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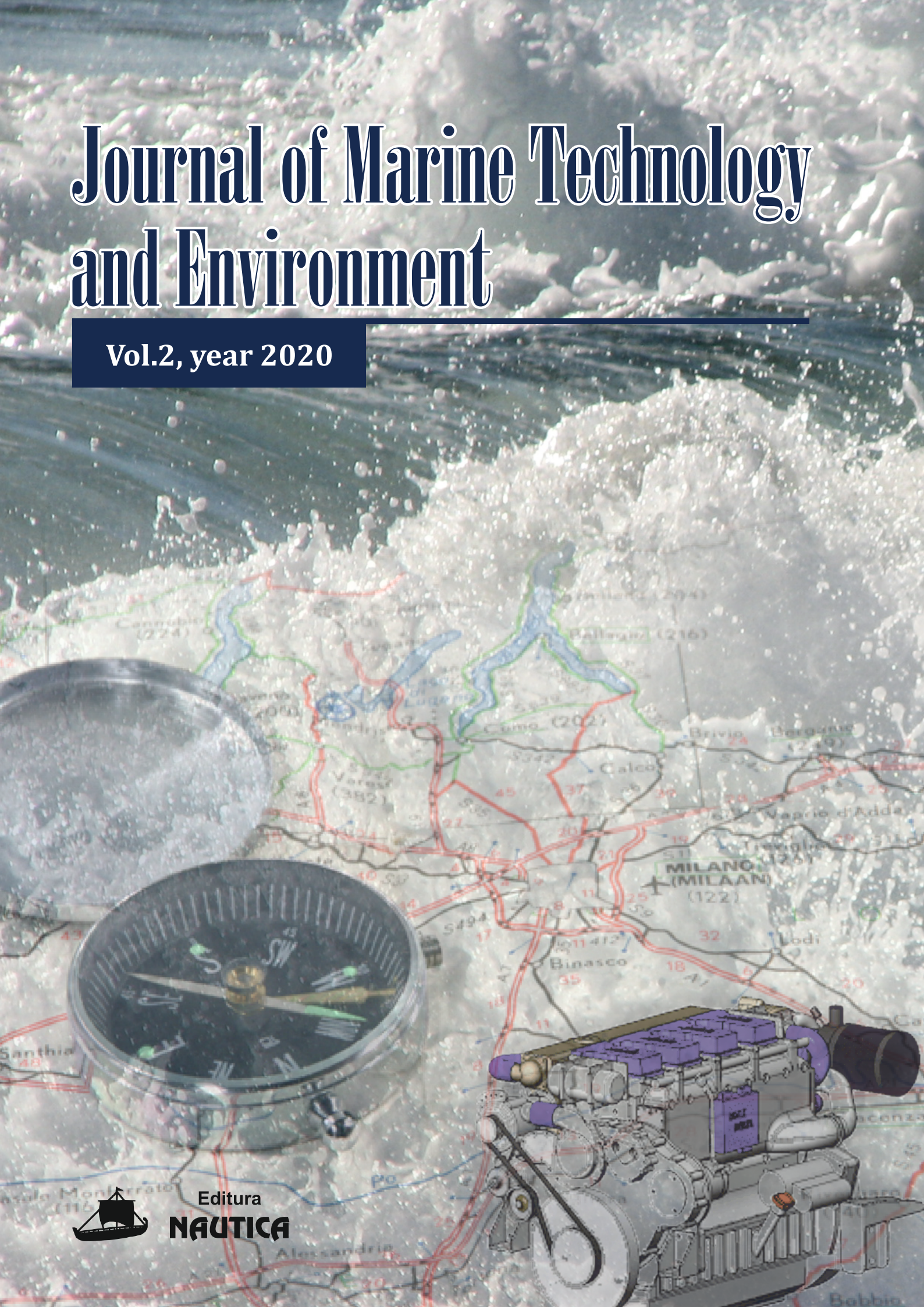

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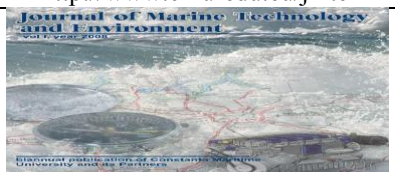

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Constanta Maritime University/ROMANIA

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- Marine Science and Engineering
- Marine Environmental Issues
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SUSTAINABLE DEVELOPMENT IN MET: THE MAAP PHILIPPINES AND CONSTANTA MARITIME UNIVERSITY ROMANIA BEST PRACTICES

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Abstract : Sustainable development (SD) is defined as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

The result of the analysis from the gathered data is presented in this summary. The analysis was based on the following research objectives: (1) analyze the concept of SD and applicability to Maritime High Education Institutions (MHEIs); (2) MHEIs integration of sustainability principles in their management, operations and curricula activities; (3) identify barriers to integration; (4) analyze contemporary approaches of MHEIs for SD; (5) suggest ways of improving the SD performance of MHEIs.

Key words : development, sustainable, need, generation, maritime, analysis, integration, questionnaire.

1. INTRODUCTION

The participants of this study are the maritime institution from Europe represented by CMU Romania and maritime institution from Asia Pacific represented by MAAP Philippines .

The data was gathered by interviewing the participants using the structured questions developed by the SDiMET researchers (WMU Sweden, AASTMT Egypt, UPC Spain, Blackpool College, UK and MAAP Philippines).

Furthermore, after gathering the data, it was studied, coded and analyzed using Atlas.ti which is an application intended for Qualitative research.

The gathered data from Europe Institution (1EU) and Asia Pacific Institution (1AP) are described and discussed in this report. The following are the generated analysis to answer the research objective (1) analyze the concept of SD and applicability to MHEIs. 1EU described the concept of SD by relying on the definition from our common future also known as the Brundtland report, they also described its effect on humans,

"Sustainable development meets the needs of current generations without compromising the ability of future generations to meet their own needs" – 1EU [1]

"Sustainable development improves the quality of human life, within the limits of the functioning of life support systems on the planet" – 1EU [2].

On the other hand, 1AP defined the concept of SD by expanding the definition used by 1EU

"Sustainability is that we should be able to provide whatever is needed for today in the best way that we can without compromising the requirements of the future. So, that's just "Provide for today. Make sure that we have something for tomorrow." -1AP [3]

1EU discussed SD as a process of change than an end which is similar to the understanding of 1AP that SD implies a change of belief in practices, culture, etc.

"Sustainable development is more of a process of change than an end in itself; it can introduce new visions of our cities and villages, but it must start from the interests of the local community." – 1EU [4]

"Sustainable development does not simply require an "add on" to existing structures and curricula, rather, it implies a change of belief in our culture, choices, thinking, practice strategies & actions in integrating the concepts of sustainability principles in work and

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curricula that lead to optimum sustainable development outcomes" [5].

1AP explained the practices of MHEIs towards a sustainable community and showed an example on how they applied SD in their institution,

"A truly sustainable MHEIs functions as a sustainable community, practicing responsible use of water, food, energy and supports the sustainable development of their locality and region." – 1AP

"MAAP incorporated SD in the MAAP New Educational Quality Policy to wit "We at MAAP commit to manage a maritime education and training environment that satisfies its learners', stakeholders 'social responsibility and intellectual property requirements and achieves greater efficiency by continual – 1AP

educational quality standard system, scientific, technical and sustainable development and improvement" under Section 5 Leadership of the MAAP Educational Quality Standard System Manual"

Also on how they are being sustainable in maritime education and training,

"We ensure that we are sustainable in maritime education and training and making sure that we are able to provide for our students, for the young professionals, and even the existing professionals. Provide them with necessary instruments and tools that they need so that they can do their jobs without compromising, without reducing what is needed in the future." – 1AP .

2. THE ANALYSIS TO ANSWER THE RESEARCH OBJECTIVE (2) MHEIS INTEGRATION OF SUSTAINABILITY PRINCIPLES IN THEIR MANAGEMENT, OPERATIONS AND CURRICULA ACTIVITIES

The following are the generated analysis to answer the research objective (2) MHEIs integration of sustainability principles in their management, operations and curricula activities.

In terms of integrating sustainability principles in the institution's management. 1EU and 1AP have these accreditation requirement to integrate SD in their system.

"Yes , these are the Local agenda 21` ; the Integrated quality-environment management system; the Process BOLOGNA- Erasmus , Erasmus+, Horizon 2020-credit mobility for incoming and outcoming participants for studies and practices (teachers, researches and students)" -1EU

"None in the Philippines because it is voluntary. However, it is a Yes for external accreditation like DNV-GL wherein sustainable development is one of the expected outcomes of the educational organization. MAAP is the first institution in the Philippines and in the region to be accredited by DNV-GL for ISO 21001:2018 for the Management systems for educational organization. This standard contributes to Sustainable Development Goals Number 4, 10 and 1" – 1AP

1EU's organizational arrangement regarding SD revolves on the provided policy for the field of quality and environment which provides satisfactory services. Similar to 1AP in which they also incorporated SD into their new quality policy.

- *"Integrated policy applied by the Maritime University of Constanța in the field of quality and the environment is based on the commitment of its management to provide satisfactory services customer requirements in terms of efficiency and effectiveness, without significantly affecting the environment and to ensure health and safety at work, in accordance with the defined and assumed policy driving.*

The general objectives of our University in the field of quality and environment are:

-Increasing the competitiveness of services provided through the qualification and experience of employees, as well as by developing the university infrastructure.

-Ensuring the necessary human, material, informational and infrastructure resources continuous improvement of system efficiency, thus improving the working environment in order to achieve compliance with the determined requirements.

-Process management in accordance with the requirements of the reference standards for achieving and continuously improving performance in the field of quality, environment and a the effectiveness of the integrated management system.

-Fulfilling the organization's specific compliance obligations, applicable to the activities University in the field of quality and environment.

- Pollution prevention.

-Performance management of waste resulting from the University's activities.

"MAAP incorporated SD in the MAAP New Educational Quality Policy to wit " We at MAAP commit to manage a maritime education and training environment that satisfies its learners', stakeholders 'social responsibility and intellectual property

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requirements and achieves greater efficiency by continual educational quality standard system, scientific , technical and sustainable development and improvement" under Section 5 Leadership of the MAAP Educational Quality Standard System Manual ." -1AP

Also, 1AP for the improvement of their management system, they have been given an ISO accreditation that includes SD and contributes to SDG

"This 2020, MAAP is the first institution in the region to be accredited by DNV-GL for ISO 21001:2018 Management systems for educational organization. This standard contributes to Sustainable Development Goals: https://www.iso.org/standard/66266.html *Under 3.29 social responsibility to wit "responsibility of an organization (3.1) for the impacts of its decisions and activities on society and the environment, through transparent and ethical behaviour that contributes to sustainable development, including health and the welfare of society. Hence, MAAP updated its Educational Quality Policy and included sustainable development."*

This ISO accreditation as stated was given by DNV-GL which has a big impact in the institution's management and operations.

"With the new DNV accreditation, MAAP community from bottom to top are encouraged to integrate SD in their respective procedures and processes as part of their strategic action plan so that we in MAAP shall jointly contribute to the accomplishment of SDGs for a sustainable future" – 1AP

1AP is also working on accreditation as center of excellence.

"Currently, MAAP is working towards a PACUCOA Level IV accreditation. AUSN accreditation, NI and IMAREST Centre of Excellence Accreditation. "– 1AP.

They also integrate SD in their management by sustainability assessments in their respective institutions. For 1EU, they have an internal assessment for sustainability.

"Yes, thru Internal-Integrated quality-environment management system-manual for institutional sustainability assessments" – 1EU

While in 1AP, they both have the external and internal assessment for sustainability.

"Yes. Internally thru Outcomes-based Assessment and Evaluation wherein:

- The knowledge and skills of students are being assessed and monitored through the conduct of course/learning outcomes, midterms and final examinations. The assessment covers both theoretical and practical requirements of courses, as applicable. For trainees, they are assessed on achieving the required standards of competence for the particular program in accordance with the methods and criteria in the Approved Training and Assessment Standards.
- Assessment standards are in accordance with STCW, MARINA, CHED, OPITO and other statutory requirements. The assessment tools are validated and reviewed by the trained and accredited assessors within the institution.
- Third class midshipmen or second year students are required to undertake the nationwide National Maritime School Assessment Program (MSAP) to assess their competencies in Mathematics, English, and Technical subjects wherein MAAP always tops the exam vis-à-vis other MET schools in the country
- The MAAP Center of Competency Assessment. (CCA) is in-charge of item analysis, data-banking and item writing to ensure the administration of valid and reliable periodical examination for all subjects. CCA is equipped with the Optical Mark Reader (OPR) which is used for checking test papers, item analysis and item banking." – 1AP

"Yes, Externally, thru getting feedbacks from various stakeholders, shipping sponsors and partner organizations of MAAP thru feedback form mechanism. However, the assessment does not specifically indicate for sustainability, although it involves and affects people, environment and economy (cost/budget). " – 1AP.

3. THE ANALYSIS TO ANSWER THE RESEARCH OBJECTIVE (3) IDENTIFY BARRIERS TO INTEGRATION

In terms of the barriers in implementing SD principles in campus management, both institutions (1EU and 1AP) said that there is no barriers in their institution since all personnel are actively involved in such implementations.

"No. All members of the academic community together with the administrative staff contribute to the implementation of the institutional sustainable development policies." – 1EU

"No barriers, as long as implementing rules will be provided, all MAAP personnel strictly adhere and

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execute the policies directed by the Office of the President." – AP

However, in a more general concept, 1EU and 1AP also discussed the possible or foreseen barriers in integrating sustainable development in maritime institution. For 1EU the following are the possible barriers for SD:

"Limited resources and therefore must seek funding from external sources (e.g. Sustainability related grants and fellowships)

- Academics and therefore must demonstrate relevance of discipline-specific topics and issues to sustainability in classes
- Lack of Innovation and therefore must seek ways to shift the focus of existing campus programs toward sustainability topics and issues
- Community and therefore must describe connections between sustainability and local groups, particularly as they affect future careers for graduates
- Collaborations and therefore must undertake collaborative writing and research projects." – 1EU

While for 1AP listed are the barriers in integrating SD:

"SD concepts might already been integrated but may come in different terminologies

Status quo or resistance to change in integrating concepts or elements of sustainable development in the existing curriculum, procedures, policy, planning and operations

There may be no terms of reference or guidelines for the departments, divisions or offices for them to integrate principles of sustainable development to the existing MAAP curriculum or operational procedures or developmental programs and services

There may be limited or no knowledge about SD and its principles among the faculty, staff and students

No topics or Issues on Sustainable maritime development in the Research Agenda

Existing curriculum does not reflect the sustainable development concepts " – 1AP

3.1 Educational Quality policies

While 1AP has CSR and is also a part of their new educational policy which also adapts SD policies:

"*Yes and they are incorporated in the newly revised MAAP Educational Quality Policy to wit* " We at MAAP commit to manage a maritime education and training environment that satisfies its learners', stakeholders 'social responsibility and intellectual property requirements and achieves greater efficiency by continual educational quality standard system, scientific , technical and sustainable development and improvement" under Section 5 Leadership of the MAAP Educational Quality Standard System Manual ."

Such activities that they are conducting are based on the dimensions of sustainable development: social, economic and environmental aspects.

"Various extension services programs are participated in by MAAP community (faculty, staff and students) either voluntarily or as requested by external agencies. These include health, environmental care and protection, and education and training extension programs.

3.2 Health programms

On Health Program, MAAP students assist in feeding programs, medical/dental missions and gift giving to indigent residents in Bataan. Biannually, MAAP midshipmen/personnel donate blood to the Philippine National Red Cross (PNRC) and Veterans Memorial Hospital and Medical Center (VMHMC) thereby helping save people's lives. Due to its contributions, MAAP received Sandugo Tandang Sora, Gawad Papuri, and other awards from various agencies such as PNRC, Department of Health and VMHMC. Also, MAAP annually collaborates with TOTAL and LIQUIGAZ for Christmas cheers to less fortunate children of Sitio Marina and other selected areas in Bataan by organizing fun games and giving meals and school supplies.

3.2 Environmental care and protection programms

On Environmental care and protection program, MAAP cadets conduct tree planting, coastal clean-up and waste management activities. MAAP, with all its cadets, annually supports the International Coastal Clean-up Day celebration every September in coordination with the local government of Bataan. MAAP cadets also take part in the Annual Brigada Escuela in the neighbouring public schools by helping in cleaning and refurbishing their facilities.

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4. THE RESEARCH OBJECTIVE (4) ANALYZE CONTEMPORARY APPROACHES OF MHEIS FOR SD

1EU and 1AP are both working on the improvement of their buildings by modernizing its facilities to provide quality services in terms of education and training to their customers while progressing towards a sustainable community.

"Improving the educational infrastructure of the Maritime University of Constanța by expanding / rehabilitating / modernizing and equipping Corps B - Nautical Base (Lac Mamaia Headquarters)

Infrastructures of which has CMU and associated quality facilities including modern classrooms, library and student accommodations with sustainable facilities-natural lighting or fluorescent lamps, systems with renewable energies (photovoltaic pannels, wind turbines on Maritime Nautical Base of CMU), connection high speed internet, multi-functional labs with new sustainable technologies and equipment and sports facilities." – 1EU

"In the furtherance of the UN SD goals, particularly SDG5 , MAAP built a separate dormitory for women and sought job placements aboardship for our women students and graduates.

MAAP has state-of-the-art facilities that include a Simulator Center with the most modern Full Mission Bridge Simulator on a Motion Platform and Full Mission Engine Room Simulator with Big View®, GMDSS laboratory, Computer Laboratory, ten (10) LabVolt training systems for Refrigeration and Airconditioning, Fluid Power, Electromechanical System (EMS), Automation, and Electrotech Laboratory; Firefighting Complex; Vessel Training Center consisting of an Integrated Bridge System, an Operating Control Room, two main engine and two (2) auxiliary engines; Language Laboratory, and other modern facilities. MAAP has a 5,020 DWT dedicated training ship (T/S KFO) and pier facility. Also, the MAAP's Sea Survival Center at the pier consists of an enclosed lifeboat on a the local government of Bataan. MAAP cadets also take part in the Annual Brigada Escuela in the neighbouring public schools by helping in cleaning and refurbishing their facilities.

5. THE IMPROVEMENT IN TECHNOLOGY

With the use of modern technology, MAAP was able to cope up with the increasing demand of internet and network usage of midshipmen, faculty, and staff. With a total of 525 computer units from Data Servers down to client workstations from laboratories, study rooms and offices, MAAP provided high-speed internet access through capable Internet Service Provider (ISP) with a total bandwidth of 38mbps and Gigabit network speed access. Also, the installation of 56 WiFi routers located at different hotspot areas provided additional access to mobile users which include faculty and midshipmen for research, computer-based training courses, access to Learning Management System for E-Learning materials, and other academic purposes. Connections to the internet and the local network are controlled by Firewall System for network security and reliability. In addition, MAAP is also provided with 3G and 4G network services for network connectivity for laptops, mobile, and other gadgets for internet connection. MAAP has state of the art ISDN and VOIP lines for outgoing and incoming calls for both Manila and Bataan. Students have their own tablets" – 1AP

1AP also expanded their resources for academic purposes:

"*MAAP Library has enhanced its services with 15,784 volumes of books (with 5,100 titles), an increase of 88% from 8,385. The Library's collection also include e-books, e-journals, and other e-resources can be viewed at maaplibrary.wordpress.com. Computers are available for students especially for accessing electronic resources and internet for academic and research purposes.*"- 1AP

In 1AP institution, they also regularly inspect the quality system of their facilities for continual improvement.

