefits of evolving battery technologies in wind power systems.

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STATE OF THE ART IN BATTERY TECHNOLOGY: INNOVATIONS AND ADVANCEMENTS

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Abstract: This paper examines various types of batteries and their modes of operation in a rapidly evolving technological world. From the definition of batteries and the distinction between cells and batteries, to their history and uses in various applications, this study provides a comprehensive overview of the subject. Primary and secondary batteries are explored, with examples such as alkaline and nickel-metal hydride batteries, highlighting the characteristics of each. Additionally, lithium-ion batteries are examined in detail, including their specific properties and innovative mode of operation. The article also addresses charging and discharging methods, including LiFePO4 technology, providing a comprehensive understanding of these essential components in modern devices.
Key words: batteries, lithium-ion, operation mode, charging

1. INTRODUCTION

A battery is a device that directly converts the chemical energy contained in a drug into electrical energy through an electrochemical redox (oxidation-reduction) reaction. In this type of reaction, the exchange of electrons from one substance to another takes place through an electrical circuit.[1]

Although the term battery is often used, the cell is the actual electrochemical unit used to generate or store electrical energy.[2]

To understand the difference between a cell and a battery, we should think of a battery as one or more cells arranged in pairs in series, parallel or both, depending on the specified voltage and output capacity.[3]

Batteries play a vital role in our lives, providing power to everything from small appliances to cars. They come in various shapes and sizes, each tailored to specific applications and advantages. However, choosing the right type of battery for your needs can sometimes be a perplexing task.[4]–[7]

In 1800, Italian physicist Alessandro Volta invented the first battery, marking a significant milestone in battery technology. Since then, battery innovation has been explored and adopted worldwide.[8]

A battery functions as a device that stores and releases electrical energy through chemical reactions. It is composed of one or more cells, each containing an electrical charge.[8]

- Positive electrode
- Negative electrode
- Electrolyte

When a battery is linked to a circuit, a chemical reaction occurs between the positive and negative electrodes (+ and -). This reaction results in the conversion of expelled chemical energy into electric current.[9], [10]

Currently, batteries play a significant role in environmental protection by reducing CO2 emissions, as they have the capacity to store electric energy from renewable energy sources.[11] A major global issue today is the pollution generated by ships, as 80% of worldwide transportation occurs through maritime shipping. A potential solution to mitigate this pollution involves generating electric energy onboard ships using renewable sources and storing it in batteries.[12]–[16]

2. TYPES OF BATTERIES

Electrochemical cells and batteries are categorized into two types.[2]

- Primary (non-rechargeable)
- Secondary (rechargeable)

2.1 Primary batteries:

Essential batteries serve as a control source for real devices and gadgets. These include radios, observatories, toys, lights and cameras. It's cheap, easy and convenient to use without a stand.[17]–[19]

They are usually round and hollow like alkaline batteries. A critical battery of this type can be a chemical composed of zinc (Zn) and manganese dioxide (MnO2). [4], [20]–[22]

Button battery chemistry is also fusible. However, it also contains the chemicals lithium and silver oxide. These connections make this small battery more

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productive and provide a uniform and constant voltage. These include a control current of 270 Wh/kg .[23], [24]

2.2 Secondary batteries

The biggest advantage of these batteries is that they can be recharged and reused. It is therefore also called a rechargeable battery.[3], [25], [26]

Auxiliary batteries usually consume more energy than the backup batteries. However, because it is rechargeable, it lasts a long time. They can be used in two applications.[27]–[30]

- energy storage devices
- applications where the battery is used and discharged as a primary battery.

Once it has been completely or almost completely discharged, it can be fed with charging components. For example, smartphone batteries. Most models have a lithium-ion battery that will last a long time if recharged regularly.[31]–[33]

Another good example is the lead-acid battery found in most cars and vehicles. Lead-acid batteries power the car's lighting system. The nominal voltage is from 2V to 24V and the power density is 7Wh/kg[28], [34]

2.3 Alkaline Batteries:

A water-soluble battery using commercially available primary batteries. They were invented simultaneously but independently by Waldemar Jungner and Thomas Edison. However, early batteries were overshadowed by the first dry antacid developed by Canadian Lewis Alley in the 1950s.[1], [2]

Soluble batteries require zinc as a negative electrode and manganese dioxide as a positive electrode. Both substances are consumed as the battery discharges. Acid batteries are therefore disposable, consumable batteries. Once discharged, it cannot be safely reactivated. Acid-resistant batteries have the lowest price per unit. They deliver reliable performance from start to finish. In other words, you won't notice loss of control until the lead-acid battery reaches the end of its life. Unfortunately, recycling lead-acid batteries is very difficult.[8], [21], [35]

2.4 Lithium Batteries

Lithium-Ion Batteries – A lithium-ion battery is a rechargeable battery variant that consists of a lithium cathode, a typically graphite anode, and an electrolyte. During the charging cycle, lithium ions shift from the cathode to the anode, and they reverse direction during discharge. While charging, lithium compounds decompose into lithium ions, electrons, and other lithium compounds.[1]

Electrons transition from the cathode to the anode via external conductors, while lithium ions traverse from the cathode to the anode through the electrolyte. Simultaneously, current travels from the anode to the cathode. Graphite is predominantly employed as the anode material in most Li-ion batteries due to its intercalated configuration, which effectively captures lithium ions and augments battery capacity. Through a reaction with carbon on the anode, lithium ions and electrons combine to form a lithium carbon compound. This sequence of reactions is inverted when addressing the discharge phase.[1], [2], [36] Li-ion cells typically exhibit extended lifespan, with even the smallest ones designed for approximately 300 cycles, if the battery is discharged to no less than 70% of its maximum storage capacity. Under specific usage conditions specified by the manufacturer, certain Li-ion cells can achieve a longevity exceeding 1000 cycles.[20]