"*MAAP subjects itself to both internal and external audit for continual improvement and sustainability, hence there is a monitoring checklist to ensure and assure quality system at MAAP in all aspects including facilities and operations* "

Even this time where the world is currently facing a pandemic, nothing can stop 1AP in providing the best services.

"*With Covid 19 pandemic , there is a new work arrangements for the new normal at MAAP . MAAP will*

be utilizing various technologies and apps in the delivery of our services. The MAAP memo with guidelines is already in place and emailed to all concerned as per online meeting via ZOOM." -1AP

Furthermore, 1EU and 1AP also adapted SD in their operations by using sustainable source of energy.

"The main sources of energy used by our institutions is 100% percentages fluorescent lamps and on the Nautical Base 20% of this is with renewable energies (The HORESEC project supports intelligent
specialization in the field of energy, through the holistic analysis of the impact of energy sources on climate change, achieving the evolution, the progress of knowledge, for a sustainable development of Romania." – 1EU

"There are six sources of renewable energy: Biomass, Geothermal; Solar, Hydrothermal, Ocean and Wind. MAAP uses 10% Solar Energy. The rest is electrical energy using LED lights and also re-chargeable batteries and gasoline ." -1AP

In terms of campus management, 1EU collaborates with other maritime institutions to develop and promote learning programs as well as exchange programs for training.

"CMU concluded more than 20 partnerships with world-renowned maritime institutions to explore and promote cooperation in learning and research,
CMU has Established bilateral protocols with naval universities and crewing companies around the world to ensure the exchange of students and teachers and to achieve an exchange of experience in the maritime field.
CMU has developed partnerships with other universities (supporting mobility through the Erasmus + program) in order to develop common specializations and conduct university and postgraduate education programs;
CMU stimulated staff exchanges and continuing training in areas of common interest, and expand the experience of partner students and faculties, giving them real opportunities to develop cultural skills;
CMU is active in training of general, specialized and transversal competencies compatible with the modernization stage of the society" – 1EU

1AP's manages their campus effectively by establishing departments/centers that serves its own functions, this is in order for the institution to be productive and give satisfactory services to its customer.

"MAAP's Center for Advanced Maritime Studies (CAMS) was established to answer the growing demand for qualified and well-trained Marine office executives and Maritime educators. CAMS cater for the needs of the stakeholders by offering graduate programs and high-level short courses/seminars for seafarers, research, and consultancy for the maritime industry."
"MAAP also has a Professional Career Development Center (PCDC), being supported by AMOSUP which includes the PRC computerized walk-in examination system (WES) which speeds up the certification and licensing process; hence, accelerating production of more officers. This PCDC serves as a computer training and review center for WES to encourage marine officers to upgrade their licenses. MOA between AMOSUP-MAAP and PRC was signed for the PCDC to also serve as an off-site WES testing center."

They also made improvements in their facilities for training that are being used by students.

"Other MAAP Innovations on Facilities and Operations include: Workshop Skills Lab (STCW Compliant); 2 Training Ships (MV KFO and MV KGO);Upgraded Bridge and Engine Simulators to K –SIM; Upgraded Lab Volt Laboratories; LMS with Seagull and Viodeotel CBTs; Tablet for each Cadet; Robotics subject and Club to acquaint our cadets with the advances in Mechatronics and Artificial intelligence; Smart TV in Classrooms; Two 3D Printers; Two Drones and Blockchain Technology for Certificates , TOR Etc."- 1AP

6. ACADEMICS

One of the contemporary approach of 1EU for SD is by including and considering education for sustainable development (ESD) topics in their curriculum.

"CMU offers various subjects on :

a. *Sustainable Development*
b. *Environment and unconventional energy sources*
c. *Ecological transport systems and sustainable development*
d. *Biodiversity-course for acquiring knowledge about the environment, environmental quality, environmental resources, protected areas, protected area management, environmental bioindicators*
e. *Aquatic ecosystems for acquiring knowledge about hydrobiology of aquatic systems*
f. *Ecopedology-the science that deals with the soil*
g. *Environmental chemistry*
h. *Ecological monitoring*

i. *Hydraulics*
j. *Dynamics of polyphasic fluids*
k. *The basics of emergency management*
l. *Ecology*
m. *Ecotoxicology*
n. *Thermal efficiency of buildings and industrial processes*
o. *Marine ecological technologies*
p. *The impact of combustion plants on the environment*
q. *Wind engineering*
r. *Environmental protection procedures and techniques*
s. *Radiation sources and protection techniques*
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z. *Economics and environmental accounting*

While for 1AP, they developed enhancement and development programs for students as a form of academic approach to SD.

"There is No exclusive course on Sustainability in the maritime course offerings but there are some academic approaches to sustainable development thru various *Enhancement and Development Programs for students, to cite some examples are:*

Academic Ramp Program (ARP) *was initiated based on the Warsash Mari time Center's study that recommends developing academic ramp in the form of model course (s) covering basic math, physics and other relevant subjects needed to take maritime training in accordance to STCW standards. Since 2006, MAAP extended its one-month refresher courses in Math and English to two-month ARP with additional course in Physics. This program is part of the admission requirements for incoming students conducted during the Indoctrination Orientation Period (IOP).*

Instructional Materials and Curriculum Development Program *raises academic standards as the academic courses are systematized and standardized in accordance with IMO standards and QMS Policy Manual. Course manuals and documents are being periodically evaluated and revised to conform to the current MET standards, including the Outcomes Based Education (OBE) guidelines, for students' academic development.*

English Computerized Learning Program *was acquired on November 21, 2005 in support for the MAAP English Only Policy to develop the communication skills of students in preparation for their employment onboard international vessels where English is the primary means of communication. This software involves 60-hour sessions of enhancing language skills and pronunciation capability. Pre and post tests are conducted to assess the performance of the students.*

DNV Sea Skills Program*, this is an IT-Aided Competence Management Standard for Watchkeeping Engineer/Officer (WKE/WKO), is a maritime tool aimed to safeguard life, property and environment against the catastrophes and tragedies at sea as it used to anticipate and evade risks such as accidents most related to human error. This tool is used by midshipmen who are future officers to boost their "situational awareness" towards improved operational safety and competence.*

Integrated Simulator Training Program*– This aims to make the students aware of their jobs onboard and be able to apply what they have learned. The simulator exercises intend to gauge the knowledge of the deck and engine cadets on the application of the theoretical information they have acquired in their respective academic instructions. This program is an additional service to students conducted beyond academic hours, apart from the curriculum, to enhance their knowledge and skills as they learn how to solve case scenarios." – 1AP*

The following are the generated analysis to answer the research objective (5) suggest ways of improving the SD performance of MHEIs. According to 1AP, transparency of SD efforts in the institution and maintaining strong partnerships with other maritime and non-maritime institutions could help improve the implementation of SD. As for 1EU, they didn't clearly suggested ways on how to improve the implementation of SD

"Transparency, documentation and reporting of institutional SD efforts would improve implementation of SD in HEIs. Incentives or awards for sustainability efforts would also help improve SD implementation.

Also , an SD maritime policy and strong linkages and partnership for SD with various maritime and non-maritime institutions for academic, research, extension and professional development both local and international would improve SD in Higher Education Institutions that is cost effective, relevant and efficient.

MAAP thru ERO pro-actively develops cooperative relationships with relevant contacts–maritime education and training officials, faculty members, facilitators, government officials and other stakeholders to maintain the Academy's reputation, while paving the way for future maritime partnerships and opportunities.External Activities at MAAP which are in partnership with external partners or linkages are carried out in accordance with the directives of MAAP President as well as current trends for innovative development. External activities and expansion of external contacts are important for an effective quality management system which allow meeting of excellent education standards." – 1AP

1AP and 1EU both agreed that IAMU is a vital player or has the ability to help in implementing SD in higher education institutions, since IAMU is a global association that binds various renowned maritime institutions. Both institutions also noted the role of research in the implementation of sustainable development.

"YES, IAMU is in position to help with this. Scientific research and cooperation play a key role in internationalization policy. UMC is an active member of two major international networks with great potential for the development of student and teacher mobility, as well as research projects: the International Association of Maritime Universities (IAMU) and the Black Sea Association of Maritime Institutions (BSAMI).

UMC is an active member of the International Association of Marine Universities (IAMU), which brings together 57 institutions from around the world. IAMU is the most authoritative voice in promoting quality education and standardizing the curriculum and certification of graduates worldwide. In the period 2012-2013, the Maritime University of Constanța ensured the presidency of this prestigious association through Mr. Prof.univ.dr.ing. Cornel Panait." – 1EU

"Yes, certainly. The funding of this SDIMET project is considered a start because all decisions and actions of IAMU must be based on research as an objective reference on what can possibly be done to support the IAMU MET institutions perspective on SDIMET for possible assistance by IAMU as part of the development projects that can be funded by IAMU for desired outputs or outcomes.

1. *IAMU could create or establish an SDIMET Network wherein all its institutional members can share annually their respective best practices for sustainable development. This could serve as the annual venue of sharing and reporting in respect to SD, that could be documented thru presentations and publications.*
2. *IAMU to include SD in maritime as part of its Research Agenda and Developmental projects.*
3. *IAMU can launch search for best practices on SD to be participated by IAMU member institutions with incentives to encourage submission of entries for presentations and publications*
4. *IAMU institutional member institutions can also sign an SDiMET declaration and come up with a 6-point action Plan to serve as terms of reference to jointly contribute to sustainable future" – 1AP.*

7. CONCLUSIONS

As institutions of higher education concerned about the state of the world environment and the advancement of sustainable development, CMU and MAAP universities strive to promote actions that will achieve a sustainable future.Together endorse the Talloires Declaration and agree to support environmental citizenship at all levels including senior managers, administrators,faculties, staff and students.

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CURRENT CONTROL FOR STEPPER MOTOR OPERATION

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Abstract: The maximum benefit of a stepper motor can only be obtained if it is ordered correctly, this requiring a direct current source, an electronic switch and a controlled pulse generator (numerical information). For all their advantages, stepper motors have several limitations that can cause significant implementation and operation problems depending on the application.

Key words: stepper motor, unipolar, bipolar, power, torque.

1. INTRODUCTION

A stepper motor, which operates without load outside its working frequency range, will have resonant points. When a motor is supplied with a constant value voltage the output torque decreases with increasing speed.

This is due to the increase in the inverse electromagnetic field and the intensity of the electric current through the winding, thus limiting the power supplied to the engine. This effect is determined by the engine time constant (L/R).

Due to the high winding resistance, unipolar motors have a better L/R ratio than their bipolar equivalents.

The effect can be compensated either by increasing the power of the voltage source to keep the current constant as the speed of rotation increases, either by increasing the supply voltage to a certain value and adding series resistors in the circuit.

The compatibility of the stepper motor with numerical calculation technique led to obtaining superior performances in the positioning process, which determined the extension of their fields of applicability.

The stepper motor performs the direct conversion of the input signal, given in numerical form, in a discontinuous or incremental angular motion.

Due to these properties, stepper motors allow the realization of discrete type control systems, which have the advantage of not needing feedback loops to correct movement.

2.STEPPER MOTOR CIRCUIT

The stepper motor circuit can be presented in two basic variants: unipolar and bipolar.

The motor variant with the unipolar circuit only needs a single switch. This means a specific winding factor and the thread is thinner and much stronger.

The engine variant with bipolar circuit needs a single winding, with a good coefficient, with low winding resistance.

The motor variant with the bipolar circuit needs two switches and therefore several semiconductors.

When a motor is supplied with a constant value voltage, the output torque decreases with increasing speed.

This is due to the increase in the inverse electromagnetic field and the intensity of the electric current through the winding, thus limiting the power supplied to the engine.

This effect is determined by the engine time constant (L/R).

By adding series resistors to the control circuit, engine performance can be improved at high rotational speeds, by reducing the L/R ratio.

Due to the high resistance of the windings, unipolar motors have a better L / R ratio than their bipolar equivalents.

The effect can be compensated either by increasing the power of the voltage source to keep the current constant as the rotational speed increases, either by increasing the supply voltage by a certain value and adding series resistors to the circuit.

By implementing discrete electronic devices, the conductive circuit of unipolar motors is improved.

Using integrated circuits, the motors built in bipolar variant can be driven without additional components.

The speed of the stator's electromagnetic field is the same as that of the stepper motor. Increasing the speed can be achieved by reducing the electric power.

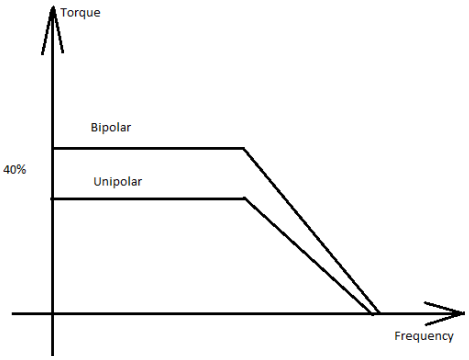


Figure 1 The bipolar motor has a higher speed than the unipolar motor

Bipolar motors therefore have an advantage over single-pole motors, because of the resistance caused by the copper conductive material, they have a double section of wire. [1]

Feeding only one winding at a time is called wave excitation and produces the same position increment.

When only one winding is supplied, the retaining torque and the working torque are reduced by 30%.

This, within certain limits, can be compensated by increasing the supply voltage.

The advantage of this control method is the higher efficiency, but at the cost of reducing the accuracy of the motor.

It is possible to control the engine in a half-step sequence, which causes movements with half steps, for example with a step angle of 3.75 ° instead of a step of 7.5 °.

A possible disadvantage, for some applications, consists in the fact that in this case the retaining torque is alternately strong and respectively weak, at successive steps of the engine.

This is because in the case of the full-step control only one phase of the winding is supplied, while, in the case of the half-step control, two stator windings are supplied.

Also, in the case of the second method, the directions of current and magnetic flux are different at alternative steps, which results in lower travel accuracy.

The winding current can be multiplied by cu √2 and this produces a proportional increase in speed.
Bipolar motors bring a 40% increase in speed compared to unipolar motors.

Keeping the current value within limits and controlling this value at the same time, the electric power of the stepper motor is kept constant.

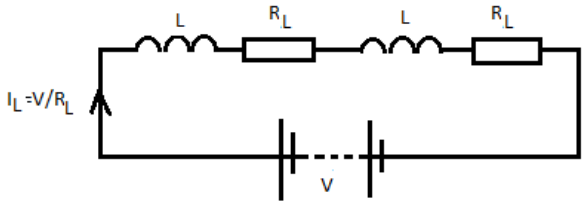


Figure 2 Circuit for current limitation

The role of the RL resistor is to control and limit the current to obtain the value of the electrical voltage required for the stepper motor.[5]

Another accepted solution is the use of a current generator in the circuit to obtain an independent current.

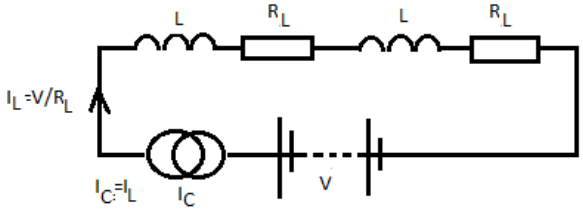


Figure 3 Circuit for limiting with current generator

We know that the motor power is proportional to the current intensity.

The dynamic operation of the stepper motor changes the poles of the winding current at the same time as the stator after two steps.

The speed at which the current changes is after an exponential function and depends on the specific inductance, the resistance of the coil and the electrical voltage.

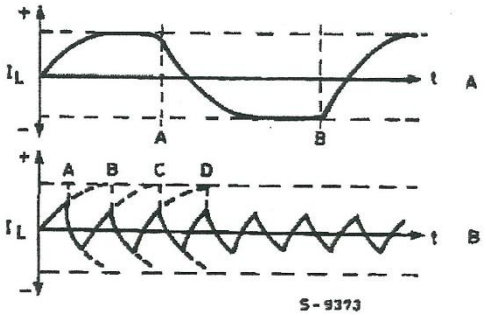
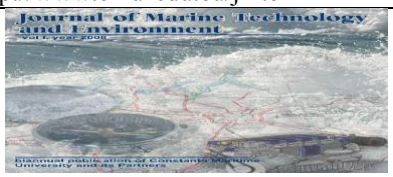


Figure 4 Frequency of winding current using the two circuits in turn

At higher speeds an increase in speed is possible using a current generator.

The current generator limits the current per phase and becomes active only when the current has reached the nominal value.

Up to this value, the generator current is saturated and the voltage supply is applied directly to the winding.



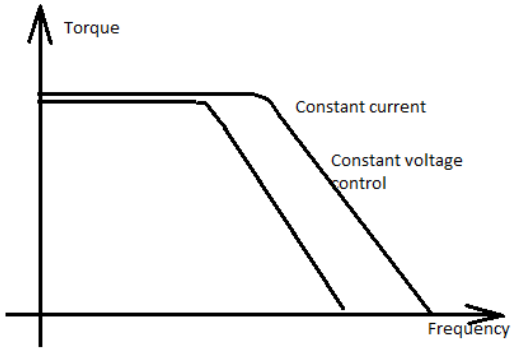


Figure 5: Current control for stepper motor operation and speed for a high frequency

3. STEPPER MOTOR CALCULATION

Electromagnetic voltage in the inductor

$$E_M = U_N \frac{1+\eta}{2} - \Delta U_{pe} \quad (1)$$

$$E_M = 3.2 \frac{1+0,83}{2} - 2 = 0.928\,\text{V} \quad (2)$$

The induced current

$$I_{aM} = I_{NM}(1 - k_e) \quad (3)$$

$$I_{NM} = \frac{P_N}{\eta U_N} = \frac{2,14}{0,83 \cdot 3.2} = 0,86\,\text{A} \quad (4)$$

Intern power

$$P_{iM} = E_M \cdot I_{aM} = 2,88 \cdot 0,786 = 2,262 \quad (5)$$

$$P_{iM} = 2.262\,\text{W} \quad (6)$$

Number of poles: p = 2

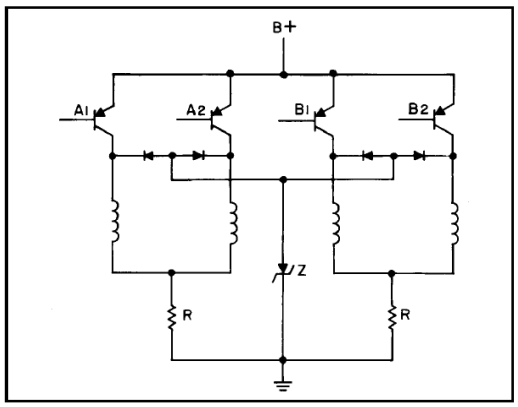


Figure 6 Increasing stepper motor performance [7]

Whenever the power supply is turned off, a high voltage inductance will be generated, which can damage the drive circuit.

The normal method used to suppress these inductions is to put a diode over each winding.

This, however, will reduce the torque output of the engine, unless the voltage on the switching transistors is allowed to have a value of at least twice the supply voltage.

If it is bigger these voltages than the faster the induced field will be created, and the current will decrease and therefore better performance.

4. CONCLUSIONS

Stepper motors are mainly used in applications where incremental movement is desired, using numerical control systems.

The advantages of using stepper motors are the following:

- ensures the univocity of the impulse-displacement conversion and can be used in open circuit;
- wide range of control frequencies - increased accuracy and power (number of steps per rotation);
- allow starts, stops, reversals, without loss of steps;
- memorizes the position;
- are compatible with numerical technology.

For all their advantages, stepper motors have several limitations that can cause significant implementation and operation problems depending on the application.[2]

Stepper motors have no spare power.

A loss of 80% of rated torque to 90% of top speed is typical.

Trying to speed up a load too fast when the stepper motor cannot generate enough torque to move to the next step before the next pulse unit will lead to a jumped step and a loss in position.

Most stepper motors are bidirectional and allow fast acceleration, stopping and reversing without loss of steps, if they are controlled with a frequency lower than the limit frequency corresponding to the respective operating mode.

In order to extend the operation of stepper motors at speeds higher than the speed corresponding to the limit frequency, it is necessary to accelerate by gradually increasing the frequency of the control pulses.

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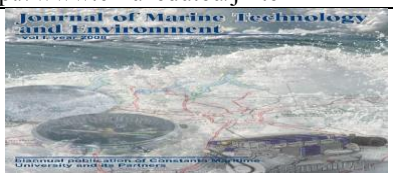

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MODERN TECHNOLOGIES IMPLEMENTED IN THE OPERATION OF MARITIME CONTAINER AND RO-RO TERMINALS

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Abstract: Maritime transport is constantly changing and adapting. With the evolution of containerized transport, the concept of RO-RO transport and ships also took shape - it was initially developed for the sustainability of general freight transport on ordinary routes. The geographical position of the Black Sea is ideal for sea traffic and also has a high potential for the development of the Ro-Ro market. Ro-Ro ships are particularly well adapted to the requirements of short-distance transport, where transport speed and optimum operability are essential. The introduction of a Ro-Ro / Ro-Pax line that will connect the Port of Constanta and Karasu, Turkey will offer a cheaper and faster alternative to highly congested land routes around Turkey / Bulgaria and Bulgaria / Romania. Ro-Ro intermodal transport has many advantages, such as: high reliability, safety, low level of administrative complexity, reduces exposure to road accidents. Designed exclusively for container transport, the project provides for some changes to the terminal to determine the proper functioning of Ro-Ro / Ro-Pax intermodal transport, as follows: construction / installation of a pontoon, modification of the vehicle access road, extension of the ramp operation, arranging a quay for ships with a total length between 180-200 m, ensuring all facilities for good operability. The ship must complete a round trip between the ports of Constanta, Romania and Karasu Turkey within 24 hours. It approximates a stationary time of berth of maximum 2 hours and a journey of maximum 10 hours round trip.
Key words: Ro-Ro, transport, maritime, port, highly congested land routes, geographical position

1. INTRODUCTION

The concept of Ro-Ro ships was originally developed to replace conventional ships in general cargo transport. Ro-Ro-type vessels are particularly well adapted to short-distance transport requirements, in which optimum transport speed and operability are essential. The Ro-Ro market can be defined as a subsection of the vehicle transport market, so it is difficult to use containerized transport services, customers preferring Ro-Ro type ships that are specifically designed for such transport and cargo.

Ro-Ro type ships are of 3 types:

- Ro-Ro multidesk- associated with the transport of vehicles on whose platforms are found packaged goods, palletized or containers;
- With cellular system - intended for both the transport of vehicles on wheels and goods in containers, which require stacking in the cellular system of the ship;
- With cellular system and conventional loading space - intended for the transport of vehicles on wheels, conventional goods and in containers;

Ro-Ro type ships, from a constructive point of view, are divided into 3 other categories:

- Ro-Pax- intended for the carriage of goods and passengers;
- ConRo- is a hybrid between a Ro-Ro ship and a Portcontainer, this type of ship has an area used for storing vehicles while stacking containerized cargo is done on the upper decks;
- RoLo- hybrid ship with ramps that serve the lower decks, but the containers on the upper decks are handled with cranes;

The geography of the Black Sea is ideal for short sea shipping. It has an increased potential to support the

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development of a Ro-Ro / Ro-Pax transport network between neighboring countries. An existing route is between Istanbul, Turkey and Chornomorsk, Ukraine - totaling 4 trips per week. This provides a much faster and cheaper alternative, to the detriment of overcrowded land routes through Turkey-Bulgaria-Romania-Moldova-Ukraine.

2. NEW ROUTES IN THE MARITIME TRANSPORT NETWORK

A thorough market analysis found that the introduction of a Turkey-Romania transport route would have multiple advantages, the most important of which is the much cheaper and faster alternative to highly congested land routes around the Turkey / Bulgaria and Bulgaria borders. /Romania.

Figure 1 Transport network between Turkey and Romania in the Black Sea [1]

The main competitors are road transport. Although it is an important competitor, shipping with Ro-Ro ships has benefited from its many advantages, thus making road transport far outdated.

Between the 2 ports, Constanța-Karasu, it is desired to implement a "24/7" service concept. This concept will provide a regular and reliable transport service, which interconnects points in the land transport infrastructure. The operated route serves as an essential connection between Europe, Turkey and the Middle East.

2.1. Ro-Ro terminal in Karasu, Turkey

Karasu Port, Turkey has a strategic location on the Black Sea, located 150 km from Istanbul, in the Asian part and has a total area of 250,000 m². It also has 2 berths, 1 wharf for mooring, and the water depth is on average 11 m.

Since 2011, Karasu-Turkey has had a monopoly on Ro-Ro transport in the Black Sea. It has easily gained a leading position in freight and passenger transport between Turkey and Europe, offering 24/7 services, low costs and a flexible schedule.

Currently, Karasu-Turkey offers services between Istanbul, Turkey and Chornomorsk, Ukraine with 4 weekly sailings and offers a shorter alternative to the highly congested land routes through Turkey, Bulgaria, Romania, Moldovia and Ukraine. There are currently 2 Ro-Pax companies offering similar services on the route and may consider extending this service to 6-8 weekly sailings, this would require additionally one vessel to the existing fleet.

2.2. Important landmarks of investments

a) Robust Market Fundamentals with Positive Outlook

- Attractive underlying macroeconomic profile driving growth in Turkish international trade;
- Recovery in key European markets and growing trade with MENA region;
- Structural advantages of Ro-Ro offering driving up its market share vs. land;

b) Leading and Entrenched Market Position as an Indispensable Part of the Value Chain

- Sea Lines can take a market leader position in the Black Sea Ro-Ro sector;
- Limited competition on its core routes and primarily competing with overland transportation;
- Modern fleet and limited Ro-Ro terminal access can create competitive advantages for Sea Lines;

c) Unique Network and Compelling Service Offering

- "Traffic machine" concept provides a reliable, timely, flexible and cost-efficient method of transportation;
- Unique intermodal infrastructure offering gives direct access to key European industrial areas;
- An established network provides best connectivity to different parts of Europe and additional flexibility to clients;
- The Company's unique service offering makes it a provider of choice for the whole Turkish trucking industry;

d) Well Invested Asset Base and Access to Key Infrastructure

- Investment can result in one of the youngest purpose-built/acquired fleets with high operating efficiency and low capex requirement for further growth;

- Secured access to key ports: by ownership/concession of terminals and secured slots and priority access provide secure access to scarce Ro-Ro port facilities;
- Unique expertise in intermodal service offering with links to rail infrastructure;
- Ample capacity to grow the business further with the current asset base;

e) Strong Management Track Record and Development Through the Cycle

- Proven track record of continually enhanced business model while maintaining attractive financial characteristics;
- Well managed recovery of the business post financial crisis;
- Materially improved quality of operations and organisational structure, creating an attractive platform for further development;

f) Attractive Structural Growth Opportunities

- Further multiple opportunities to outgrow the market through promotion of intermodal services, continuing conversion of land to Ro-Ro, and incremental increase in capacity;
- Attractive potential for new lines;

In order to differentiate itself from the rest of the competitors, the Constanta-Karasu route wants to offer its customers a series of auxiliary services, as follows:

- **Terminal services**: Customs pre-declarations, train connections, resting, restaurant areas for drivers;
- **IT solutions**: Online reservation and tracking;
- **Support for intermodal projects:** Priority booking is provided to customers booking sea plus rail services which enables customers to prioritise their cargo and hence prevent potential delays;
- **Tax-free Fuel**: Tax-free fuel is offered to customers in Karasu terminal.

3. OPTIMIZATION OF THE RO-RO TERMINAL IN CONSTANȚA PORT

Following the evaluation regarding the arrangement of keys, berths and port access by road and sea transit for a Ro-Ro/Ro-Pax ship operating from Constanta, Romania to Karasu, Turkey, it was found that the strategic position and the possibility of modernizing the current terminal will facilitate trade between the Middle East and Central Europe.

The baseline assumptions for the inspection are outlined as follows:

Vessel details:

- LOA: 180-200m;
- Beam: 27-30m;
- Draft: 6.8-7.2m (loaded);
- Cargo: 100-120 Standard trailer/self-drive tractor trailer (13.5-16.5m);
- Cargo Mix: 30% trailer/ 70% Self Drive tractor trailer;
- Voyage: Constanta, Romania to Karasu, Turkey
- Distance: 280 Nautical Miles;
- Voyage time: Stated 10 hrs berth- berth, est'd vessel speed 21kts. (TBC);
- Port Turnaround: 2 hr maximum.

Vessel is required to complete one round trip between ports Constanta, Romania and Karasu Turkey within 24hrs. Assumes vessel full load discharge and return load each port. Maneuver without tugs however, existing harbour bylaws require tug assistance for all ships in excess of 1000 NRT. Request exemption to operate with no tugs via Harbour Masters for each port. Acts of pilotage and tugs for port arrival/departures will be introduce additional time to voyage considerable overheads to vessel operating costs.

Voyage distance are 240 Nm. The schedule will consist of port departure approx. 10:00hrs and 22:00hrs from respective ports. Voyage time berth to berth should not exceed 10 hrs. Vessel speed profile should support voyage time and it is estimated that 21kts will be minimum services speed wind not exceeding Beaufort 3 and wave's not exceeding Douglas sea state 3.

3.1. Quayside/Berth infrastructure

Designated berth for Ro-Ro operations is located within Constanta, berth No 126-127. Overall length of quay inway of berths is 505mtrs. Fendering consists of 13 single extended groin structures each 90 deg to quay which form the dented quay configuration. Each has installed one mooring bollard and fenders facing consists of 3 x 300mm dia. hollow section butyl neoprene rubber tube held in position by chains.

Figure 2 Butyl neoprene rubber tube [2]

Vessel entry to berth is unobstructed on seaward side (East) with approx. 500m turning circle to the east of the quay. The most effective approach to berth consists of a head to west and starboard turn head to North.

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Large ships/bulk carriers operate within the confines of berth 126 to 130. There is a manmade breakwater to the east which forms a seaway channel approx. 250 m width. This allows for large vessels 200mtrs LOA x 35-50mtr Beam to access berth 128-130. The introduction of a fixed landing stage/pontoon for Ro-Ro operations would impact on the vessel access channel to berth 128-130 reducing the width to approx. 150 m.

The construction/installation of landing stage/pontoon at berth 127 will require access road/gantry linking the shore to pontoon for cargo to transit onto vessel. Position of the vehicle access link road/gantry may require modifications to the berth at 127. With tidal range 1-1.5 m chart datum the access road/gantry for cargo should be achieved with limited gradient. The overall dimensions of pontoon landing for ships ramp should be within the confines of 126-127 berth.

The current design considerations for Ro-Ro berth would require modifications to the quay within confines of berth 127, with infill of void spacing to three locations inway of dented quay. This is essential to install cargo access link to pontoon and support the axle weight of cargo which will transit to and from vessel.

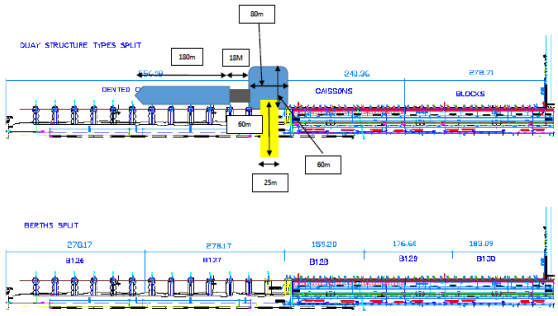

Figure 3 Berth arrangements [3]

It is assumed the ships ramp will sit onto a prefabricated floating pontoon or fabricated landing extension sat 90 deg to the quay. Overall size of the construction would be approx. 80mtrs x 80mtrs. When installed this would extend to the East adjacent to the berth.

3.2. Cargo Operations – Shore side

Two locations are identified for transit/holding of cargo. The areas are noted as Area A and Area D. Area A (12 Hectares) sit adjacent to operational berth 126-127. This stated as prepared with sub-base and will require clearing of vegetation and application of constructed surface to support trailer traffic.

Figure 4 Area A [4]

Area D (13 Hectares) sits 600 m to south of berth 127 accessible via an underdeveloped track. It is adjacent to existing rail infrastructure; this area is noted for clearing and preparation for vehicles. The access road to all berths 127-130 requires leveling and reconstruction to support cargo axle loads 50-100 MT. The link road which extends 100 m form Area D up to berth 130 and adjacent to storage warehouse requires widening to ensure dual access road to and from Area D to berth and Ro-Ro berth. See photos and sketch of layout.

Figure 5 Area D [5]

To achieve 2hr turnaround, flow of traffic across the ramp should be simple and free flowing for all cargo types. It was considered inbound cargo would exit port to the south onto Area D. With existing estimates for cargo mix 30%/70% unaccompanied trailers/ Self Drive Vehicle this must be achieved within 40 min.

Outward bound or export cargo would enter port via south gate maintaining separate ISPS control of Ro-Ro operations to that of container terminal. With Area D optimised for customs clearance with fixed office facilities for boarder control this could double up to support clearance of export trailers ready to load onto ship.

The traffic would then transfer via the 600 m newly engineered road and held in Area A for loading onto vessel. This area would have simple driver facilities i.e. toilets. The pre-load safety checks for trailer could be

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achieved in efficient manner and loading commence when practical but no later than 40 min after vessel arrival. Vessel must complete load and ramp closed within 80 min with vessel departure 2hrs post arrival if schedule is to be maintained.

The 2hrs turnaround for 100-120 trailers will require a detailed plan and review based on selection of vessel, cargo deck loading configuration, experience of officers, crew and shore loading stevedores.

3.3. Vessel Operations

To meet cost effective manning model limit passengers to 120 maximum. The deck and engine room manning would consist of minimum manning plus additional for cargo operations, maintenance and to meet Marine Labor Convention minimum hours of rest. OBS manning for passenger offer would consist of ten which includes three stewards dedicated to cabin cleaning and front of house services restaurant and bar if this were required.

Crew manning model would consist of similar profile as North Sea / Irish Sea overnight service with experienced officers and crew with STCW certification working similar duty periods onboard.

Key to the success of the project will be the safe and efficient cargo operations with reliable service speed for vessel voyage time of 10 hrs. Fuel consumption would be consistent with the speed of operation. Utilization of shore stevedores with a minimum of 6 tractor tugs and 2 on site as backup/supplement trailer cargo will be required for trailer traffic. In event trailer traffic were to exceed 30% the provision for additional stevedore services should be considered. Lashing of cargo using ship's crew or shore staff will require review.

Black Sea weather conditions and sea state are not considered adverse for operation however significant wave heights have been reported in excess of 5 mtrs during periods of cyclonic activity. Wind speed can exceed Beaufort 10 and the prevailing winds direction is notably North / North West. There records to confirm that vessel services will be affected for a period of 19-26 days per annum.

4. CALCULATION INDICATORS FOR RO-RO TERMINAL

Quality indicators are:

- waiting time during service (W / S);
- berth occupancy rate;
- total return time;

There are four important stages in terms of developing the methodology for obtaining quality and level of service, as follows:

• the optimal value for the operating time is estimated;

• the waiting probability associated with the obtained operating time is calculated;

• the capacity graph for the current terminal is drawn and finally;

• the level of the service scale associated with the terminal is obtained;

The total stationary time (t_s- the time allocated to a single ship at berth) can be obtained once the port operation time (t_{sv}) is known. t_s varies greatly depending on the volume of cargo, the characteristics of the ship, and its specifications.

Service time (t_s) is the amount of time the dock or berthing points is/are devoted to a specific ship including berthing, loading and other operations the ship does in each scale in port such as ramp lowering and berth approaching maneuvers. Service time has been split in two other times:

- operation time (t_o);
- stevedoring time (t_{sv});

Vessel operation time (t_o) refers to all times a berth is involved to a specific ship, but the time spent in stevedoring.

$$t_o = 16 \bullet d + 3 \bullet R + 20 \quad (1)$$

where R represents the number of ramps and d the distance to be traveled from the port entry to the final mooring dock.

Stevedoring time (t_{sv}) represents the larger parameter in the service time calculation. In order to be stimated it,is proposed a linear ecuation between the ship capacity and the time needed to load and unload. In equation 2, in equation 2 the service time is highlighted.:

$$t_{sv} = t^t + t^p + \max(t_y^{st} + t_v^{st}, t_y^{cc} + t_v^{cc}) \quad (2)$$

Trucks and passenger vehicles times (t^t and t^p) - both values can follow a linear distribution if is a uniform process. Equation 3 and 4 can be obtained to estimate t^t and t^p, where$\mu_1^p$and μ_1^t represents the number of vehicles/trucks that can be loaded in a time unit, μ_u^p and μ_u^t are the amount that can be unloaded and n_1^p, n_1^t, n_u^p and nut their respective number of trucks/vehicles to (un)load:

$$t^t = \frac{1}{\mu_1^t} n_1^t + \frac{1}{\mu_u^t} \mu_u^t + t_{af}^t \quad (3)$$

$$t^p = \frac{1}{\mu_u^p} n_u^p + \frac{1}{\mu_1^p} n_1^p \quad (4)$$

Semi-trailer times (t_v^{st} and t_y^{st}) are stevedored in the same time. During stevedoring, the main difference

between these kinds of cargo and the previously defined is that semi-trailers (as well as car cargo) are not self-stevedored, and thus, the limiting factor it is no longer the ship's ramp capacity, but the number of stevedoring units, how long do they have to travel to stevedore one unit and the configuration of both the terminal's yard and the ship. The semi-trailers ship time (t_v^{st}) and its variability need to be calculated for each kind of ship berthing at the terminal.

$$t_v^{st}=\mathrm{N}(\frac{t_v^m(n_u^{st}+n_l^{st})}{n^m}, \frac{\sigma_v^{m^2}(n_u^{st}+n_l^{st})}{(n^m)^2}) \quad (5)$$

Car-cargo times (t_v^{cc} și t_y^{cc}) are the average distance to be travelled from the storage area to the ramp(s), when loading (and unloading) as well as the maximum circulating speed allowed, the number of drivers per van used in stevedoring as well as the number of vans.

$$t_y^{cc}=(\frac{3}{1000}d^{cc}+1)\frac{n^{cc}}{n^c} \quad (6)$$

Equation 6 is important to highlight the equation to estimate the yard time (in minutes) which are necessary to stevedore n^{cc} car units accounting for both, loading and unloading, assuming a travelling speed of 40km/h.

5. CONCLUSIONS

Ro-Ro traffic is likely to increase worldwide and therefore an increase in the capacity of Ro-Ro terminals is needed. The geography of the Black Sea is ideal for short sea shipping. It has an increased potential to support the development of a Ro-Ro / Ro-Pax transport network between neighboring countries.

A thorough market analysis found that the introduction of a Turkey-Romania transport route would have multiple advantages, the most important of which is the much cheaper and faster alternative to highly congested land routes around the Turkey / Bulgaria and Bulgaria borders. /Romania.