Lithium manganese oxide batteries ($LiMn_2O_4$ or Li-manganese) – This battery type derives its name from the utilization of a manganese-based matrix structure within the cathode. It was developed during the late 1970s and early 1980s, establishing itself as a well-established and dependable cell.[18] Li-manganese batteries exhibit the capacity to handle relatively high-power output in brief bursts while maintaining excellent thermal stability. Consequently, they are regarded as exceptionally safe cells, demonstrating resistance to elevated temperatures and aggressive chemical reactions.[20] These cells can be customized to prioritize either increased power or enhanced energy storage capacity, although this customization comes at a trade-off between the two. The primary drawback of these cell types is their limited lifespan, which is not their strong suit when compared to other lithium-based batteries.[5]

Batteries with lithium and cobalt oxide (LiCoO_2, Li-cobalt, Li-cobalt) – The development of Li-cobalt batteries occurred in tandem with the emergence of Li-manganese batteries, solidifying their position as one of the pioneering lithium-ion battery technologies. These batteries are characterized by their distinctive cathodes, featuring a layered cobalt structure. This structural design was a key innovation at the time and played a vital role in their early success.[18]Li-cobalt batteries gained recognition for their affordability and remarkable energy storage capacity. Their ability to store substantial amounts of electrical energy was a significant advancement, making them suitable for various applications where energy density was a critical factor.[37]However, it's essential to note that Li-cobalt batteries have certain limitations. They typically exhibit a lower nominal current, which means they may not provide as much instantaneous power as some other lithium-ion variants. Additionally, their lifespan tends to be shorter when compared to alternative lithium-ion battery types. This limitation made them less suitable for applications where long-term durability was paramount.[18], [37]

Nonetheless, Li-cobalt batteries have been favored in situations where safety is a top concern. The chemical reactions occurring within these batteries generate

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relatively low temperatures, reducing the risk of overheating and thermal runaway. This inherent safety characteristic has made Li-cobalt batteries a preferred choice in critical applications where stable and secure power sources are essential.[20], [37]

In conclusion, Li-cobalt batteries, which evolved alongside Li-manganese batteries, mark one of the early phases in the history of lithium-ion battery technology. Their cost-efficiency, impressive energy storage capacity, and safety attributes have rendered them indispensable for applications, notwithstanding their constraints regarding current output and longevity.[38]–[40]

Batteries with Lithium Nickel Cobalt Aluminum (NCA) – These batteries bear a striking resemblance to NMC batteries, with their primary distinction lying in the use of aluminum within the cathode instead of manganese. [37]The incorporation of aluminum into the cathode bestows upon these batteries the highest energy storage capacity when compared to all other lithium-ion battery technologies available. However, they are not without their limitations, including a modest reduction in cycle life and power output. Much like NMC batteries, this type holds great promise for driving significant advancements in lithium-ion cell technology in the foreseeable future.[35] NCA batteries excel in their ability to store substantial quantities of electrical energy, making them particularly suitable for applications that demand high energy capacity. When employing larger-sized cells, their relatively lower power output can be effectively compensated for. Tesla's choice to employ NCA batteries in their electric vehicles serves as a prime example of this suitability.[39], [40] Nevertheless, ongoing research in this field remains focused on refining and augmenting the power output of NCA batteries, seeking to further enhance their performance.[9], [21], [24]

3. TECHNICAL SPECIFICATIONS OF BATTERIES

This section explains the significance of the technical specifications of a battery. These specifications may be inscribed on the battery (although it's not mandatory) but are typically found in the product's manual or technical specifications sheet:[8], [21], [23], [24]

Nominal Voltage (V) – The reported or reference voltage of the battery, sometimes also referred to as the battery's "standard" voltage.

Cut-off Voltage – The minimum allowable voltage. Generally, this voltage defines the "empty" state of the battery.

Capacity or Nominal Capacity (Ah for a specific C rate) – When the battery is discharged at a specific discharge current (specified as a C rate) from a 100% charge state to the cut-off voltage. Capacity is calculated by multiplying the discharge current (in amperes) by the discharge time (in hours) and decreases with increasing C rates.

Energy or Nominal Energy (Wh (for a specific C rate)) – The "energy capacity" of the battery, the total watt-hours available when the battery is discharged at a specific discharge current (specified as a C rate) from a 100% charge to the cut-off voltage. Energy is calculated by multiplying the discharge power (in watts) by the discharge time (in hours). Like capacity, energy decreases with increasing C rates.

Cycle Life – The number of charge-discharge cycles a battery can undergo before it no longer meets certain performance criteria. Cycle life is estimated under specific charge and discharge conditions. The actual battery lifespan is affected by the rate and depth of cycles and other conditions such as temperature and humidity. A higher depth of discharge (DOD) results in a shorter cycle life.

Specific Energy (Wh/kg) – The nominal energy of the battery per unit mass, sometimes referred to as gravimetric energy density. Specific energy is a property of the battery's chemistry and packaging. Along with the vehicle's energy consumption, it determines the battery weight required to achieve a specific electric range.

Specific Power (W/kg) – The maximum power available per unit mass. Specific power is a property of the battery's chemistry and packaging. It determines the battery size required to achieve a specific performance target.

Energy Density (Wh/L) – The nominal energy of the battery per unit volume, sometimes referred to as volumetric energy density. Energy density is a property of the battery's chemistry and packaging. Along with the vehicle's energy consumption, it determines the battery size required to achieve a specific electric range.

Power Density (W/L) – The maximum power available per unit volume. Power density is a property of the battery's chemistry and packaging. It determines the battery size required to achieve a specific performance target.

Maximum Continuous Discharge Current – The maximum current at which the battery can be continuously discharged. This limit is typically defined by the battery manufacturer to prevent excessive discharge rates that could damage the battery or reduce its capacity. Together with the maximum continuous power of the motor, it defines the sustainable maximum speed and acceleration of the vehicle.