Following the evaluation regarding the arrangement of quays, berths and port access by road and sea transit for a Ro-Ro/Ro-Pax ship operating from Constanța, Romania to Karasu, Turkey, it was found that the strategic position and the possibility of modernizing the current terminal will facilitate trade between the Middle East and Central Europe.

In order to achieve the proposed objectives, a substantial investment is needed in a modern Ro-Pax fleet and in the modernization / arrangement of a Ro-Ro operational terminal in the port of Constanța, optimal for the operability of a medium-sized ship.

Therefore, the terminal in the Port of Constanța will undergo some modifications so that the Ro-Ro type ships can benefit from all the port operations necessary for a good development of the project. Piloting services (if applicable), storage, stacking, mooring, access to railways and highways will be provided.

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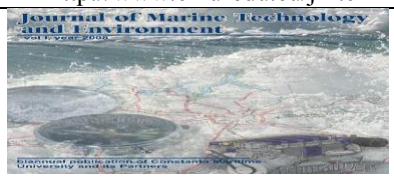

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ENERGY EFFICIENCY OF BULGARIAN MARITIME TRANSPORT

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Abstract: Efficient transport plays an important role in the process of economic and social development of modern society. Maritime transport provides significant opportunities to increase efficiency and improve environmental performance. The purpose of this paper is to present an analysis and various opportunities for energy efficiency improvement of maritime transport.

The strategic geographic location of Bulgaria between Asia and Europe, defines our country as an important partner in the international trade. The participation of the Bulgarian transport on the international transport market and the development of the transport system, as part of the European transport system is one of the important directions for improvement of its efficiency. The transport sector is at a stage where existing measures for energy efficiency improvement need to be deepened and expanded in order to meet the sustainable development scenario.

Environmental protection, energy efficiency and optimal use of the resources are among the main goals of the modern scientific community. Energy efficiency optimization in maritime transport could be achieved by applying a complex analysis and a combination of organizational, technical and operational measures for improvement.
Key words: energy efficiency, maritime transport, environmental protection.

1. INTRODUCTION

Water transport, including maritime transport and inland waterway navigation provides significant energy efficiency (EE) opportunities. The importance of river and sea transport today is due to the fact that water transport offers a serious alternative for quality, effective and economic transport service, while protecting the environment.

The article aims to present an analysis and various opportunities for increasing the energy efficiency of water transport in the Republic of Bulgaria. The development of the Bulgarian transport system, as part of the European transport system is one of the important directions for increasing its efficiency.

A transport strategy is being prepared in Bulgaria, which aims to outline the most important guidelines for the development of the efficient transport system and activities up to 2030. [5] The transport sector is an important component for economic development. When transport systems are efficient, they provide economic and social opportunities and benefits.

The main goals set in the strategy are discussed in the article: efficient use of the resources; limiting the impact of transport on the environment; energy efficiency; an integrated approach; interconnectedness of different modes of transport (Improving the accessibility of areas using transport modes in various combinations); increasing transport safety and quality of life.

2. THE MARITIME TRANSPORT STRATEGY OF THE EU AND THE REPUBLIC OF BULGARIA

The transport sector is the second largest emitter of CO_2 emissions from fuel combustion, and therefore global transport policy over the last decade has focused on implementation of various technical and economic measures to increase efficiency and protect the environment.

The industrial sectors have the following share (Figure1): Electricity and heat generation - 13.6 Gt CO_2; Transport - 8.04 Gt CO_2; Industry - 7.81 Gt CO_2; Other - 0.62 Gt CO_2.

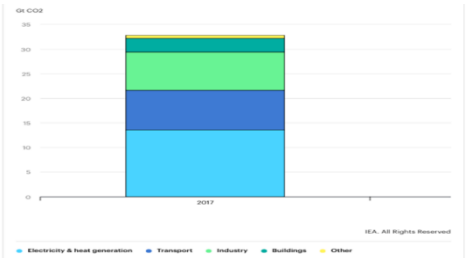

Figure 1 IEA, Global CO_2 emissions by sector, 2017 [2]

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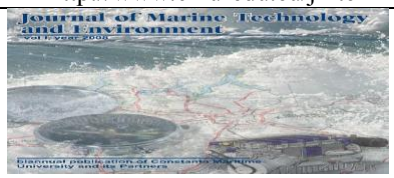

The transport sector is in a position in which existing measures to increase efficiency and reduce energy demand must be deepened and extended for compliance with the Sustainable Development Scenario (SDS). Global transport sector energy intensity dropped by 2.1% in 2018 after falling by 1.5% per year from 2000 to 2017. However, to meet the sustainable development scenario, energy intensity must drop by 3.4% annually from 2019 to 2030. [2]

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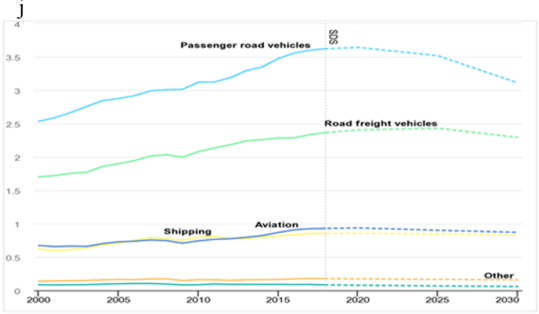

Figure 2 Share of CO2 emissions from the transport sector by industry in the sustainable development scenario 2000-2030 [2]

It is necessary to implement energy efficiency measures in the transport sector while reducing CO_2 emissions, to achieve optimization and in order to meet the projected demand for transport services. The use of cleaner fuels and stricter emission control standards for vehicles would improve air quality. Energy efficiency measures include: transport demand management to reduce the frequency and distances of trips, switching to the most efficient transport modes; implementation of energy efficient technologies and operational measures for fuel economy. The use of sustainable, low-carbon fuels and the introduction of strict emission control standards for vehicles would protect the environment.

Maritime transport is the most efficient mode of transport, and as shipping increases with the development of commercial and economic activities, it is necessary to pay more attention to greenhouse gas emissions from international shipping and the possibilities for their reduction.

The most important directions for energy efficiency optimization in Maritime transport are: development and improvement of transport system of Bulgaria and the coordination of transport policy objectives with those of the Integrated Maritime Policy for the European Union, namely: improving the efficiency of maritime transport in Europe; limiting the impact of ships on climate change; developing technology and innovation base for maritime transport.

The European Commission pursues a consistent policy for improvement of the European transport network (TEN-T), using a variety of concepts and programs: Short-sea shipping, Naiades (river transport), MoS (Motorways of the Sea), Marco Polo II (intermodal/combined transport), Freight transport logistics and so on.

It is necessary to promote the growth of maritime transport, through measures including: infrastructure modernization, synchronization of procedures and equipment, improving safety and protection of the marine environment.

In January 2009, the European Commission presented the main strategic objectives for the European maritime transport system up to 2018 and identifies the key areas of action that will strengthen the competitiveness of the sector and improve its environmental performance. The main goals set in the document are:

• Strengthening the role of European maritime transport in the globalized market

• Preservation and accumulation of human resources, maritime skills and practical experience

• Improving the quality of maritime transport services

• Achieving a comprehensive international regulatory framework for maritime transport

• Utilizing the full potential of short sea shipping and other types of maritime transport services

• Ensuring Europe's place as a world leader in research and development of innovations in maritime transport. [3]

In order to achieve the set goals, a number of measures and recommendations are aimed at increasing the role of short sea shipping in the logistics chain of intermodal freight transport, improving the internal market, simplifying administrative procedures related to maritime transport; traffic and port infrastructure improvement.

In June 2009, the European Council instructed the European Commission to develop a "European Union Strategy for the Development of the Danube Area".

The priority areas for the development of the Strategy are outlined on the basis of the three "pillars" proposed by the Commission:

• Connectivity - planning initiatives to improve accessibility, transport connections and communications on and to the Danube and the efficient use of energy resources

• Environment - implementation of a policy including measures for water quality improvement, biodiversity, prevention and risk management

• "Unlocking the potential" – covers a wide range of economic areas, with an emphasis on economic development and increasing the competitiveness of regions, education, culture, tourism.

In September 2016, the European Commission published a Staff Working Document on the implementation of the EU Maritime Transport Strategy 2009-2018, presenting developments and achievements covering the period 2009-2015, whilst highlighting the areas where further work is needed. The document

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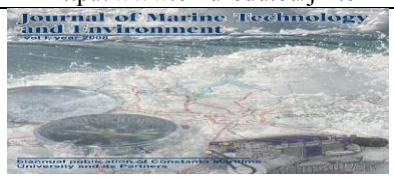

provides an overview of all maritime transport policy activities and a starting point for the modernization in 2017. [3]

In April 2018, the International Maritime Organization (IMO) agreed to reduce GHG emissions by at least 50% by 2050 compared with a 2008, with carbon intensity reduction targets for 2030 and 2050. This process must be activated in the next decade, as the delay will require more stringent measures after 2030, which could significantly increase the cost of meeting the targets. Comprehensive efforts in all modes of transport and reduction of CO_2 emissions will play a crucial role in achieving the goals.

EU strategy goals in the field of water transport [4]

• Strengthening the role of short sea shipping and inland waterway transport;
• Establish rules and regulations for maritime safety, including minimum social requirements for seafarers;
• Introduction of a European traffic management system;
• Increasing the share of intermodal transport (connecting the sea, the river and railways) - Marco Polo Program;
• Increasing container traffic;
• Development of the Trans-European Network and in particular The European Transport Corridor VII – Danube River;
• Introduction of the concept of Motorways of the Sea (MoS);
• Placing users on transport services at the centre of transport policy.

Bulgaria's strategy goals for water transport development

• Restructuring and improvement of sea and river transport;
• Improving the quality, safety and security of passenger and cargo transport;
• Development and optimization of port infrastructure;
• Increasing transit traffic through Bulgaria to and from the EU;
• Increasing the contribution of transport to economic growth and the quality of life in Bulgaria.

Achieving the transport strategy goals is important for economic development and for the integration of Bulgarian transport system into the European network.

3. TRANS-EUROPEAN TRANSPORT CORRIDORS THROUGH BULGARIA

Due to the fact that Bulgaria is located on the crossroads between Europe and Asia, 5 out of 10 transport corridors in Central and South-eastern Europe pass through the territory of the country.

Figure 3 The European Transport Corridors [industrial-zones.com]

The European Transport Corridor (ETC) No IV - Dresden - Prague - Bratislava - Gyor - Budapest - Arad - Kraiowa - Sofia - Plovdiv - Istanbul with a branch Sofia - Kulata - Thessaloniki is the route connecting the Central European countries with the Aegean Sea (the Thessaloniki Sea port). The ETC section on the territory of Bulgaria (Vidin-Sofia-CBCP" Kulata") is 446 km long.

The ETC No VII - Danube waterway - river route "The Rhine-the Mein-the Danube". Its length is 760 km. The ETC section on the territory of Bulgaria Danube, being an European water route, is of international importance. The ETC No VIII - Duras-Tirana-Kaftan/Kafasan-Skopje-Deve Bair-Gueshevo-Sofia-Plovdiv-Burgas-(Varna) is the connection between the Adriatic Sea and the Black Sea regions, Russia and the countries of Central Asia and it crosses Albania, Macedonia and Bulgaria.

The ETC No IX - Helsinki-Sankt Petersbourg-Pskov-Vitebsk-Kiev-Lyubashevka-Kishinew-Bucharest-Russe-Dimitrovgrad-Alexandroupolis serves to connect the countries of North East Europe through Romania and Bulgaria with the Seaport Alexandropoulos on the Aegean Sea. The total length of the Corridor on the territory of Bulgaria in the direction Rousse-Veliko Tarnovo-Gabrovo-Stara Zagora-Dimitrovgrad-Kardjali is 455 km plus 20 km new road construction.

The ETC No X - Salzburg-Lubliana-Zagreb-Belgrade-Nish-Skopje-Veles-Thessaloniki, with branches: Gratz-Maribor-Zagreb; Budapest-Novi Sad-Belgrade; Nish-Sofia (Dimitrovgrad-Istanbul); Veles-Bitolya-Florina-Via Ignatia-Igumenitsa. [6]

Bulgaria is connected with all countries share a border with the Black Sea - Romania, Turkey, Ukraine, Russia, and Georgia. This offers great opportunities for the development of transport connections and improves accessibility through the large bays of Varna and Bourgas.

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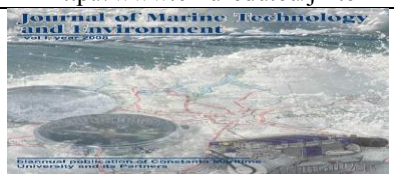

Due to the growth of trade with Russia and Ukraine, ferry port was built and the waterway Varna - Devnya. The Danube River connects the countries of Eastern Europe with the inland waterways of Western Europe. Its importance increased especially after the completion of the Rhine-Main-Danube navigable canal. A combined transport of goods under the river-sea and river-land scheme is carried out along the river. The development of intermodal freight transport in recent years is among the main priorities in European Union transport policy.

Maritime transport in Bulgaria maintains 9 regular lines: Western European, Mediterranean and Far Eastern. Freight transport is carried out mainly from the Black Sea ports of Russia and Ukraine; the ferry connections Varna-Ilyichovsk; lines: Varna-Novorossiysk; and since 1999 - Varna-Ilyichovsk-Poti (Georgia), which opened the way for our country to participate in the project "Traseka" (the Silk Road), as well as the lines between Varna and Bourgas with Odessa, Mariupol and Novorossiysk. Bulgaria also participates in the International Enterprise "Interlichter" based in Budapest, which performs combined intermodal transport "river - sea - river". [1]

Development of Bulgaria's maritime transport system as part of European transport system is the most important direction for energy efficiency optimization in Maritime transport. Development of the Trans-European Network; The European Transport Corridors and introduction of the concept of Motorways of the Sea, will ensure sustainable and efficient maritime transport.

4. THE MOST IMPORTANT DIRECTIONS FOR ENERGY EFFICIENCY OPTIMIZATION IN MARITIME TRANSPORT

Transport system must be considered as a complex system, whose important subsystems are vehicles, infrastructure, transport hubs, storage facilities, etc. In order to achieve higher efficiency of transport services, it is necessary to fully develop the transport system and implement interconnectedness of different modes of transport (rail, road, water, etc.), ports and carriers. To optimize energy efficiency, it is necessary to implement a certain energy policy - determine the initial data of the system and to select the most appropriate measures and activities that could affect and increase efficiency.

The main directions for energy efficiency optimization of water transport are the following:

4.1 Development of a transport system

Bulgaria's maritime transport has strategic, economic and social significance for the country's policy. When conducting maritime policy, it is essential to apply such mechanisms that bring us as close as possible to the principles applicable in the EU. Instruments favouring the development of maritime transport are:

- Harmonization of the Bulgarian legislation with the European one;
- Introduction of integrated communication systems for fleet control and management;
- Introduction of ISPS code - on the terms and conditions for achieving security of ships and ports;
- Improvement of the performance of maritime administration by providing financial, organizational and human resources;
- Development of new transport technologies for transport optimization;
- Optimization of the taxes - adequate policy for providing preferential tax schemes to increase freight traffic and so on.

4.2 Optimization of vehicles

An important part of energy efficiency optimization in maritime transport is the efficiency of ships. Most of the ships sailing in the region are 20-30 years old, which determines the need to build new and optimize existing ships. Measures and activities to achieve energy efficiency are divided into several categories: activities to achieve fuel efficiency; optimized ship operation; optimization of construction and propulsion, machines and equipment; optimized cargo handling and energy saving methods.

The main guidelines for optimizing the ship's EE are the following:

CONSTRUCTION OF THE SHIP

- Increasing the size of the ship
- An optimal choice of the main dimensions
- Lightweight construction and optimal body shape
- Improvement of ballast systems
- Reduction of friction losses by creating air bubbles around the hull (air lubrication)

PROPULSION SYSTEM

- Improving the interaction of the propeller with the hull and between the propeller and the rudder of the ship
- CRP (Counter-rotating propeller) propulsion
- Using an electric propulsion module (Azipod)
- Optimization of the propeller tip and blades

SHIP EQUIPMENT

- Diesel - electric drive
- Improvement of the energy system (optimization of generators; reduction of transmission losses)
- Main Engine Tuning and electronic control, common rail setting
- Fuel-water emulsion
- Use of alternative fuels (LNG, hydrogen, biodiesel)
- Utilization of waste energy (Waste heat recovery)
- Using shaft generator
- Energy saving lighting (LED)

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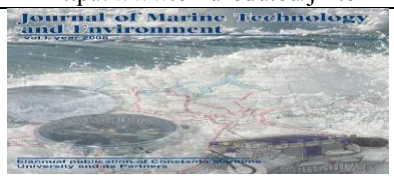


- Increasing the EE of consumers - application of frequency drives for pumps, fans, compressors
- Energy management
- Automation in the operation of ships;

OPERATIONAL MEASURES

- Navigation planning and speed control (weather routing)
- Periodic maintenance of the ship (condition of the hull, propeller, equipment) - cleaning and polishing the hull and propeller, creating a routine maintenance schedule for equipment and machinery
- Improvement of port activities (shorter loading and unloading operations, intermodal transport)
- Autopilot setting
- Use of shore power

4.3 Use of renewable energy and innovative technologies – sun (Solar panels), wind energy (sails, kites, rotors) and sea waves

Switching from conventional fuels to liquefied natural gas, biofuels and hybrid auxiliary power (batteries, fuel cells) will reduce operational costs and promote the protection of the vessel and the environment.

4.4 Construction and development of the infrastructure

The most important optimization areas of ports are providing access to waterways and to the common infrastructure - construction and modernization of rail and road connections to sea and inland ports terminals.

It is important to improve and upgrade the approaches to the river and sea ports in the country and to provide access to the national road network.

Development of a suitable warehouse and construction of transshipment points and logistics centers also provide efficiency optimization.

The concept Motorways of the Sea (MoS) will provide efficient, safe and environmental friendly transport system. It includes ports, short-sea routes, infrastructures, equipment and promotes the use of intermodal transport and development of integrated transport system.

4.5 Construction and modernization of ports (construction of new terminals and improvement of the technological and operational parameters of the existing terminals)

The efficiency of water transport depends on the capacity of ports and their technical equipment. Ports represent complex transport hubs to which road and railways are directed and goods are transported for shipment. The port site infrastructures include piers, storage areas, warehouses, and equipment such as cranes.

The availability of new equipment and qualified staff provides shorter loading and unloading operations and leads to the optimization of efficiency.

To optimize the port activity it is necessary to carry out:

- Change of the configuration of the terminals to improve loading and unloading activities;
- Construct large intermodal port terminals (facilities for container cargo handling, entry point for trucks, computer system, and management center);
- Application of new efficient equipment for container transshipment;
- Qualified staff is needed;
- Development of electronic system for information exchange - about cargo, routes, traffic and for communication between ports, carriers, different modes of transport and other stakeholders in the transport chain.

4.6 Transport demand management, route selection and delivery time planning - provides an opportunity for predictability of all costs and delivery time.

Navigation planning and speed control (weather routing) - software is applied that combines meteorological data with transport activity data and indicates the safest and most efficient route. In order to increase efficiency, appropriate transport maps and route schemes must be developed to reduce fuel consumption and transport costs.

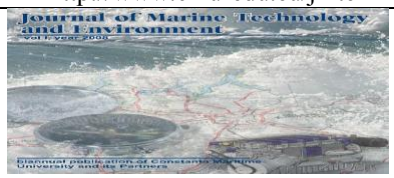
The main guidelines for optimization are the following: travel demand management to reduce frequency and distance, shifting travel to the most efficient transport modes; technological and operational efficiency measures for vehicles (i.e. fuel economy) and use of sustainable, low-carbon fuels.