Charging Voltage – The voltage at which the battery is charged when charged to full capacity. Charging schemes usually involve constant current charging until the battery voltage reaches the charging voltage, followed by constant voltage charging, allowing the charging current to decrease to very low levels.

Float Voltage – The voltage at which the battery is maintained after being charged to 100% State of Charge (SOC) to preserve this capacity by compensating for battery self-discharge.

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Charging Current (Recommended) – The ideal current at which the battery is initially charged (at around 70% SOC) in a constant current charging mode before transitioning to constant voltage charging.
Internal Resistance – The resistance within the battery, typically differing for charging and discharging processes.

4. CONCLUSIONS

This paper highlights the importance of batteries in our everyday lives and categorizes them into two main types: primary batteries and secondary batteries. This division is essential for understanding the uses and advantages of each battery type.

Primary batteries, also known as non-rechargeable batteries, are suitable for devices that require a temporary and efficient power source. These include radios, toys, flashlights, and many other everyday objects. They are convenient and cost-effective, making them a popular choice for most consumers. However, it's important to note that primary batteries are single-use, and once depleted, they cannot be recharged. Additionally, recycling them can be challenging.

In contrast, secondary batteries, or rechargeable batteries, are essential for applications with higher energy consumption and for devices that require a long-term power source. They can be recharged multiple times and are ideal for devices such as mobile phones, laptops, or electric vehicles. Secondary batteries are a cost-effective long-term solution because they can be recharged and reused. However, they may have a shorter lifespan and lower nominal power than primary batteries in certain circumstances.

In addition to clarifying the differences between primary and secondary batteries, the article also provides an important overview of the technical specifications of batteries. These technical data include essential specifications such as nominal voltage, cutoff voltage, nominal capacity, and nominal energy. This information is crucial for choosing and using batteries correctly in various applications.

Furthermore, the article emphasizes a crucial aspect of batteries in the context of environmental protection. Batteries play a significant role in reducing CO2 emissions as they have the ability to store electric energy generated from renewable sources. Thus, they play an essential role in promoting the use of clean energy and sustainable power sources. In a world where pollution from maritime vessels is becoming increasingly problematic, batteries can offer a potential solution by storing electric energy from renewable sources and using it onboard ships, thereby contributing to reducing the negative impact on the environment. Understanding the differences between primary and secondary batteries is crucial for making the right choice based on individual needs and applications. Each type of battery has specific advantages and disadvantages, and the correct choice can lead to cost savings and efficient use of energy resources.

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ANALYSIS AND DIMENSIONING OF THE FUEL SUPPLY SYSTEM OF BULK-CARRIER

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Abstract : In the context of the global oil crisis, in all fields, an optimization of fuel consumption and an improvement of the efficiency of energy installations are being attempted. Thus, the shipping and transport industry is converging towards this idea by implementing energy installations with increased yields and reduced consumption. At the same time, for this purpose, it is also tried to increase the efficiency through the appropriate preparation of the fuel or its burning in optimal conditions.
Thus, in this context, the chosen topic aims to deal with aspects related to the dimensioning of the fuel supply system for a 178,000 tdw universal Bulk-Carrier. The ship is propelled by a B&W 8L60MC main engine that has been modernized in order to reduce consumption, noxious emissions and increase the energy efficiency index.
Bulk-Carrier ships are intended for the transport of various goods in bulk: iron ore, grain, coal, phosphates and other similar goods.

Key words : marine propulsion engine, fuel consumption, bulk carrier.

1. INTRODUCTION

In the naval and transport industry, due to the global oil crisis, in recent years, the improvement of energy installations has been aimed at increasing efficiency but at the same time by decreasing their consumption.

In this sense, the International Maritime Organization (IMO) has the following objectives:

- maximizing the level of efficiency for new ships;
- stimulating the continuous technical development of all the components that influence the fuel efficiency of a ship
- separating measures based on technical projects from commercial and operational ones;
- comparing the energy efficiency of individual ships with similar ones that could do the same type of transport.

The chosen topic aims to deal with aspects related to the dimensioning of the fuel supply system for a 178000 tdw universal Bulk-Carrier. The vessel is powered by a B&W 8L60MC heavy fuel main engine.

Heavy fuels are those fuels characterized by high flash point, high viscosity, high water and sediment content, high sulfur content, low calorific value and high ash content.

The composition and structure of heavy fuels create, in the operation of naval engines, certain problems that cannot be neglected. If the calorific power is lower, the flow rate of the injection pump can be increased, but other factors cannot be neglected. Thus, sulphur, carbon and ash act differently and always result in different phenomena such as: wear and tear of the organs bordering the combustion chamber, clogging of injector holes, deposits of calamine, etc. The presence of water in a high percentage in heavy fuel has an influence on the quality of the fuel and implicitly on the combustion. The water content contributes to the abrasion effect due to the salts contained, generally sodium chloride.

There is a close correlation between the internal combustion engine and the fuel used. For a given type of engine, its performance in normal operation depends on the fuel used, respectively on its judicious choice, control and maintenance of its quality within the prescribed limits.

2. PRESENTATION OF VESSELS CARRYING PRODUCTS

Bulk carrier is a dry cargo ship intended for the a priori transport of ores or other bulk cargo.

Bulk-carrier vessels must provide superior operating conditions for the loading, transport and discharge of solid bulk cargoes, except for special cargoes such as cement. At the same time, like all transport ships, they must be able to navigate in ballast under appropriate conditions.

In general, these ships are intended to transport as main cargo: heavy ores (0.35- 0.45 m^3/ t), light ores

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(0.55- 0.60 m³/ t), coal, heavy grains (1.25- 1.30 m³/ t) and light grains (1.55-1.60 m³/t).