4.7 Implementation of intermodal transport – provides energy efficiency, reduction of transport costs and environmental protection

It represents cooperation between ports, carriers, different modes of transport and other stakeholders. Intermodal transport contributes to reducing road traffic, protects the environment and is safer. The main advantages are the following:

• Cooperation between different modes of transport;
• Non-transshipment transportations are applied – containerization of the cargoes;
• Predictability of the time for arrival at the transport hub of the different types of transport;
• The delivery terms of the goods are shortened by reloading and reducing the storage time;

The main part of international intermodal transport is container transport. Ro-ro shipments are a relatively small part and take place mainly in the ports of Bourgas and Varna. Combined transport makes it possible to transport goods from anywhere in Europe to the Caucasus and Russia. There is a regular Ro-Ro line in the Black Sea Burgas - Poti - Novorossiysk.



River ro-ro transportations to Passau, Germany, are realized through the Danube port of Vidin, and on the line Vidin - Calafat. In 2010 the ferry complex Nikopol - Turnu Magurele was put into operation. There are built ro-ro terminals in the area of the port of Ruse-East and Silistra.

By rail, there are transit combined services to and from Turkey with several major European operators: Inter Ferries (Antwerp, the Netherlands), Schenker (Vienna, Austria), and Adria Kombi (Maribor, Slovenia), Express-Interfracht (from the group "Rail Cargo Austria").

European Rail Corridor for Competitive Freight № 7 Orient Prague - Vienna / Bratislava - Budapest - Bucharest - Constanta and - Vidin - Sofia - Thessaloniki – Athens, has been put into operation. It is part of the European Competitive Rail Freight Network, on which freight trains can run under good conditions and cross without administrative barriers from one national network to another. It was created in cooperation with 7 European countries - the Czech Republic, Slovakia, Austria, Hungary, Romania, Bulgaria and Greece. [1]

The aim is to build a connection between Central and South-Eastern Europe, as well as a connection to Asia via the Black and Aegean Seas, which will provide a reliable service, based on synchronized technical and organizational measures.

5. CONCLUSIONS

The process of increasing the energy efficiency is associated with the rational use of technical and economic resources to achieve efficient maritime transport. As a rational solution for achieving effective management and increasing EE, it is proposed to use an integrated strategy, combination of two approaches-application of organizational measures and application of technical and operational measures for improvement. Organizational measures cover regulations and training. Changes are introduced in the maritime legislation related to the reduction of harmful emissions from ships, organizational and methodological support is provided in the management of energy consumption and increase of EE. Technical and operational energy saving measures include development and modernization of infrastructure, ports, and vehicles, implementation of intermodal transport and use of cleaner low-carbon fuels.

The integration of Bulgarian transport system into the European network is important for energy efficiency optimization of maritime transport. The main goals of all this strategies and measures are: improving efficiency, safety and protection of the marine environment.

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BODE AND NYQUIST PLOTS: ASSISTANCE IN SOIL CHARACTERIZATION

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Abstract: Climate change is a phenomenon manifested for instance, among other things, by alternating dry and flood episodes with an impact on the environment. Therefore, one must deal with the issues such as: how to retain water in the landscape, protect the soil from erosion or oneself from the consequences of floods. There are used well-known and proven principles supplemented by modern techniques and technologies to understand individual processes and solve their impacts. Electrical impedance spectrometry (EIS), in which a sinusoidal test voltage or current is applied to the sample under test to measure its electrical impedance over a suitable frequency range, is a powerful technique to investigate the electrical properties of a large variety of materials. EIS is used in a broad range of applications as a quick and easily automated technique to characterize solid, liquid, semiliquid, organic as well as inorganic materials. The subject of interest of the paper is the monitoring of selected soil characteristics in the water-soil interaction. Measurement of electrical impedance of soils in the frequency spectrum and processing of results in the form of Bode and Nyquist plots provides information on the water content in the soil and the possibility of estimating its structure. This is very important for various purposes of engineering geological practice, and especially for constructions. Model or limit curves of grain size, table values or indicative standard characteristics are used for the approximate assessment of some soil characteristics. Often, selected soil characteristics are described by the size of their effective grain or this parameter is used in mathematical formulas. In practice, the measured impedance spectra, represent an electrical fingerprint of the sample providing an insight into its properties and behaviour. The selected measurement results are obtained by new apparatus with Z-meter device in field and laboratory conditions.
Key words: soil, drought, floods, environment, electrical impedance, frequency analysis, Bode and Nyquist plots.

1. INTRODUCTION

Climate change is the defining issue of our time. 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. Although Earth's hydrosphere has been around

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for about 4 billion years, it continues to change in shape. This is caused by seafloor spreading and continental drift, which rearranges the land and ocean. Therefore, the quantification of water in this system is complicated, because water can occur here in all three phases (solid, liquid, gaseous). The phase transformations that take place in this system are associated with consumption or energy production. The interpretation of the processes taking place in this system is currently based on the results of observations, partial measurements and their application in mathematical modelling. Part of the systemic point of view is also the understanding of the hydrological cycle as a fragmented whole, which is composed of several parts, between which there are connections.

The circulation of water in the hydrosphere can therefore be understood as an open physical system that can be divided into atmosphere, plant cover, unsaturated zone and groundwater [1, 2, 3]. The size and intensity of links between individual subsystems depends on the geographical, geophysical and climatic conditions of the area. The result of the study of connections and processes are temporal and spatial changes of water reserves in the natural environment. However, it is important to note that in this system it is the supply and source of water for the biosphere. The function of individual variables and parameters is relative, as individual subsystems change dynamically and interact with each other. This can result in increasingly frequent episodes of drought and floods. Closely related to these processes are their impact on the complexity of measuring and modelling techniques aimed at the safety and health of people and the environment.

One of the measuring techniques that has the potential to document changes in the water content of the soil [4, 5] is the method of electrical impedance spectrometry [6].

2. METHOD AND MATERIAL

Electrical impedance spectrometry (EIS) is a method to study the characteristics of organic and inorganic materials, based on their passive electrical properties, determined by the observation of the tissue electrical response to the passage of external electrical energy. The electrical impedance and phase angles of the materials is measured by a multiple frequency impedance analyser (in this case: Z-meter developed by project E!7614 in program EUREKA) that is able to scan each sample at different frequencies. EIS can be used in a wide spectra of applications [7, 8, 9, 10, 11].

In case of measurement by Z-meter EIS is essentially carried out the so-called "potentiostat EIS" version, a sine-wave voltage,

$$u(t) = U_{DC} + \hat{U} \cdot \sin(\omega t), \qquad (1)$$

is applied to the soil sample under test and induced electrical current

$$i(t) = I_{DC} + \hat{I} \cdot \sin(\omega t + \varphi), \qquad (2)$$

is measured. Then the complex electrical impedance is calculated

$$Z(j\omega) = \frac{U(j\omega)}{I(j\omega)} = \frac{\hat{U}}{\hat{I}} \cdot e^{-j\theta} = |Z| \cdot e^{j \cdot \mathrm{Arg}(Z)} = \mathrm{Re}(Z) + j \cdot \mathrm{Im}(Z), \qquad (3)$$

where, $\hat{U}$ and $\hat{I}$ are the electrical voltage and the electrical current amplitude, U_{DC} and I_{DC} are the direct (DC) electrical voltage and current values, the angular frequency $\omega = 2\pi f$, f is the test signal frequency, θ is the phase angel, φ is the phase shift of alternating (AC) voltage $u(t)$ relative to the electric current $i(t)$ flowing through the material, $U(j\omega)$ and $I(j\omega)$ the Steinmetz transforms of $u(t)$ and $i(t)$, $|Z|$ is the magnitude (module) of electrical impedance. The sine-wave parameters can be calculated from the acquired signals using a fitting algorithm in the time domain or by applying Fourier transform algorithm.

The heart of the multiple frequency electrical impedance analyser Z-meter is a commercially available processor measuring separately the real Re(Z) and imaginary Im(Z) components of the electrical impedance of the test environment. An electric circuit is formed by individual electronic components, through which electric current can flow continuously. Electric voltage is the measure of potential energy present in a circuit capable to move electrons from one point to another one (Fig. 1), where l [m] is length of the soil sample and S [m^2] is electrode area, A is ampere meter.

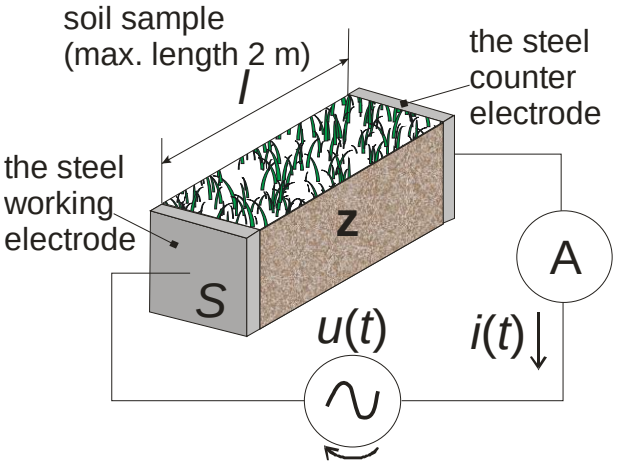

Figure 1 Measurement configurations used in EIS featuring two electrodes

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So, the electromagnetic properties of the test environment are recorded in the measured resistance *R* and reactance *X*. If the measurement is performed in the soil (ground) environment, the reactance has a capacitive character, i.e. the value of reactance is negative. The electrical impedance **Z** (phasor) from the measured parameters can be calculated in Cartesian (*R* and *X*), or polar (|*Z*| magnitude and phase angle θ) (3) coordinates. These parameters are related as follows,

$$\mathbf{Z} = R + jX = |Z|\cos\varphi + j|Z|\sin\varphi = \sqrt{R^2 + X^2}\cdot e^{-j\cdot\theta} \text{ and } \operatorname{arctg}\varphi = \frac{X}{R}, \quad (4)$$

where *R* is electrical resistance, which describes tightly bound water in the material and also mineral salts ions in pores, which can contain liquids and gases and *X* is reactance represents the imaginary part of the measured impedance, which characterize the solid part (grains) of the ground or other material by their dielectric constants. But these measured parameters comprise also the parasitic electrical impedances of the probe, cable, electrode, contact with environment, electromagnetic potential of Earth's field [12] and so on. Therefore, differences between the original and actual measurement are monitored and evaluated, if it is know nothing about the test environment and is impossible to take soil samples for tests, e.g. from a long-term point of view of building, objects stability and others.

Other electrical parameters like conductance, conductivity, resistivity, admittance or susceptance [13, 14] can be calculated from the measured quantities and the measurement disposition.

In the measured frequency spectrum, it is possible to display the values of electrical impedance by Bode or Nyquist plots.

2.1 Bode plot:

In electrical engineering and control theory, a Bode plots [15] are a graphs of the frequency response of a system. It is usually a combination of a Bode magnitude plot, expressing the magnitude of the frequency response, and a Bode phase plot, expressing the phase shift. Bode's plots is a well-known technic belongs among several important contributions to circuit theory and control theory, from the 1930s. It is devised a simple but accurate method for graphing gain and phase-shift plots.

Bode developed the graphical design technique of the Bode plots to show the gain margin and phase margin required to maintain stability under variations in circuit characteristics caused during manufacture or during operation. The principles developed were applied to design problems of servomechanisms and other feedback control systems. The Bode plot is an example of analysis in the frequency domain.

In summary, subjected to an input with frequency ω the system responds at the same frequency with an output that is amplified by a factor $|Z(j\omega)|$. These quantities, thus, characterize the frequency response and are shown in the Bode plot. For many practical problems, the detailed Bode plots can be approximated with straight-line segments that are asymptotes of the precise response. The effect of each of the terms of a multiple element transfer function can be approximated by a set of straight lines on a Bode plot. This allows a graphical solution of the overall frequency response function.

It is also possible to evaluate the frequency dependence of directly measured components of the unknown electrical impedance of the environment. However, the range of values of measured parameters is usually very wide. For example, the electrical resistance of dry soil can be in the hundreds of thousands of ohms, while the electrical resistance of water-saturated soil is in the order of tens of ohms. Therefore, Bode's dependences [16] are presented as logarithmic or semilogarithmic graphs, in which the range of measured frequencies (usually the horizontal axis) is always on a logarithmic scale.

To characterize soils in relation to the size of their effective grain, extremes of Bode dependence are sought, and it is shown (so far unrepresentative number of soil samples) that the first measured extreme Bode magnitude plot correlates with the effective grain matrix value of the examined soil sample and the corresponding frequency is the best for measurement of this environment, other extremes in the characteristic determine impurities.

2.2 Nyquist plot:

One related plot that display the same data in different coordinate system is the Nyquist plot [17]. This is parametric plot, with frequency as the input and magnitude and phase of the frequency response as the output. The Nyquist plot displays these in polar coordinates, with magnitude mapping to radius and phase to argument (angle) and is used in automatic control and signal processing. Similar like Bode's plots this technic is known from the 1932s. Nyquist plot can be applied to systems defined by non-rational functions, such as systems with delays. In contrast to Bode plots, it can handle transfer functions with half-plane singularities. In addition, there is a natural generalization to more complex systems with multiple inputs and multiple outputs.

For the characterization of soils in connection with previous considerations, including the as yet unrepresentative number of their samples, it turns out that the Nyquist graph distinguishes between homogeneous soils (smooth course of the curve) and

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inhomogeneous ones (the wavy curve). Although experiments have been performed with air-dry and water-laden soils, this conclusion can only be drawn for soils with water content.

2.3 Z-meter:

Within the solution of the E!7614 project, the measuring apparatus with a multiple frequency electrical impedance analyser – Z-meter has been developed, constructed and tested. This apparatus was verified by laboratory experiments and measurements on objects in a long- and short-time monitoring in field's conditions. Phenomena identifiable by changes in electrical impedance like water content in the dam's soil, water infiltration to the soil in different forest conditions, obtaining water by the root system of various types of grasses, water content in masonry, water content in wooden structural elements of buildings during their treatment by thermosanation, maturity of beef, monitoring the process of soil sealing with BioSealing technology, monitoring the composting process, evaluate of moisture of alternative floor structures in livestock housing and others were investigated. However, as with any indirect measurement method, there is a problem of how to work with the acquired information, how to evaluate it. This part usually requires the knowledge of experts from several disciplines and combines their practical experience. The multiple frequency electrical impedance analyser was applied for measurement in inorganic and organic materials and gave information about the processes, which take place in a porous environment (water, soil, stone masonry, woods, meats, humus).

EIS techniques developed through the project within the EUREKA program (Fig. 2) is very modular [18].

Figure 2 Measurement configurations

It is possible to use the system as manual, semi or fully automated with maximal number of monitoring positions 256 (Table 1).

Table 1. The technical specification of the Z-meter

parameter	specification
impedance range	10 Ω – 1 MΩ
frequency range	100 Hz – 200 kHz
measuring voltage	0.2 V; 1.0 V
accuracy of module |Z|	±2% of the range
accuracy of phase	±2°
communication interface	USB, SD card, Ethernet, bluetooth
number of channels	1, 8, 16, 32, 64, 128, 256
switch	internal to count 16 channels, external
power	Li-Ion battery (a concept with a mains power source or a solar panel)
hours of continuous operation is about 10 h	
weight	496 g
width × length × height	100 mm × 212 mm × 35 mm

It can be changed monitoring frequency (detection of environment characteristics), the excitation amplitude of the signal (sensitivity, reduction errors caused by the measurement technique), but also a number of sensors including the geometry of monitoring (Fig. 3) and the connection of sensors in the probes (two- or three-terminal electrode connecting as "pair probe" or "single probe").

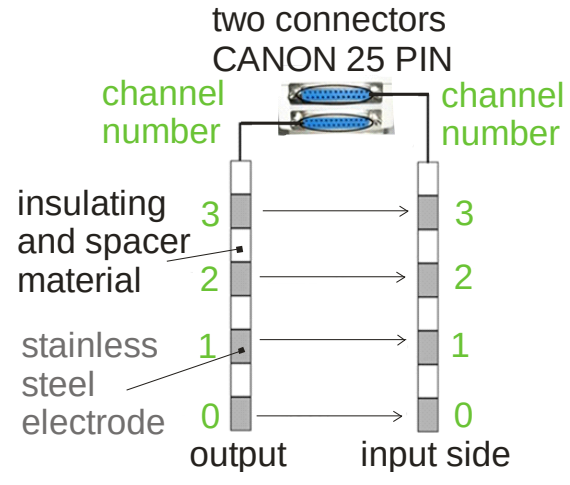

Figure 3 Example of connection when one measurement probe pair ("1 probe pair ') to 4 channels

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3. RESULTS AND DISCUSSION

The following section presents some of the results achieved in the implementation of frequency analysis of soil materials in laboratory and field conditions.

3.1 The laboratory conditions

The laboratory experiments 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.

Particle size distribution is used to classify soils for engineering and agricultural purposes. Particle size influences how fast or slow water or other fluid moves through a soil. In water engineering and study of water structures field, one of the important parameters is effective grain size $d_{ef} = \Sigma d_i \cdot p_i / \Sigma p_i$ (where d_i [mm] is the mean size of the grain of the fraction and p_i is percentage of grain fractions) of soil determined from the grain size distribution curve [19]. The experiments seeks a possible connection between the electrical impedance frequency spectrum measurement of and the d_{ef} of soils for the grain size estimation [20]. For the frequency analysis of soil samples it was used the frequency range 100 Hz up to 20 000 Hz with a step of 10 Hz. The tested soil samples were loaded with distilled water to eliminate the effect of conductive ions on the measured value of electrical impedance, they were in a pseudo-saturated state, because it was not possible to displace all air micro-bubbles from the samples (Fig. 4) and during the measurement a temperature of 25 °C was ensured.

Figure 4 Air bubbles when measuring a soil sample loaded with distilled water

An example of the soil samples description is shown in Table 2, Fig. 5. Homogeneous as well as inhomogeneous soil samples were tested, mainly sandy and aluminous-sandy soils were represented. Of the clays, there were only two representatives of bentonitic clays of different mineralogical composition (the green points in Fig. 7).

Table 2. The soil samples description

soil material: sand	homogeneous	inhomogeneous
d_{ef} [mm]	2.50	1.10
air temperature [°C]	25.8	25.8
sand temperature [°C]	25.6	25.3
weight [kg]	0.4942	0.6381
sand humidity [%]	45.0	47.8
f_M [Hz]	2080	2110
$\|Z\|$ [Ω]	2070	2090

Figure 5 The samples of homogeneous and inhomogeneous sand

It was found that the frequency f_M of the minimum value of the measured imaginary component of Bode plot resp. maximum value from Nyquist plot (Fig. 6) of electrical impedance approximately correlates with the d_{ef}. To correctly determine the dependence between the effective soil grain size and the measuring frequency, an as yet unrepresentative number of soil samples was evaluated (only 40). However, it is likely that this link could exist. The curve obtained of the relationship between the frequency f_M and the size of the effective grain d_{ef} is given in Fig. 7.