Universal bulk carriers must meet a number of specific requirements, among which: the capacity of the holds must be such as to allow the transport of various grades of solid bulk cargo, from heavy ores to light grains, at a draft corresponding to the lines load, and the variation of transverse stability in the case of transporting different loads should be minimal.

In addition, it must meet additional requirements, namely:

- to have a sufficient number of warehouses to ensure the simultaneous transport of different sorts or batches of grain and at the same time to minimize the replenishment of bags;
- not require longitudinal separations or supply wells;
- to allow a quick cleaning of warehouses and with minimal expenses;
- the value of the bending moments in different transport options should not affect the longitudinal strength of the ship;
- the volume and layout of the ballast tanks to ensure a satisfactory draft and the stability required for navigation in ballast.

From a constructive point of view, universal bulk carriers are of three types:

- → Bulking with ballast tanks
- → Bulkhead with two longitudinal partitions
- → Bulk carriers with tween deck upper warehouses

2.1. Classification of bulk-carrier ships

Bulk carrier is a dry cargo ship intended for the a priori transport of ores or other bulk cargo.

Depending on the tonnage, bulk ships are classified as follows:

- Small <10000 tdw;
- Handy size 10000-35000 tdw;
- Handymax 35000-55000 tdw;
- Panamax 60000-80000 tdw;
- Capsize 80000-200000 tdw;
- VLBC > 200000 tdw.

Figure 1. shows the distribution of ships larger than 5000 tdw in percentage. Thus, handy size ships have the highest percentage, around 33.4%, followed by handymax with 28.6%. Thus, it can be observed that large ships, with a tonnage of over 80,000, such as Capsize and VLBC, are in smaller proportions, namely around 13% of the total existing bulk carriers.

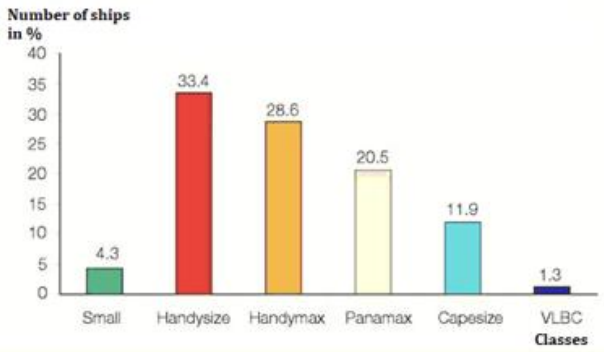

Figure 1 The distribution of ships by classes

When we refer to the tonnage of ships, we notice from figure 2. that bulk carriers with large tonnage are more numerous than those with small tonnage.

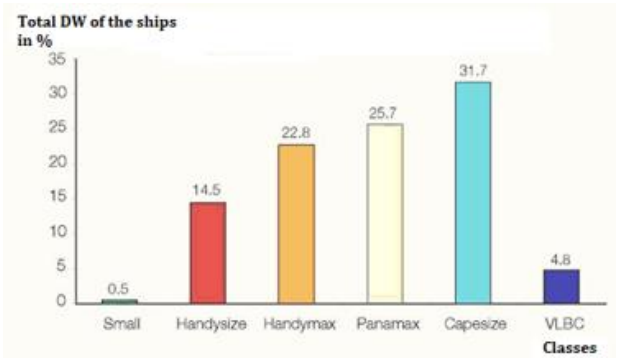

Figure 2. Distribution of bulk vessels according to tonnage.

2.2. *Characteristics of the prototype ship*

The prototype ship (figure 3) is a universal CAPESIZE type bulk carrier (100,000 ÷ 180,000 tdw) intended for the transport of various bulk goods: iron ore, grains, coal, phosphates and similar. The dimensions of the ship are:

- Maximum length
  $$L_{max} = 291.80\ m$$
- Floating length
  $$L_{cwl} = 285.79\ m$$
- Length between perpendiculars
  $$L_{pp} = 282.20\ m$$
- Width
  $$B = 45.00\ m$$
- Draft (calculation / sampling)
  $$T = 16.50\ /\ 18.42\ m$$
- Construction height
  $$H = 24.75\ m$$

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- Deadweight (at the calculation / sampling draft)

$$D_w = 172{,}420.8 / 178{,}000\ tdw$$

- Marching speed

$$v_N = 14.90\ Nd$$

Figure 3. Prototype ship

The ship has a single continuous deck with a bulkhead at the bow, a dune at the stern, a single line of masts and the machinery compartment as well as the hold with the living arrangements and navigation control are also located at the stern.

The cargo space is divided into nine warehouses of practically equal length (approx. 15 m) with self-cleaning (typical octagonal section with bilge and deck tanks - wing tanks). All nine warehouses are equipped with MacGregor side-rolling type covers operated electro hydraulically (the pumps and the rest of the hydraulic aggregates related to the actuation of the covers are located in a roof located on the main deck between warehouses 4 - 5). The covers of the magazine openings have two segments each with lateral displacement towards the edges, unlike the small ones, they are provided with a group of 2 covers each. Also, its own loading-unloading facility is absent, the ship using the existing infrastructure in the specialized ports operated.

The warehouses are built to allow operation with grapples, therefore having a reinforced double bottom ceiling for an admissible load of 20 tons/m2 (warehouses 2,4,6 and 8) and 35 tons/m2 (warehouses 1,3,5, 7 and 9). The warehouses are naturally ventilated, their mechanical ventilation installation being therefore absent.

The main engine is designed for operation with heavy fuel (H.F.O. – heavy fuel oil) with a maximum viscosity of 380 cSt, the consumption in running mode at a speed of 14.60 Nd being approx. 58.20 tons / 24 h and an autonomy of 23800 Mm.

The ship's speed on a starboard keel and at summer draft T = 16.50 m, with a clean hull in deep water, with wind and waves up to 20 on the Beaufort scale (Bf 2 or sea margin 15%), is 14.90 Nd at 85% of maximum continuous power (85 % MCR).

The ballast installation is equipped with two self-priming centrifugal electric pumps, with a flow rate of 3,000 m3/h at a pressure of 35 mCA, the capacity of the ballast tanks being 52,643 m3.

The bilge installation is equipped with an electric piston pump with a flow rate of 320 m3/h at a pressure of 40 mCA. The bilge water from the CM is discharged overboard through a bilge separator in the areas where international legislation allows it and only under conditions where the concentration of hydrocarbons in the discharged water is less than 15 ppm.

3. SIZING OF MAIN ENGINE TANKS

Fuel tanks are used in equipping ships to store fuel. Fuel tanks are divided into several categories: storage tanks (bunkers), settling tanks, service (consumption) tanks, fuel overflow tanks.

On marine ships, the storage tanks are located in the double bottom. They are provided with filling and emptying pipes, ventilation pipes, System for measuring the fuel level, manholes.

The fuel is loaded into the storage tanks using transfer pumps or quayside means. A coarse filter is provided on the boarding pipe to remove foreign bodies that would be in the fuel.

From the storage tanks, the fuel is taken and sent to the settling tanks and further to the service tank that feeds the main engine.

The settling and service tanks, according to LLOYD REGISTER norms, are located in the engine compartment. In order to ensure a good service in operation, increased safety in operation and to make it possible to clean them, these tanks are executed in pairs.

In order to ensure the circulation of fuel from these tanks, they are equipped with coils heated with steam, which ensure an optimal temperature of the fuel inside them. The storage tanks are heated to ensure a fuel temperature of 40 [ºC], and in the settling tanks, the temperature is 60 [ºC].

The volume of each tank is determined from the condition of covering at least the fuel consumption of the main engine during 4 hours of operation. When calculating the volume of consumption tanks, the need for them to be installed in the car compartment must be taken into account. In installations where the main engine is fuelled with heavy fuel, the volume of the consumption tank for diesel will be allowed within the limits of 20 - 25 [%] of the volume of the consumption tank for heavy fuel.

The quantities of fuel for making a trip are determined taking into account the operating regimes of the ship's energy installation, using relation (1):

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$$\sum G = G_{march} + G_{st} \quad (1)$$

where:
- G_{march} - represents fuel consumption in navigation mode,
- G_{st} - fuel consumption during the stationary period.

The autonomy of the ship and the stationary period are adopted at 1000 hours, of which: 760 hours of marching and 240 stationary hours. During the 760 hours of marching, it was considered to be working:

- the main engine,
- two auxiliary engines
- recovery boiler (gas);

during the 240 h of stationary operation, only one auxiliary engine and the auxiliary heating (with burner) are considered to be operating.

Taking into account the above, we have relation (2):

$$\sum G = G_{march} + 0 = C_h \cdot t_{ME} \cdot 10^{-3}[t] \quad (2)$$

.

where:
- C_h - fuel consumption of the main engine;
- t_{ME} - duration of operation of the main engine;

The amount of heavy fuel required for the main engine will be determined using relation (3):

$$G_{c\,HFO} = C_{h\,HFO} \cdot t_{ME} \cdot 10^{-3} = \\ = 3{,}341.876559 \cdot 760 \cdot 10^{-3} = 2{,}539.826185[t] \quad (3)$$

where:
- $C_h = C_{h\,HFO} = 3{,}341.876559\ [l/h]$
- $t_{ME} = 760\ [h]$

For ships where the main engine runs on heavy fuel (H.F.O.), a quantity of medium viscosity fuel, diesel, is added, representing (15 ÷ 20) [%] of the quantity of heavy fuel required by the main engine, which will be used for its supply when starting, stopping and in the maneuvering area.

The amount of diesel fuel required by the main engine is calculated with relation (4):

$$G_{c\,DIES} = (0.15 \div 0.20) \cdot G_{CHFO} = \\ = 0.18 \cdot 2{,}539.826185 = 457.1687133\ [t] \quad (4)$$

3.1. Storage tanks volume

For the embarkation of heavy fuel (H.F.O.) and medium viscosity fuel (diesel) the required volumes will be calculated with the relations (5) and (6):

$$V_{c\,HFO} = c_1 \cdot c_2 \left(\frac{G_{c\,HFO}}{\rho_{c\,HFO}}\right)[m^3] \quad (5)$$

$$V_{c\,DIES} = c_1 \cdot c_2 \left(\frac{G_{c\,DIES}}{\rho_{c\,DIES}}\right)[m^3] \quad (6)$$

where:
- $c_1 = 1.15 \div 1.20$ - is a coefficient by which a surplus of fuel is admitted, c_2 for unforeseen situations;
- $c_2 = 1.07 \div 1.10$ - is a coefficient that takes into account the reduction in the volume of the tanks due to the residual fuel adhering to the walls of the storage spaces.
- $\rho_0\ [t/m^3]$- is the fuel density

Is chosen:
$c_1 = 1.20;\ c_2 = 1.08$
The values are known:
$\rho_{c\,HFO} = 990[kg/m^3]$
$\rho_{c\,DIES} = 840[kg/m^3]$

We replace these values in relations (5) and (6) and obtain the following values (7) and (8):

$$V_{c\,HFO} = 1.20 \cdot 1.08 \cdot \left(\frac{2{,}539.826185}{0.990}\right) \\ = 3{,}324.863369\ [m^3] \\ \approx 3{,}325\ [m^3] \quad (7)$$

$$V_{c\,DIES} = 1.20 \cdot 1.08 \cdot \left(\frac{457.1687133}{0.840}\right) \\ = 705.346015\ [m^3] \approx 705.4\ [m^3] \quad (8)$$

Also here it is taken into account the fact that the burner boiler works when stationary, and the fuel used by it is also stored in the tanks intended to feed the main engine.