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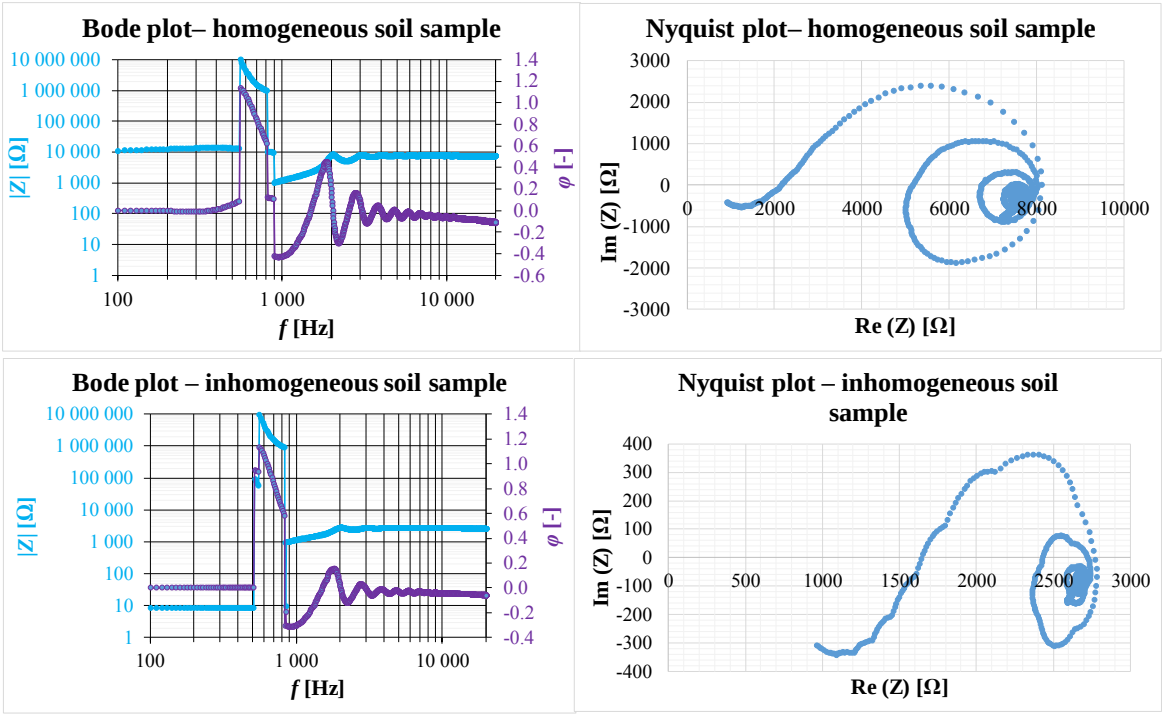

Figure 6 Bode and Nyquist plots of homogeneous and inhomogeneous soil sample

It is described by a power regression line in the form

$$f_M = \frac{5850}{d_{ef}}, \qquad (5)$$

with $R^2 = 0.7$ the reliability value.

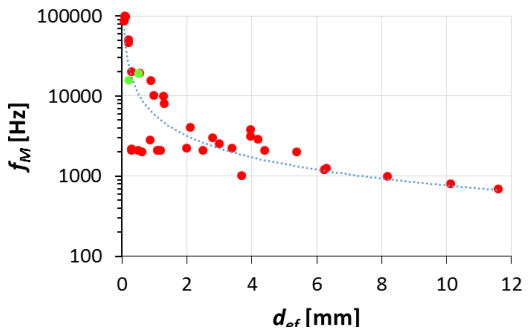

Figure 7 Relationship between a suitable frequency of measurement of soils and the effective grain size $f_M = f(d_{ef})$

This relationship was further applied to estimate the effective grain size of the soil under field conditions during the measurement of the Karolinka earth-fill dam.

3.2 *The field conditions – Karolinka dam*

The Karolinka dam and water reservoir [21, 22] is located in the Czech Republic on the Stanovnice stream at the river kilometre 0.75 above the town of Karolinka in the Vsetin District (Fig. 8). The total volume of the reservoir is 7.644 mil. m^3 and the area of the catchment is 23.1 km^2. It was built from 1977 to 1985.

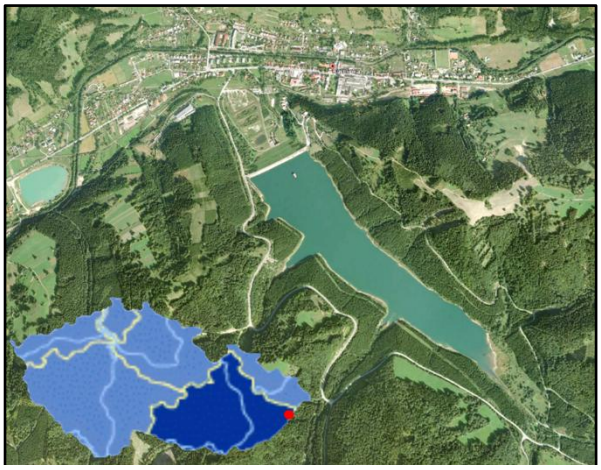

Figure 8 The Karolinka village, dam and reservoir

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It is a straight (plan view), inhomogeneous earth-fill dam made of local gravel materials with a central loamy core connected to a concrete grouting gallery (Fig. 9). The height of the dam above the base of its foundation is 47 m, and the length of the dam crest is 391.5 m. The slope of the upstream face is 1 : 3.3 and of the downstream face 1 : 2.2 - 2.4. The purpose of this hydro-engineering structure is to deliver raw water for supplying the Vsetin area and the Vlara area, to protect the downstream area from floods, to maintain a minimum discharge in the river below the dam and to use it for power generation.

Figure 9 Earth dam Karolinka (Zedníček, photographed from a height of 130 m, 23. 5. 2014)

For the reason of seepage detected on the downstream face of the dam, the water reservoir was operated in a limited regime practically from its beginning [23]. That's why much attention was paid to the engineering-geological survey also after the construction [24, 25]. Based on the long-term measurement and observation of seepage conditions [26] in the dam body it was decided to build a vertical sealing wall along the entire length in the earth-fill core of the dam (Figs. 10 and 11). The sealing wall was realized in the year 2013. The total length of the wall from the inlet to the inlet is 355.0 m and the depth is variable – from 10.5 m to 19.3 m. The thickness of the wall is 0.6 m.

In March 2011, a monitoring system of the earth-fill Karolinka dam [27] was supplemented by 4 probes (Fig. 11) to the downstream part of the earth-fill sealing core of the dam, which monitors changes in the electrical impedance of soil using the EIS method. The total length of each probes is 13 m and the length of measuring electrodes 0.05 m; always 20 sensors are on one probe, however, their placement in height is not regular. The first EIS electrode is at the height h = -2 m (2 m below the dam crest).

The correlation of the results obtained from the whole measurement system is not easy. Based on the performed engineering geological surveys [25], a wide range of soil grain size was found (Fig. 12).

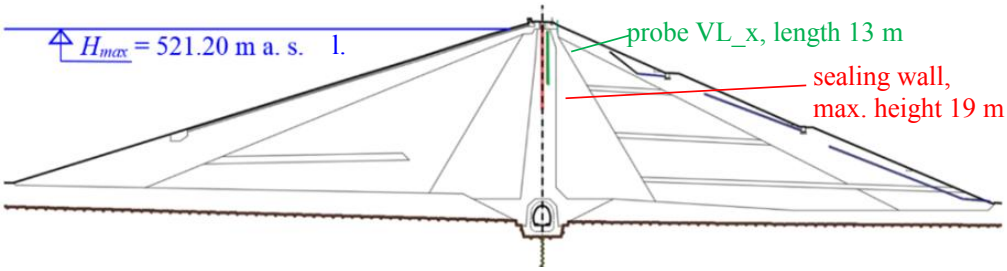

Figure 10 Schematic cross section of the earth-fill dam with the sealing wall (red line) and EIS probe (green line) position

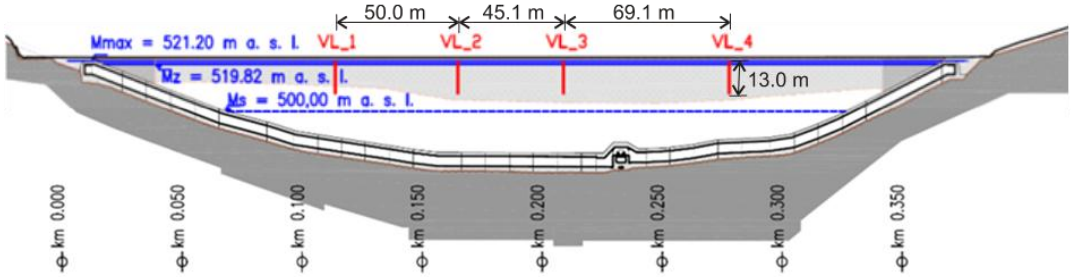

Figure 11 Longitudinal section through the grouting gallery – the situation of the dam sealing wall and EIS monitoring probes VL_1, VL_2, VL_3 and VL_4

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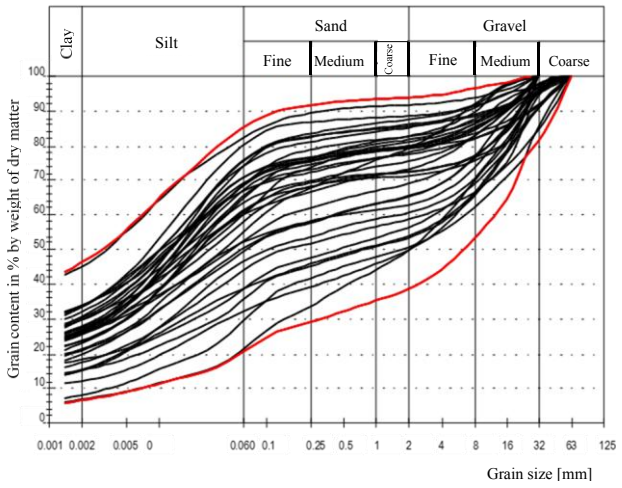

Figure 12 Cover curves of Karolinka dam soil [25]

By performed frequency analysis and by evaluation of Bode and Nyquist plots, it was possible to divide the soil characteristic in the monitoring levels of installed probes into five groups on the probe VL_1 and VL_3, into three groups on the probe VL_2, into four groups on the probe VL_4 from the long-time view to the measured values. Due to the scope of work performed, it is not possible to document all findings in the paper. Based on monitoring and visual observations was, in terms of water seepages, as the active area of the dam evaluated the part in the vicinity of the installed probe VL_1. Of the five groups of the measured curves of a similar character, the knowledge obtained on the base of Bode and Nyquist plots is documented by one group comprising four measured levels numbered 0, 4, 13 and 14. Their vertical position, including the frequency determined from Bode's and Nyquist's plots and the estimation of the effective grain size of the soil according to relation (5) is given in Table 3. Fig. 13 shows the Nyqiust's plots and the Bode's electrical impedance plots in the measured component form in different years of measurement. The frequency range and the step of changing the frequency was variable.

Table 3. The soil levels description

level	depth -*h* [m]	f_M [Hz]	d_{ef} [mm]	photo-documentation and description [25]
0	12.9	1860	3.1	 Clay loam, sandy with gravel and cobbles from 2 cm to 5 cm, occasionally up to 10 cm
4	10.6	2500	2.3	 Clay loam, fragments around 3 cm, cobbles up to 10 cm
13	3.6	2060	2.8	 Clay loam, gravels from 2 cm to 4 cm, fragments up 10 cm
14	3.3	1840	3.2	 Clay gravel loam, gravels from 2 cm to 4 cm

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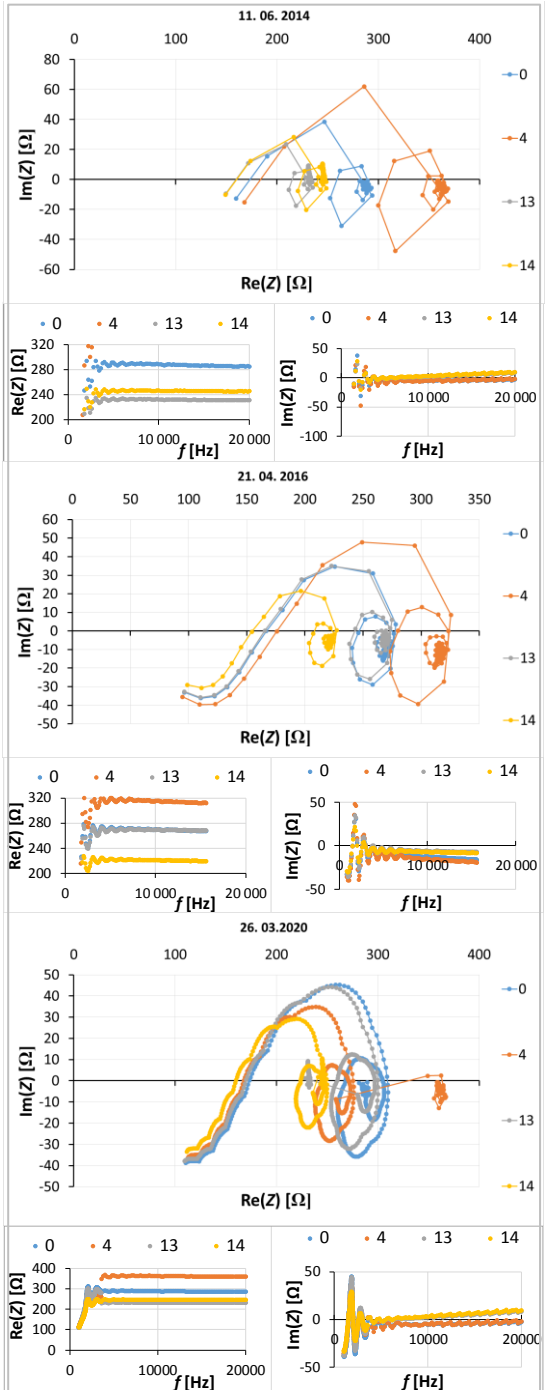

Figure 13 Frequency characteristics of Karolinka dam soil from four levels measured in different years

In 2014, was used an analyser which could to measure frequencies above 1000 Hz (it was given by the processor used), so the beginning of the Nyquist plot is shifted. This is also related to its rendering, notwithstanding the measurement took place in the range from 1.4 kHz to 20 kHz in steps of 200 Hz. In 2016 and 2020 was chosen the frequency range from 100 Hz to 20 kHz (selected on the basis of measuring the characteristics of soils used by the multiple frequency electrical impedance analyser – Z-meter in other localities and laboratory experiments) and the step of changing the frequency was 100 Hz in 2016 resp. 10 Hz in 2020. Due to unfavourable weather on the day of measurement at the site in 2016 (Tab. 4), the frequency analysis was terminated at a frequency of 15.6 kHz.

Table 4. The measurement conditions

year	2014	2016	2020
rainfall [mm]	0	0	0
water level in reservoir [m a. s. l.]	516.01	519.13	518.24
water temperature [°C]	21.2	9.4	4.2
air temperature [°C]	17.5	-2.1	-1.0

When evaluating the Nyquist plot, it is possible to state almost the same range of values in both components of electrical impedance in the measured years. However, the displacement of the individual curves in the direction of the Re(Z) axis is obvious. Since in this case it is a measured resistance, which changes mainly with the water content in the soil (assuming its constant chemical composition), it is possible to assume these changes in the individual layers. This assumption is supported by Bode curves given in components form. In all evaluated years it is possible to state the lowest water content in the soil at the level h = -10.6 m of the dam. This is followed by the level h = -12.9 m, where the water content in the soil measured by the EIS method is approximately 15% higher. Although the external conditions of the measurements were always different, a certain correlation can be observed between the behaviour of the individual layers.

4. CONCLUSIONS

Based on the achieved results, it is clear that the EIS method with the multiple frequency electrical impedance analyser Z-meter represent a certain suitable potential in the field of recognizing soil characteristics.
The relationship for estimating the effective grain size of soils is derived from an unrepresentative number of soil samples. Its application to the results of EIS measurements at the Karolinka dam does not contradict

practical findings. The use of Bode and Nyquist graphs expands the possibilities of characterizing soils.

5. ACKNOWLEDGMENTS

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CAPTURE OF WAVE ENERGY

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Abstract: Electric power generation contributes to approximately 40% of the total CO2 emission across the globe. The Oceans cover more than 70% of the total surface of the Earth and have possess important source of energy stored in the form of: thermal energy, kinetic energy (waves and currents) along with chemical and biological energy with a combined potential of approximately 2 TW globally. Focus of this study is about the expansive potential of wave energy which can be exploited to meet the ever increasing global energy demand. Wave energy harnessing technology is still in its nascent stage of development, but there has been steady technological advancement and research to optimise wave energy conversion efficiency, proper planning with regards to location of the plant installation and impact on the marine environment. The main advantage of harnessing wave energy is it would cause insignificant pollution damage, negligible greenhouse gas emissions and economically viable as per various feasibility studies carried out globally.
Key words: energy, environmentally friendly, prediction, wave.

1. INTRODUCTION

It is paramount to control and reduce CO2 emission on the planet or in broader sense it is important to reduce and prevent air pollution in order to preserve the environment for ourselves and future generations. A study done in 2019 and published in February 2020 IEA [1] states that energy production from renewable sources has led to decrease in CO2 emissions i.e. 130 tons in 2019 when compared with previous years. Energy production from renewable sources has been on a constant rise in recent years, there has been 12% rise in energy produced using wind power (wind farms) when compared with year 2018 and around 28% rise in energy production using solar power (photovoltaic panels).

World Energy Council survey in 2001 states that the energy potential which can be harnessed from waves globally is approximately 2TW, in European waters alone the wave energy potential estimated is such that it can cover more than 50% of Europe's total energy demand.

Conversion of wave energy into consumable power can be achieved by various methods or process, these process are characterized by their efficiency and by constraints that must be controlled. Figure 1.1 shows the abundance of resource available to us globally, in form of wave energy.

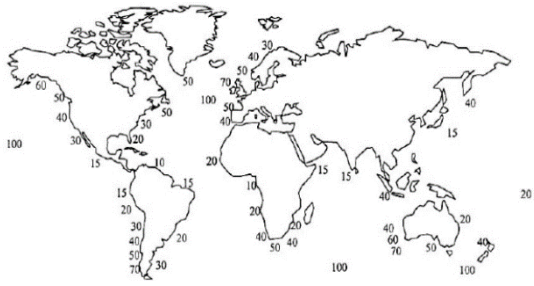

Figure 1 Wave energy, global distribution in kW/m [2]

2. WAVE ENERGY CONVERTOR CLASSIFICATION

Wave Energy conversion is a challenging process and the sector is still immature. Existing wave energy convertors (WEC) are complex and costly to construct, install and maintain. They are vulnerable to the extreme condition present in open seas and their power out is limited. To overcome the above challenges, there are various concepts in different stages of development and being tested at different depths of water, at different distances from shore and incorporate different methods to capture the energy from wave movements.

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2.1 Surface floating devices

Aquabuoy (Figure 2.1) is a device comprising of a buoyant chamber which floats on the surface of the water. The chamber comprises of cylinder and piston arrangement which extends to a length which is submerged under water and secured to the sea bed. The wave motion causes the buoyant chamber to move vertically in up-down motion thus causing a pumping effect in the cylinder-piston unit. Due to the pumping action water is pressurised and this pressurised water is then used to drive a turbine coupled to an electric generator. [3].