Knowing the hourly consumption of heavy fuel of the boiler of $C_h = 1\ l/h\ HFO$, we can determine with relations (9) and (10), the quantity required for boarding and the equivalent volume, calculated for 240 h of operation.

$$G'_{c\,HFO} = 1 \cdot 240 = 240\ [t] \quad (9)$$

$$G'_{c\,DIES} = 0{,}15 \cdot 240 = 36\ [t] \quad (10)$$

$$V'_{c\,HFO} = c_1 \cdot c_2 \left(\frac{G'_{c\,HFO}}{\rho_{c\,HFO}}\right)[m^3] \quad (11)$$

$$V'_{c\,DIES} = c_1 \cdot c_2 \left(\frac{G'_{c\,DIES}}{\rho_{c\,DIES}}\right)[m^3] \quad (12)$$

where:
- $c_1 = 1.15 \div 1.20$ - is a coefficient by which a surplus of fuel is admitted, c_2 for unforeseen situations;
- $c_2 = 1.07 \div 1.10$ - is a coefficient that takes into account the reduction in the volume of the tanks due to the residual fuel adhering to the walls of the storage spaces.

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- ρ_0 $[t/m^3]$- is the fuel density

Is chosen:
$c_1 = 1.20;\ c_2 = 1.08$
The values are known:
$\rho_{cHFO} = 990[kg/m^3]$
$\rho_{cDIES} = 840[kg/m^3]$

We replace these values in relations (11) and (12) and obtain the following values (13) and (14):

$$V'_{c\,HFO} = 1.20 \cdot 1.08 \cdot \left(\frac{240}{0.990}\right) = 314.1818182\ [m^3] \approx 314.182\ [m^3] \quad (13)$$

$$V'_{c\,DIES} = 1.20 \cdot 1.08 \cdot \left(\frac{36}{0.840}\right) = 55.54285714\ [m^3] \approx 55.543\ [m^3] \quad (14)$$

3.2. The volume of settlings tanks

The volume of the settling tank is determined using relation (15):

$$V_s = \frac{c_1 \cdot c_2 \cdot 4 \cdot (c_e \cdot P_e)}{\rho_c}\ [m^3] \quad (15)$$

where:
- $c_1 = 1 \div 6$ - represents the number of carts during which the propulsion engine will be fed from the respective tank;
- $c_2 = 1.07 \div 1.10$ - coefficient of increase of the reservoir capacity due to its clogging with viscous residues;
- c_e $[kg/kw \cdot h]$ - actual fuel consumption
- P_e $[kw]$- effective engine power

The volume of the settling tank must ensure the supply of the engine for a period of 24 hours.
Is chosen:
$c_1 = 6;\ c_2 = 1.08$
The values are known:
$c_e = C_{HFO} = 0.24142\ [kg\ /\ kwh]$;
$P_{e\,HFO} = 13{,}842.76764\ [kw]$;
$\rho_{c\,HFO} = 990\ [kg/m^3]$.

Substituting with the known values, we obtain relation (16):

$$V_{d\,HFO} = 6 \cdot 1.08 \cdot \left(\frac{4 \cdot 0.24142 \cdot 13{,}842.76764}{990}\right) = 87.4976 \approx 87.5\ [m^3] \quad (16)$$

For diesel, the volume of the tank is determined with the relationship (17):

$$V_{d\,DIES} = (0{,}20 \div 0.25) \cdot V_{d\,HFO} = 0.2 \cdot 87.5 = 17.5\ [m^3] \quad (17)$$

According to the provisions of Lloyd Register, the heavy fuel (HFO) installation must be provided with two settling tanks.
The total volume of settling tanks results from relations (18) and (19):

$$V^t_{d\,HFO} = 2 \cdot V_{d\,HFO} = 2 \cdot 87.5 = 175\ [m^3] \quad (18)$$

$$V^t_{d\,DIES} = 2 \cdot V_{d\,DIES} = 2 \cdot 17.5 = 35\ [m^3] \quad (19)$$

3.3. Service tank

The volume of the service tank is calculated with relation (20):

$$V_s = c_1 c_2 \cdot 4 \cdot \frac{c_e \cdot P_e}{\rho_c}\ [m^3] \quad (20)$$

where:
- $c_1 = 1 \div 6$ represents the number of carts during which the main engine will be fed from the service tank, the other coefficients having the same meaning as when calculating the volume of the settling tank.

I adopt:
$c_1 = 6;\ c_2 = 1.08$
Substituting with the known values, we obtain (21):

$$V_{s\,HFO} = 6 \cdot 1.08 \cdot \left(4 \cdot 0.24142 \cdot \frac{13{,}842.76764}{990}\right) \approx 87.5\ [m^3] \quad (21)$$

The volume of the service tank for diesel is determined with relation (22):

$$V_{s\,DIES} = (0{,}20 \div 0.25) \cdot V_{s\,HFO} = 0.22 \cdot V_{s\,HFO} = 0.22 \cdot 87.5 = 19.25\ [m^3] \quad (22)$$

According to the provisions of Lloyd Register, there are two service tanks for HFO and two for diesel.
The total volume of the tanks is given by relations (23) and (24):

$$V^t_{s\,HFO} = 2 \cdot V_{s\,HFO} = 2 \cdot 87.5 = 175\ [m^3] \quad (23)$$

$$V^t_{s\,DIES} = 2 \cdot V_{s\,DIES} = 2 \cdot 19.25 = 38.5\ [m^3] \quad (24)$$

Figure 4 presents a model of a service tank

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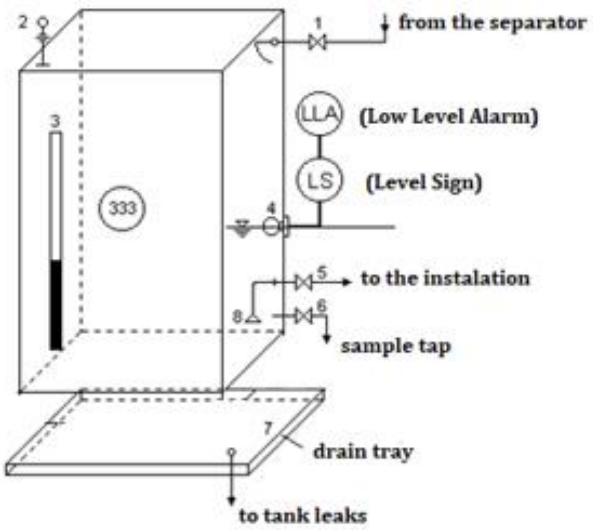

Figure 4. Service tank

Centring the values of the determined volumes, we obtain Table 1 of the form:

Table 1. Necessary volume of fuel tanks

Tank volume	*HFO [m^3]*	*DIESEL [m^3]*
V_c	3,325	705.4
V_c'	314.182	55.543
V_d	175	35
V	175	38.5

4. FILTRATION SYSTEM

Depending on their use, filters are classified into:
- pre-purification filters;
- crude purification filters;
- preventive purification filters;
- fine purification filters.

The first three filter systems are intended to protect the fuel supply system until the suction of the fuel pumps. They are mounted on the fuel boarding piping (pre-purification filters) being typified with simple constructive elements:
- cylindrical casing (pot);
- sealing cover with clingherit or marsitunit gasket;
- cap fastening system;
- tin filter sieve;
- sieve with very small meshes (up to 400 [μm]).

The raw purification filters are usually mounted at the suction of the separators. The preventive purification filters are in the equipment of the sensitive elements in the system (viscometer, flowmeter). These are filters with higher fineness having filter elements made of microporous paper with a fineness of 50 ÷ 150 [μm].

The fine cleaning filter ensures the supply of the highest purity fuel to the high pressure system through the injection pump and injector. From a constructive point of view, the first three types of filters are very varied, being used as filter materials:
- wire sieve;
- metal discs with interstices between them;
- wire filters;
- artificial felt;
- cotton fabrics.

Fine filters must retain about 98 ÷ 99 [%] of particles with sizes between 2 ÷ 7 [μm] and are made up of:
- cotton threads;
- slag wool;
- paper.

The sizing of the filters (or the verification of the correct sizing) consists in determining the filtering surface, and depending on this the dimensions of the filter. The fuel installation of the reference ship is equipped with the filters mentioned in Table 2:

Table 2 The filters in the ship′s fuel installation

Filter type	No of pieces	D_n [mm]	Filter ratio	Fine filtration [mm]
Dual main engine fuel filter	1	65	24	0.5
Double fuel filter boiler of 27,500 [kg steam/h]	1	65	24	0.5
Double fuel filter boiler of 2,000 [kg steam/h]	1	-	-	-
Double filter pumps continuous transfer	1	65	24	0.5

An example of a filter element is shown in the figure 5.

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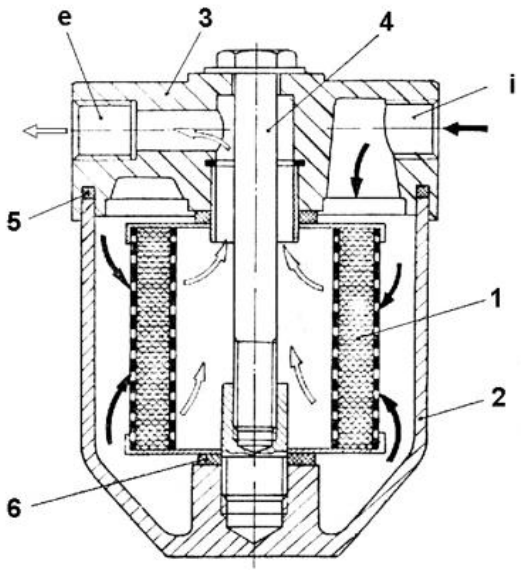

Figure 5. Raw diesel filter with felt filter element:
1 – casing; 2 – cover; 3 – assembly screw; 4 and 5 – sealing gaskets

5. SIZING PUMPS USED IN THE MAIN ENGINE FUEL

The pumps used in the fuel supply system are of the volumetric type:

- ***piston pumps*** - have a maximum suction height, and the practical flow rate changes with the increase in the resistance on the discharge path. The disadvantage of piston pumps is their complicated construction, the mass and dimensions of the piston pump are greater than those of gear or screw pumps
- ***gear pumps*** - they are simple constructions safe in operation, easy to service in operation, with small mass and dimensions, their cost is lower than that of piston pumps. These advantages have led to their spread in naval fuel installations
- ***screw pumps*** - they have become widely used in naval installations for the circulation of viscous liquids. The main disadvantages of these pumps are their complex construction and because of this, their cost is high compared to that of gear pumps.

We adopt the gear pump. The pump consisted of a housing in which two gears rotate on two axes. One of the wheels is considered driving (driven by the engine), the other driven. The play between these wheels and the pump body makes it impossible to direct the liquid in a direction other than the one commanded by the pump. The liquid is drawn by the gaps between the teeth, from the suction chamber to the discharge chamber. In order to protect the pump in the event that the pressure in the installation increases a lot, a safety valve (a by-pass) is provided for the discharge, which allows the creation of a circuit between discharge and suction, thus reducing the pressure.

A pronounced drop in the pump flow is determined by the increase in the clearance between the gears and the pump body.