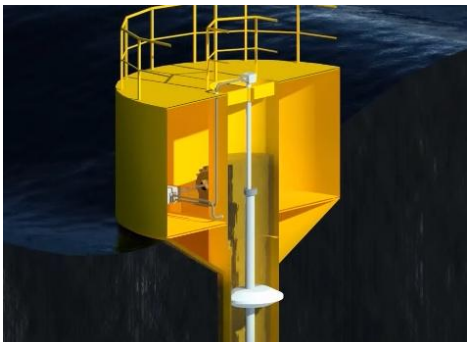

Figure 2.1 AquaBuoy

Seabased (Figure 2.2) consists of a float (buoyant chamber) which by means of a shaft is connected to a linear generator. The linear generator consists of a transducer and a stator, the transducer is connected to the float by means of a shaft. The float (buoy) follow the movement of the waves thus creating electrical power with the use of linear generator, the electrical power is then transferred ashore through underwater cables. [4].

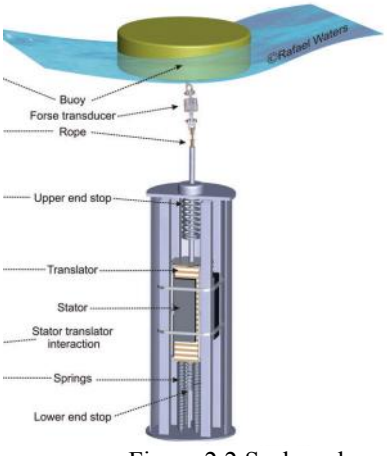

Figure 2.2 Seabased

2.2 Mechanical Oscillation devices

Oyster (Figure 2.3) is a device comprising of buoyant chambers joined to gather to form a flap like structure which is hinged to a fixed structure on the ocean bed. The flap being buoyancy positive moves forward and backward due to wave movements. The flap is attached to two hydraulic pistons which pump water in a closed circuit due to the movement of the flap, this pressurized water is then used to drive a hydraulic motor which when coupled to an electric generator produces electric power. [5].

Figura 2.3 Oyster

2.3 Oscillating water column devices

Limpet (Figure 2.4) consists of chamber constructed on the shoreline, partly submerged in water leaving a void space between the chamber ceiling and the water level inside the chamber. Due to movement of the waves on the ocean surface, the water column inside the chamber will oscillate thus compressing and expanding the air in the void space (pumping action). The air turbulence, as caused by the movement of the waves is then used to drive a bi-directional turbine, which when couples with an alternator produces electric power. The system also known as oscillating water column (OWC) is one of the first methods identified to capture wave energy. [6].

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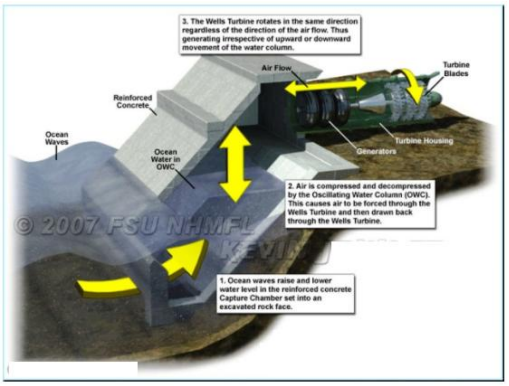

Figure 2.4 Limpet

2.4 Water accumulator/capture devices

Wave Dragon (Figure 2.5) is a large floating structure which consists of curved ramp over which incoming water waves surge (like on a beach), the water which overtops the ramp is collected in a reservoir behind the ramp. Energy is extracted by making use of the potential energy of stored water, which is drained back into the sea through a number of low-head hydro turbines located within the reservoir.

Figura 2.5 Wave Dragon

2.5 Hybrid energy devices

Poseidon (Figure 2.6) is a floating power plant concept with a hybrid design consisting of wave energy convertors which also act as floating foundation for three wind turbines. The plant transforms wave energy into electricity through hinged floats, piston pumps and a water turbine. [7].

Figure 2.6 Poseidon

3. POWER TAKE OFF MECHANISM (PTO)

3.1 Mechanical Oscillation devices power calculation

In case when wave oscillation is captured with help of swing panels which move in forward and backward motion, the forces of water is considered to be acting in plan XOZ as shown in (Figure 3.1).

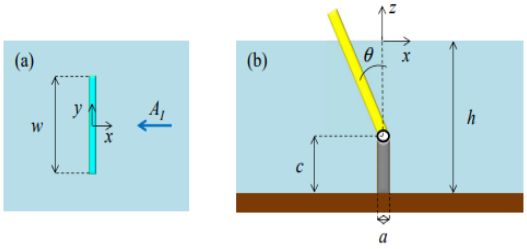

Figure 3.1 Schematic presentation of the Oyster device

Following are the conditions as assumed for calculation: The device is subject to laws of fluid dynamics, the interactions of swing flap and water wave in constant density of water, fluid is considered incompressible, Amplitude of wave is note as A and w is the length of swing flap.

Amplitude of wave prevailing to operate the Oyster system is considered A=1 m, length (height) of swing flap is w=26 m. The ration of A/w = 0.03, considering the fluid is in viscid (negligible viscosity) [8]. The speed potential of the flap device is:

$$u = \nabla\Phi \quad (3.1)$$

Where, Φ is a function of x,y,z and t, Φ(x,y,z,t),

$$\nabla^2\Phi = 0 \quad (3.2)$$

Represents the principle of conservation of masses [9],

$$\frac{\partial^2\Phi}{\partial t^2} + g\frac{\partial\Phi}{\partial z} = 0 \quad (3.3)$$

Where, z = 0 and g is the gravitational acceleration,

$$\frac{\partial\Phi}{\partial z} = 0, z = -h \quad (3.4).$$

Considering that a<<w and the height of the oyster flap with respect to sea bed is c, then:

$$\frac{\partial\Phi}{\partial x} = \frac{\partial\theta(t)}{\partial t}(z + h - c)H(z + h - c) \quad (3.5)$$

Where: x = ±0, |y|<w/2, θ(t) – angle of rotation of flap, H is unit step function, a function that ensures the absence of normal flow in the foundation [9,10,11&12].

From relations (3.1)-(3.5) → the potential velocity resulting from the interaction of waves with the flap is,

$\Phi = \Re\ \{\ [\emptyset_I\ (x,\ z) + \emptyset_D(x,\ y,\ z) + \emptyset_R(x,\ y,\ z)]e^{-i\omega t}\}$(3.6).

The last expression represents the period of oscillation of the wave T = 2π/ω,

Where, $\emptyset_I$ is an incident wave field that act on the mechanism by putting it in motion and is expressed as follows:

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$$\emptyset_I = \frac{igA}{\omega}\frac{\cos h\, k(z+h)}{\cos h\, kh} e^{-ikx} \quad (3.7)$$

Where k = number of waves,

$$\omega^2 = gk \cdot tgh \cdot kh \quad (3.8)$$

Is the relation of the dispersion of the waves;

$\emptyset_D$ is an incident wave field fuel by diffraction of waves due to presence of flap;

$\emptyset_R$ is the wave radiation potential due to movement of flap [12].

Wave energy extraction is achieved by using a generic device called Power take off or PTO, which in the case here is represented by hydraulic piston, the equation of motion of the device is:

$$[-\omega^2 (I + \mu) + C - i\omega(\nu + \nu_{pto})]\Theta = F_D \quad (3.9)$$

Where Θ is the amplitude of movement of imaginary size and F_D is torque forces.

Power extracted from a complete cycle of Oyster is thus expressed as:

$$P = \frac{|F_D|^2}{4(\nu_{pto}+\nu)} \text{ [13]} \quad (3.10)$$

3.2 Surface floating devices

Description of notations as shown in schematic representation (figure 3.2) are as follows:

- M_1 mass of the float. It is calculated on the basis of surface area A_w of the floating plane taking into account the draft h_f of the float and the water density ρ,
- a is the added mass,
- b is the hydrodynamic damping of the float,
- $S = S_{hs}$ is the hydrodynamic stiffness (a function of float plane and water density),
- d is the depreciation of the PTO mechanism,
- c is the stiffness of the PTO spring (to be measured in the laboratory, specific to the functionality of pump and hose),
- F_w is the exciting force generated by action of wave,
- M_2 mass of water in the tube accelerating, length L_t and diameter D_t,
- z_1, $\dot{z}_1$ and $\ddot{z}_1$ are the dispacement, speed and acceleration of float, measure from initial value,
- z_2, $\dot{z}_2$ and $\ddot{z}_2$ are the displacement, speed and acceleration of the piston, measured from initial value.

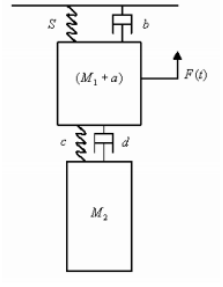

Figura 3.2 Schematic representation of the AquaBuoy device

Applying the law of D'Alembert according to which the sum of all forces that act on a body is zero, we obtain the following differential equation for a system with vertical movement of two masses:

$$(M_1 + a)\ddot{z}_1 + b\dot{z}_1 + S_{hs}z_1 + d(\dot{z}_1 - \dot{z}_2) + c(z_1 - z_2) = F_w(t) \quad (3.11),$$

$$M_2\ddot{z}_2 = d(\dot{z}_1 - \dot{z}_2) + c(z_1 - z_2) \text{ [14]} \quad (3.12).$$

Consider a case of regular wave, where: amplitude of wave is noted as $A_{val} = \frac{H}{2}$, H is the height of the wave, frequency of wave is $\omega = \frac{2\pi}{T}$ where T is the time period.

Result:

$$F_w(t) = A_{val}F(\omega)\cos(\omega t + \gamma) \quad (3.13),$$

Where γ is the phase difference between wave and force which can be considered as zero [15].

In case of irregular waves, the appearance of sea waves is characterized by height H_s, significant period as T_z and T_p for the period of spectrum of wave:

$$T_p = 1.4T_z \text{ [16]} \quad (3.14).$$

The spectrum of waves according to the studies of Pierson and Moscowitz can be written as:

$$S(f) = \frac{A}{f^5}\exp(-\frac{B}{f^4}),\ f = \frac{1}{T} \quad (3.15),$$

Where:

$$A = \frac{5{H_s}^2{f_p}^4}{16} \quad (3.16)$$

$$\text{and } B = \frac{5{f_p}^4}{4} \quad (3.17).$$

The spectrum is composed of N frequencies with f_i components, each frequency being calculated as follows:

$$f_i = \frac{\Delta f \cdot rand(1)}{2} + i \cdot \Delta f \quad (3.18),$$

Where, $\Delta f = 0.01$ and rand (1) is a number chosen randomly between 0 and N -1.

Amplitude of each wave,

$$a_i = \sqrt{2S(f_i)\Delta f} \quad (3.19),$$

With a corresponding random phase,

$$\emptyset_i = 2\pi \cdot rand(1) \quad (3.20).$$

Result:

$$F_w(t) = \sum_{i=0}^{N}[a_i \cdot \sin(2\pi f_i t + \emptyset_i)\, F\frac{1}{f_i}] \quad (3.21).$$

With the aid of a software programme the values for coefficients a and bv_1 can be derived corresponding to a particular field of periods T and excitation force F.

For the term bv_1 following formula is used:

$$\int_{-\infty}^{t} h(t-\tau)v_1(\tau)d\tau \text{ (11) [17]} \quad (3.22),$$

$$\text{Where: } h(\tau) = \frac{2}{\pi}\int_0^{+\infty} b(\omega)\cos(\omega t)\, d\omega \text{ [18]} \quad (3.23),$$

$$\int_{-\infty}^{t} h(t-\tau)v_1(\tau)d\tau = \sum_{n=1}^{N}(h(ndt)v_1(t-ndt)dt) + 12h0v1tdt \quad (3.24).$$

The deadline of the function tends to zero so only first N=40 terms are taken into account.

The added mass is calculated as follows:

$$a_\infty = a(\omega) + \frac{1}{\omega}\int_0^{\infty} h(\tau)\cdot\sin(\omega\tau)d\tau \quad (3.25).$$

Frictional force of the fluid acting on the device body is:

$$F_{ff} = A_w C_d \rho |v_1| v_1 \text{ [19]} \quad (3.26),$$

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Where C_d is a measurable coefficient.
The power of the PTO device for Aquabuoy is as follows:

$$F_{pto} = F_{ff} sign(v_1 - v_2) + c(z_1 - z_2) \quad (3.27),$$

Where: $sign(x) = \begin{matrix} -1 & if & x < 0 \\ 1 & if & x > 0 \\ 0 & if & x = 0 \end{matrix}$

3.3 Mechanical devices for capturing angular wave movement

In case of angular movements, as the Pelamis device is made of segments (figure 3.3), the motion can be described by the Lagrange-Rayleigh equation:

$$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{y}_n}\right) - \frac{\partial L}{\partial y_n} + \frac{\partial R}{\partial \dot{y}_n} = F_n \quad (3.28),$$

Equation in which, kinetic and potential energy are expressed as a function of velocity and displacement.

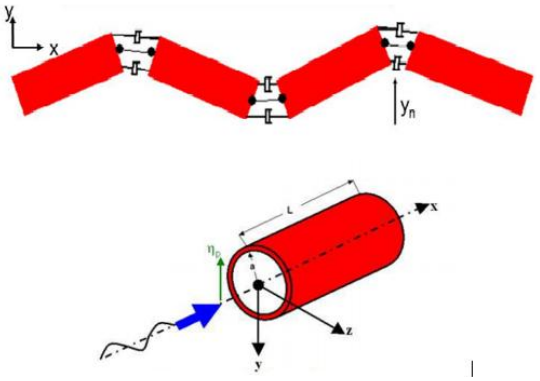

Figure 3.3 Diagram of the motion of a Pelamis segment in the Cartesian axis system

$T = \frac{1}{2} m\dot{y}^2$ is the kinetic energy (3.29).

$V = \frac{1}{2} ky^2$ is the potential energy (3.30).

The dissipating function of Rayleigh equation is defined as being half the energy of the dissipation of the shock absorber,

$R = \frac{1}{2}\{instantaneous\ rate\ of\ energy\ dissipation\} = \frac{1}{2} c\dot{y}^2$ (3.31).

Placing the obtained values in equation (3.28) we obtain the equation of motion for the system with single degree of freedom from the mass, spring and damper:

$$m\ddot{y} + c\dot{y} + ky = F \quad [20] \quad (3.32),$$

As shown in figure 3.4.

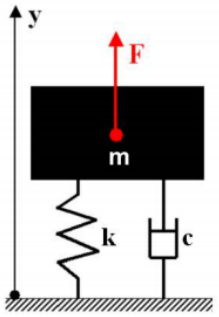

Figure 3.4 Simplified graphical representation

4. CONCLUSIONS

Wave energy, tidal energy or ocean energy, all synonymous with the same form of energy, have the potential to meet the never ending needs of humanity for energy consumption. To emphasize some positive aspects, wave energy is a relatively green energy, unlike fossil fuels, because it does not involve significant air pollution. Moreover, there are no long transportation distances involved in the wave energy production chain compared to energy produced from fossil fuels such as coal. It is a source of sustainable and renewable energy, because the oceans existed long before the human race evolved and will remain once humanity disappears, in other words, we will never run out of ocean water, which makes this technology more renewable than most other alternative energy sources. The predictable nature of ocean movement will allow us to store excess energy generated during periods of higher water movement, which can then be stored and used during periods of slower water movement to ensure a constant supply of energy.

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EMSO-EUXINUS INFRASTRUCTURE SUPPORT OF OFFSHORE UNDERWATER ENERGY

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Abstract : Recently, a multitude of studies and research have revealed the enormous energy potential of the Planetary Ocean, generated by the hydrodynamics of seawater in the form of waves, tides or submarine currents. Preliminary studies conducted with various installations (in concept or prototype phase) in various countries of the world estimate a possible renewable energy budget of the order of TW. From this point of view, the Black Sea (Romania's exclusive economic zone) is no exception, being known (at least in the riparian countries) for the dynamics and strength of sea water, thus being susceptible to generating this type of energy.
Key words: EMSO EUXINUS, underwater energy, waves, green energy**.**

1. INTRODUCTION

To study the dynamics of marine water (sea currents and waves) in the western Black Sea area, in order to establish the energy potential [1], data from the research infrastructure EMSO-EUXINUS (EMSO European Multidisciplinary Seafloor and water column Observatory) part of EMSO ERIC, where Romania trough INCD GeoEcoMar, is founding member and contributor, will be used. This infrastructure was developed in the Black Sea since 2013 (Fig.1) [2] trough cross border project MARINEGEOHAZARD. Marine hydrodynamics data, including wave and currents information, are available starting with 2014, with a sampling rate of 5 minutes, which provides access to a high volume and fine details of the data which will be translated into high quality and high-resolution results.

The EMSO-EUXINUS infrastructure, through the components that serve it is actively involved in the effort to study the planet's ocean by participating since 2013 in EMSO ERIC, the pan-European research infrastructure that coordinates research facilities and monitoring the marine aquatic environment in Europe's seas and oceans. EMSO, which became EMSO ERIC in 2016 consists of a network of observatories that provide coherent data sets containing information on surface and shallow waters (collected through the water column) and information on the ocean floor with aspects their geological, geophysical, biochemical and ecological. The research area is extensive - from the Atlantic Ocean to the Mediterranean Sea and from the Marmara Sea to the Black Sea, and this allows a wide range of studies of various environments. The collected data is transmitted to land stations via telecommunication cables or satellite connections [3].

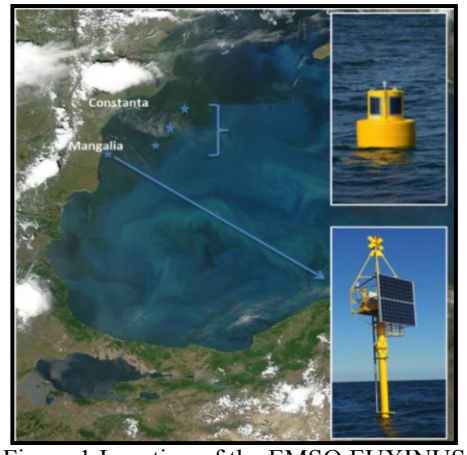

Figure 1 Location of the EMSO EUXINUS infrastructure in the Black Sea [1]

2. TEHNICAL DESCRIPTION EMSO EUXINUS

As previously mentioned in order to identify the marine energy potential, the marine environment will be studied

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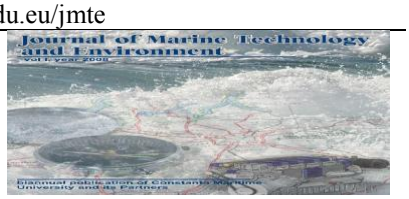


through a network of monitoring stations located offshore and coastal area of the Black Sea, consist of:

- 3 (three) treal time fully automated marine stations with equipment for measuring the characteristics and dynamics of water bodies at two level depths equiped also with automatic meteorological stations;
- Coastal station close to Mangalia harbour, equiped with equipment for measuring the movement and characteristics of the water and complete information about the waves;
- Coordination Center in Constanța - Romania, equipped with data storage and processing capabilities, transmitted by systems in real time.

The main key components used to identify the marine energy potential are detailed below, and the specifications of each sensor are presented in Table 1 (Fig.2) [3]:

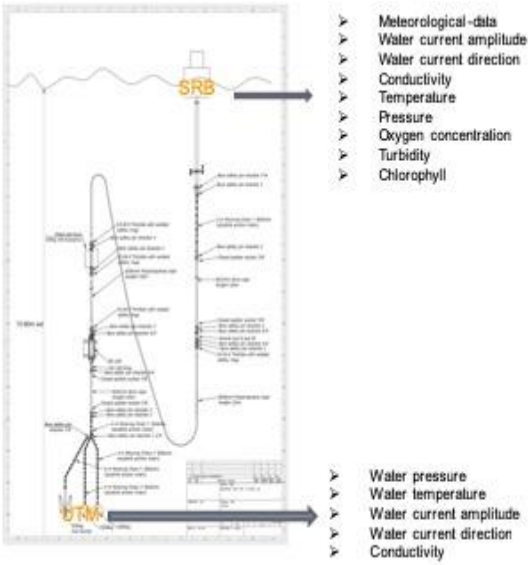
Table 1. Specifications of sensors installed on offshore systems

Sensor type	Manufacturer	Parameter	Range	Observatory/module
All-in-One Weather Station – 200WX	Airmar	Wind speed Wind direction Temperature Pressure Compass	0 – 50m/s 0 – 360° -40°C – +50°C 600 – 1100hPa 0 – 360°	EuxRo01/SRB EuxRo03/SRB EuxBg05/SRB CG
Z Pulse Doppler current sensor	Aanderaa	Current speed Current direction Tilt	0 – 300 cm/s 0 – 360° 0 – 45°	All/SRB@ UTM
AADI 4880/4880R	Aanderaa	Temperature	-4 – 36°C	All/SRB@ UTM
AADI 4112B	Aanderaa	Turbidity	0 – 500 FTU	All/SRB
AADI 4646C	Aanderaa	Pressure Temperature	0 – 3100kPa 0 – 36°C	All/SRB@IML

2.1 Automated marine stations:

Automated marine stations (Fig. 2a, b, c) located on the continental shelf, equipped with:

Figure 2a The SRBs structure



a)

Figure 2b The principle of offshore system [4]

- weather station
- multiparameter probe fixed at 5 m depth, including:
  - current Doppler sensor;
  - conductivity sensor;
  - temperature sensor;

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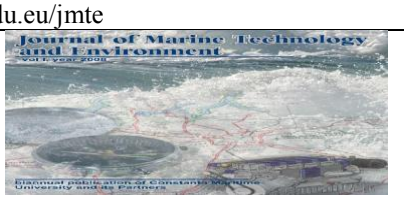


- pressure sensor;
- oxygen sensor;
- turbidity sensor;
- chlorophyll sensor;

- multi-parameter probe on the seabed:
  - current doppler sensor;
  - conductivity sensor;
  - temperature sensor;
  - pressure sensor;
  - oxygen sensor;
  - turbidity sensor;

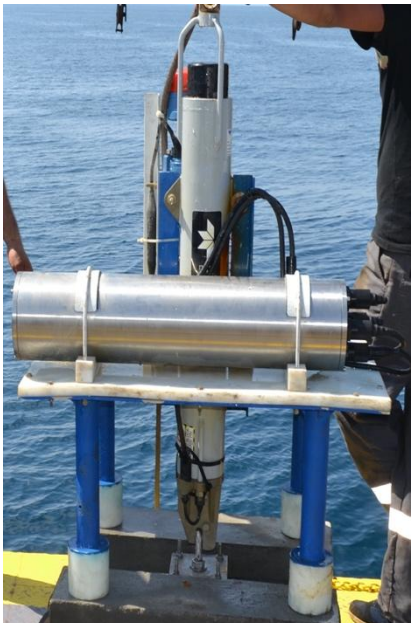


Figure 2c The seabed module

2.2 Station in the coastal area

Station in the coastal area (fig.3) [4] at a water depth of 15 m, equipped with:

- Weather station
- Multiparameter probe fixed at 5 m depth;
  - current doppler sensor;
  - conductivity sensor;
  - temperature sensor;
  - pressure sensor;
  - oxygen sensor;
  - turbidity sensor;
  - chlorophyll sensor;
- ADCP (Acoustic Doppler Profiler curent) for measuring the characteristics of waves and sea currents at 8m.

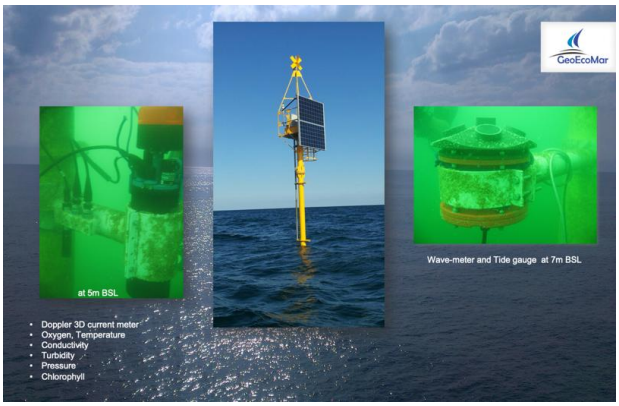


Figure 3 Coastal Station on the Black Sea [4]

2.3 Calculation of energy and wave strength in the coastal area of Romania

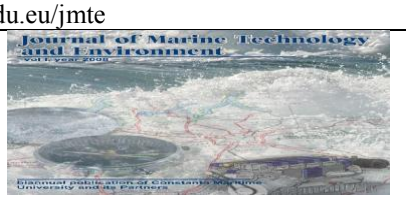
For energy and wave force calculations, marine hydrodynamics data was acquired using an LinkQuest's FlowQuest 1000 current profiler, with an information sampling rate of 5 minutes [5].

2.4 Monitoring data

Using a simple description, the data recorded by the EMSO-EUXINUS system consist of two main components necessary for such a study [6]: meteorological data (wind speed and direction, atmospheric pressure, air temperature) and oceanographic information (direction and speed of sea current, water temperature and wave data). LinkQuest's FlowQuest 1000 acoustic current profilers have the WaveQuest Directional Wave Spectrum Measurement function which is used to measure wave directions, periods and heights.

2.4 Calculation parameters

The WaveQuest directional wave spectrum measurement function generates complete wave parameters in both time and frequency domains including various kind of wave heights, wave frequencies and wave periods, such as Hmax, H3, H10, Fpeak, Tmean, Tmax, etc. The directional wave spectrum generated by the wave measurement provides a full wave spectrum. Each frequency in the wave spectrum has its stochastic mean direction [7].



2.4.1 Wave energy

For the calculation of the wave energy the relation will be used:

$$E = \frac{\rho * g * H^2 m}{8} \ (kJ/m^2) \qquad (1)$$

where: ρ -water density; ρ = 1018 kg/m^3;
g- gravitational acceleration ; g = 9.8 m/s.

2.4.2 The force of the waves

The relationship will be used to calculate the force:

$$P = \frac{\rho * g^2 * H^2 m * Tm}{32\pi} \quad (kW/m) \qquad (2)$$

3. CONCLUSIONS

The results of such a study will be used to develop a digital hydrodynamic model of the Romanian Black Sea area, using software specialized in finite elements and fluid flow modeling. The construction and calibration of the model will be performed using the data mentioned above.

Furthermore, this digital model can be the basis for identifying the energy potential of the marine environment, as well as establishing the possible optimal areas in which future installations for generating this type of electricity can be designed and built.

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WIND ENERGY CAPTURING DEVICES WITH POSSIBLE IMPLEMENTATION ON CONTAINER SHIPS

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Abstract: This article presents different types of unconventional sources of energy, green ones, which can be implemented on a container ship.
In the articleare descriebed renewable energy devices, used like an alternative source of energy, green energy suitable for container ships, for reducing environment pollution and fuel consumption.
We have made some studies by using CFD programme Ansys Fluent, for discovering the forces which influence the Flettner balloon if is installed on top of a container ship at 300 m altitude.
This article major points are: wind energy capturing devices, Makani Power Plane, Ampyx Power Plane, Altaeros Energies, Kite Gen, Joby Energy, Flettner balloon.
In the article we also highlight the influence of meteorology when we select the best, optimal and most efficient green energy device suitable for a container ship in order to upgrade it.
The present article is a piece of a big research on the installation of unconventional energy sources, on container ships.

Key words : marine pollution, renewable energy, Flettner balloon, kite, wind, modeling, ship.

1. INTRODUCTION

By unconventional (renewable) energies are meant those energy sources that can be considered inexhaustible. Renewable energy sources are widespread and non-polluting.
Installations built to capture energy have a long service life in normal operation. Renewable energies can be used directly for direct heat production without any conversion process or can be converted into electricity.
A number of companies are researching various ways to capitalize the currents and the winds flowing around the Earth at high altitudes. Although there are a number of technical challenges in capturing wind energy from high altitudes, an increasing number of small companies are working hard on many models with different capture powers and different capture speeds.

Kinetic energy can be captured at high altitudes by kits, the flying electricity generator, airships and HAWP aircraft.

2. METEOROLOGY

2.1 Introduction

Meteorology is a branch of geophysics that studies the properties of the atmosphere and the phenomena that take place in it. The weather conditions particularly influence the development of the entire aeronautical activity.
For this reason is very important to know the weather forcast before launching the wind capturing device.

2.2 The wind

The notion of wind means the horizontal movement of air, the other movements being called currents. In general, large air movements are more horizontal.

To determine the wind force, several methods can be used at different altitudes:

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- Pilot balloon. It consists of launching a balloon, thus filled with hydrogen so that it has the ascending speed we want. The balloon is followed by the theodolite, reading the elevation angles and azimuth. By making the horizontal projection of the balloon's trajectory, the wind direction and speed can be calculated graphically.
- Radiosonde method or Rawin method. It is done with the help of a radioteodolite or other radioelectric instrument. With this method, the wind can be determined up to altitudes of 20-40 km, with a fairly high accuracy.
- With the help of an airplane. It is used to measure the wind at various levels of flight, determining its direction through drift, and speed through the system of comparing its own speed, in relation to landmarks on the ground, knowing the distance between them.

2.3 Wind structure

The wind has a uniform motion both in terms of direction and speed.
The wind can show sudden increases in speed, jumps called gusts. The duration of a burst does not exceed a few tens of seconds.
The storm is an unexpected increase of wind speed often with a change of direction. It lasts a few minutes and covers a large area.
The storm is the situation in which the wind speed exceeds about 60 km/h or when the gust is higher than 78 km/h.
The hurricane is when the wind speed exceeds 116 km/h.
The statistical data showed that the wind speed gradually increases to the lower stratosphere, reaching maximum values between 8 and 12 km. Above these altitudes, the wind speed begins to decrease to about 20 km altitude, where it has a minimum. After 20 km it starts to grow again.
The frictional forces due to the influence of the soil surface decrease rapidly in relation to the height and become almost negligible at over 600 m above ground level.
Many companies from the maritime industry use various programs, such as SPOS, Bon Voyage, which are constantly updated with information, several times a day, with which they monitor the weather conditions, where the ship will make its voyage (Fig. 1, Fig. 2).

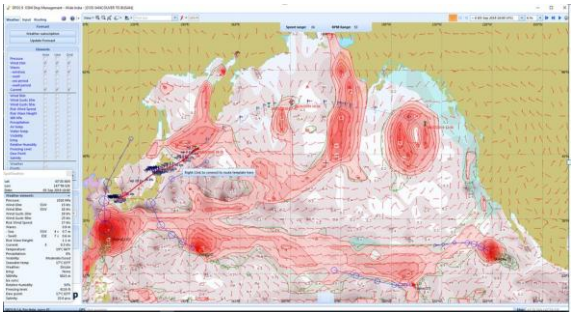

Figure 1. Monitoring of the meteorological situation by using the SPOS program

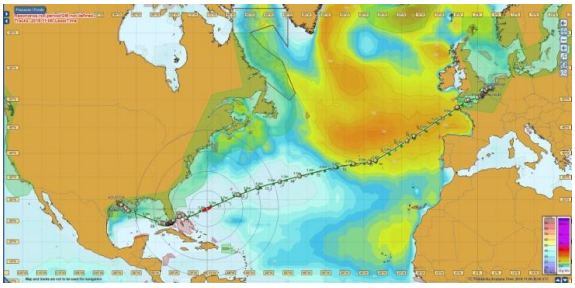

Figure 2. Monitoring of the meteorological situation by using the Bon Voyage program [1]

3. DIFFERENT TYPES OF WIND ENERGY CAPTURING DEVICES WITH POSSIBLE IMPLEMENTATION ON CONTAINER SHIPS

3.1 Makani Power Plane

Figure 3. Makani Power Plane [2]

Makani Power company from California, USA, made an airplane that works on the principle of a traditional wind turbine (Fig.3). The rotors of the kite together with the propellers have the role of being able to launch it from the ground station. Once the kite has reached the air and is in flight, the movement of air along the rotors forces the propellers to rotate, which leads to the generation of electricity, which is sent

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through a cable that is connected to the station, on the ground and on some batteries.

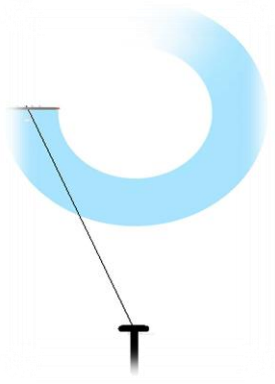

Figure 4. Makani Power System [2]

Airplane cable

The cable is made of conductive wires, with a high mechanical resistance (Fig. 4). It's role is to connect, transfer electrical power and communications between the kite and the ground station in both directions.

Ground station

It is used as an anchorage for the aircraft, but also as a storage place for the aircraft when it is not in flight.
The aircraft control computer uses GPS receivers and sensors. Together with thousands of calculations performed in real time, it guides the plane in the desired flight path, with the strongest and constant winds for maximum energy production.

Energy balance

Power rated: 600 kW

3.2 Ampyx Power Plane

Figure 5. Ampyx Power Plane [2]

Ampyx Power is a Dutch company that has built an airplane that flies at over 450 m altitude where the winds are strong and constant in the shape of the number eight, that helps for generating electricity.
Aircraft take off and land from an innovative platform on which several sensors are installed that provide the autopilot with much critical information to perform safe landing and take-off.
The aircraft can fly completely autonomously on autopilot, being equipped with many sensors (Fig. 5). The adjustments transmitted by the sensors are processed by special software, they are made within milliseconds, allowing the aircraft to fly continuously in the form of the number eight.

Generator

When the plane rises, the traction force increases, the cable that connects the plane to the winch and the generator is energized, which causes the generator to create electricity (Fig. 6).

Figure 6. Ampyx Power generator [3]

The company has created platforms equipped with special sensors and software that allows it to rotate in the wind, for directing the airplane piloted by the autopilot to land / take off safely.

Energy balance

Due to the altitude at which the planes fly, they have a very high energy efficiency, while the material and installation costs are relatively low. The prototype with a wingspan of 5.5 m produces about 50 kW, when is optimized. The commercial model has a much larger wingspan of up to 30 to 40 meters. With this plane we can generate up to 2 MW.

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3.3 Altaeros Energies

Figure 7. Altaeros Energies balloon [4]

Altaeros Energies is a US company that has created a version of helium-powered air balloons that float in the air at altitudes of about 600 m. They are used to raise the rotor of a wind turbine, which is inside them at an altitude of 600 m above the ground. At this altitude the winds are strong and constant.

The balloons are connected to the ground by a cable that sends to the ground station the electric current generated by the wind turbine (Fig. 7).

Safety

The balloons have a multitude of sensors and an automatic flight control system that manages the operations of ascent, maintenance and descent, as well as the landing of the balloon on the ground in severe weather.

Energy balance

Generating two to five times more than the production of electricity compared to a conventional turbine, about 100 kW.

Figure 8. Kite Gen [5]

3.4 Kite Gen

Kite Gen is an Italian company, which invented a ground unit that is connected to some kites, which are at an altitude of up to 2000 m. The kites are connected via a ground cable (Fig. 8). Due to the traction force of the kite, the ground unit, with the help of a generator, transforms mechanical energy into electrical energy. They have a yo-yo up/down action.

Flight directions

The kites are automatically piloted and have a predefined path, which covers a much larger area than a conventional wind turbine. They have sensors, which help the automatic control system to maximize electricity generation by positioning kites at high altitudes where the winds are constant.

Energy balance

Kite Gen can produce up to 3 MW.

3.5 Joby Energy

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Figure 9. Joby Energy kite [6]

Joby Energy is a US company that invented another model of high altitude wind turbines.
They propose a structure that has a series of rotors installed on it (Fig. 9). The structure has a series of sensors and control systems, which help the autopilot to keep the kite in constant and strong winds. The structure is connected to the ground base by a cable with the role of anchoring and transmitting electricity and data.
2
Electricity is transmitted to the ground by a cable. During occasional periods of low wind the turbines are powered by electricity to land safely.

Energy balance

This device is able to generate up to 3 MW.

3.6 Flettner balloon

The Flettner balloon is an electric generator, filled with a gas lighter than air – helium, that rotates around a horizontal axis and sends electricity using a cable [9]. The electricity generated can be used immediately or stored in a battery.

It generates electricity at high altitude. It rotates around a horizontal axis in response to wind, efficiently generating clean, renewable electricity at a lower cost than all competing systems.
The balloon is anchored to the ship by using lines.

By using the Flettner balloon, we can capture winds from 183 to 305 meters altitude.
It can generate electricity both at low wind speeds of 3 m/s but also at high speeds of 28 m/s.

We used the fluid flow modeling (CFD) program, Ansys Fluent for the study of the forces which influence the Flettner balloon, if is installed at an altitude of 300 m above a container ship (Fig. 10, Fig. 11)[10].

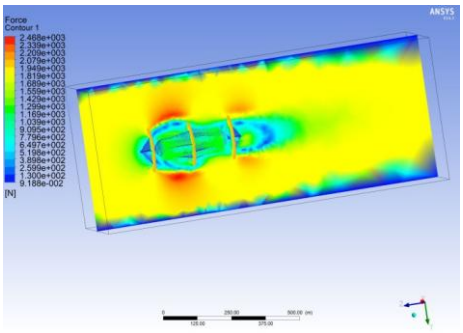

Figure 10. Force distribution on the Flettner balloon, in XOZ plan- at a wind speed of 20 m/s and a wind direction of 90°

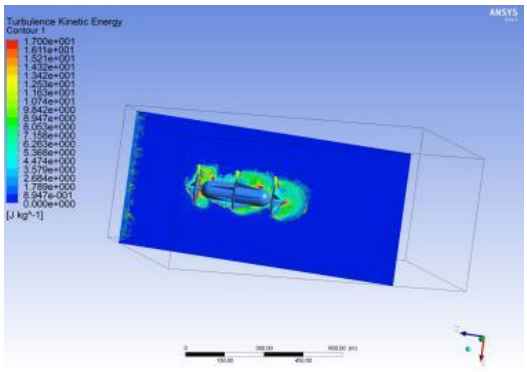

Figure 11. Turbulence kinetic energy distribution on the plan, in XOZ plan – at a wind speed of 20 m/s and a wind direction of 60°

As a result of our study we have concluded that Flettner balloon is not influencing to much the ship stability and maneuverability [7], [9].

This device is a plausible unconventional source of energy that can be installed on a container ship [10], [11], [12].

Energy balance

From the researches we found that the Flettner balloon, positioned at 300 m altitude can generate approximately 1000 kW/h.

4. CONCLUSIONS

At altitudes between 6000 m and 15000 m the wind speed varies between 25 m/s and 110 m/s, with the increase of the altitude and the wind speed increases.

High altitude wind energy is less expensive than traditional wind energy, the construction of a kite is much cheaper.

Wind energy taken from kites is the cheapest source of energy in the world. In the future, it will be able to cover all the world's energy needs at very advantageous prices.

In the future conventional sources of energy from ships will be replaced by unconventional sources of energy, in order to reduce pollution and costs.

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