The flow of this pump is calculated with the formula (25):

$$Q = 2 \cdot Z \cdot n \cdot q \ [m^3/min] \tag{25}$$

where:
2 - the number of gears;
Z - the number of gaps between the teeth (equal to that of the teeth)
n – speed (rpm)
q - the volume of an interval between two teeth $[m^3]$

$$q = f \cdot b \ [m^3] \tag{26}$$

where:
- f - the surface of the interval between two teeth, $[m^2]$
- b - tooth length $[m]$

The flow that the pump must ensure is determined with the relation (27):

$$Q = \Psi \cdot Q_c \ [m^3/h] \tag{27}$$

where:
- Ψ=1.3÷2 safety coefficient; I adopt Ψ=1.3

Actual flow is calculated using the formula (28):

$$Q_c = \frac{C_e \cdot P_e}{\gamma_c} \tag{28}$$

where
- C_e - effective fuel consumption, [kg/kwh]
- P_e - effective engine power, [kw]
- γ_c - specific weight of fuel, [kg/m3]

In formula (27), enter the known data and calculate the values through relation (29):

- For heavy fuel (HFO):

$$Q_{HFO} = \frac{1.3 \cdot 0.24142 \cdot 13{,}842.76764}{990} \approx 4.4 \ [m^3/h] \tag{29}$$

According to the technical documentation of the engine (B & W 8L60MC), we have:

- Circulation pump
  - circulation pump flow rate: 7.7 [m3/h]
  - suction pressure at the circulation pump: 4 [bar]
  - discharge pressure at the circulation pump: 10 bar

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- working temperature, maximum: 150 [ºC]
- viscosity: 20 [cSt]

- Feed pump
  - feed pump flow rate: 3.4 [m^3/h]
  - suction pressure of the feed pump: 4 [bar]
  - discharge pressure of the feed pump: 0 bar
  - working temperature, minimum: 50 [ºC]
  - viscosity, maximum: 700 [cSt]

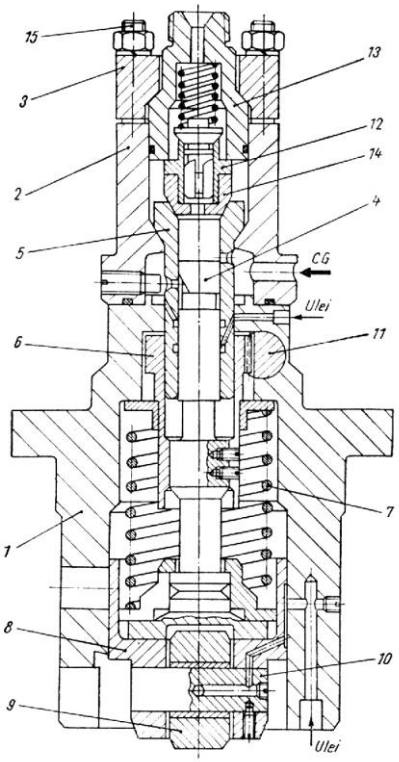

Figure 6 Fuel pump – assembly drawing:
1 – main body; 2 – secondary body; 3 – flange; 4 – piston-drawer; 5 – the cylinder of the discharge element; 6 – bushing; 7 – spring; 8 – taches; 9 – roller; 10 – roller axis; 11 – gear rack; 12 – discharge valve body; 13 – discharge connection; 14 – intermediate piece for centring and tightening; 15 – bolts

6. INJECTORS

The injector is the last component element of the injection equipment, with the role of introducing fuel into the engine cylinders, its fine atomization and the fine distribution of atomized droplets in the combustion chamber. For this purpose, the injector is provided with a sprayer, in which one or more calibrated spray holes are machined. As such, the fine atomization of the fuel is crucially dependent on the construction of the atomizer.

The uniform distribution of sprayed droplets is influenced by the construction of the sprayer but also depends on the organized movement of the air (swirl and swish) in the combustion chamber of the engine.

Injectors are classified according to the criterion of controlling the spray coefficient by a needle-shaped valve, as follows:

- the needle opening command - leads to the solution of a hydraulic injector (hydraulic command) with the diesel to be injected;
- the shape of the needle tip - for this type of injector that works on the engine with unitary combustion chambers we can say that the injector will have the valve - needle with a conical tip.

Thus, diesel injectors with needle valve are closed injectors on the injection equipment with the injection pump separated from the engine.

The advantages of closed injectors are:

- the beginning of the injection occurs at high pressure (100 bar), adjustable by changing a helical spring, which benefits the fineness of the spraying and the penetration of the jet;
- the end of the injection takes place at high pressures with beneficial effects on the penetration of the jet and the burning of the last fractions of injected fuel;
- the dripping and penetration of the flame and hot gases on the channeling from the injector is eliminated.

The disadvantages related to the complication of the technology and the existence of moving parts that determine their wear and, sometimes, seizure, as well as the vibration of the spring-spring system, are eliminated in practice in whole or in part by the proper construction and operation of closed hydraulic injectors.

The body of the injector is made of carburizing quality carbon steel (OLC 15), manufactured by forging. The flat surface of the injector, which is also the limiter of the needle stroke, carbonitriding and hardening (minimum 50 HRC) to avoid deformation and ensure proper tightness.

The sprayers are made from special steels (body from OE-18 CrNi 20), and the needle from (Rp5LS). The sprayer body mates with the needle so that the clearance in the sealing portion is within the prescribed limits (1.5 … 3 μm). Once paired, the sprayer body and needle become a non-interchangeable assembly.

7. CONCLUSIONS

The fuel installation of marine main engines must meet the following requirements:

• must ensure the formation of the fuel mixture in good conditions;

• must ensure the continuous flow of fuel to the injection pump;

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• must ensure the appropriate dosing of the fuel quantity in accordance with the engine's operating regime;
• must ensure the protection of the fuel against contamination with external mechanical impurities and water;
• must ensure the storage of a sufficient amount of fuel for the operation of the engine for a certain duration.

In this paper, we calculated the fuel installation of the main engine by dimensioning the main component elements of the installation such as: storage, settling and service (consumption) tanks.

We also chose the type of fuel supply pump of the main engine - gear pump and determined the flow rate of the chosen pump.

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