ISSN 1454-8518

ANNALS
OF THE UNIVERSITY OF PETROSANI

ELECTRICAL ENGINEERING

VOL. 24 (LI)

UNIVERSITAS PUBLISHING HOUSE
PETROSANI - ROMANIA 2022

Annals of the University of Petrosani, Electrical Engineering, 24 (2022)

ISSN 1454-8518

Editorial office address: University of Petroşani, 20 University Street, 332006 Petroşani, Romania, Phone: (40) 254/54.29.94; 54.25.80; 54.25.81; 54.33.82; Fax: (40) 254/54.34.91; 54.62.38,

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CONTENTS

ELECTRIC POWER PRODUCTION AND NATIONAL ENERGY SECURITY CONSIDERATIONS

ADINA TATAR[1], DRAGOS PASCULESCU[2], MARIUS DANIEL MARCU[3], TEODORA LAZAR[4], FLORIN GABRIEL POPESCU[5]

Abstract: This paper analyzes the electricity production system in Gorj County, the Oltenia Energy Complex, coal-based energy producer, considering the important share it holds in the electricity production market in Romania. In the current context, marked by the emergence of increasingly severe environmental regulations in the energy field, by adopting the Energy Union Strategy, the European Union has assumed an important role in combating climate change, and the CEO wants to consolidate its earned reputation on the competitive Romanian market, by guaranteeing a safe, clean and efficient lignite energy production, carried out in sustainable conditions by protecting and preserving the environment. The modeling of the Romanian energy system is also presented based on the expected evolution of policies and measures, in accordance with various other technical and economic factors and indicators.

Keywords: electricity, efficiency, pollution, strategy, energy transition.

1. INTRODUCTION

Following the EU's accession to the Paris Agreement and with the publication of the Energy Union Strategy, the Union assumed an important role in combating climate change, through the 5 main dimensions: energy security, decarbonization, energy efficiency, the internal energy market and research, innovation and competitiveness. Thus, the European Union is committed to leading the energy transition at a global level, by fulfilling the objectives set out in the Paris Agreement on climate change, which aims to provide clean energy throughout the European Union. To fulfill this commitment, the European Union has set energy and climate objectives for 2030 as follows:

- The objective of reducing domestic greenhouse gas emissions by at least 40% by 2030, compared to 1990;

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- The objective regarding energy consumption from renewable sources of 32% in 2030;
- The objective of improving energy efficiency by 32.5% in 2030;
- The objective of interconnection of the electricity market at a level of 15% by 2030.

Regarding the share of renewable energy, the European Commission recommended that Romania increase the level of ambition for 2030, up to a share of energy from renewable sources of at least 34%. Consequently, the level of ambition regarding the share of energy from renewable sources has been revised compared to the updated version of the PNIESC, from an initially proposed share of 27.9% to a share of 30.7% [5], [10].

The new target was calculated mainly on the basis of the Commission's recommendation to align national macroeconomic forecasts with those of the "Aging Report Economic and budgetary projections for the 28 EU Member States (2016-2070)", correlated with decommissioning of coal capacities.

The European Commission mentioned, on the other hand, that Romania will have to propose a greater reduction in primary and final energy consumption by 2030, in order for the Union's energy efficiency objective to be achieved [9], [13].

2. NATIONAL ENERGY SECURITY MEASURES

Romania considers the security of energy supply from internal sources a primary objective for ensuring national energy security. Romania aims to maintain a diversified energy mix on the horizon of 2030, taking into account both the decarbonisation objective of the energy system, as well as ensuring its flexibility and adequacy. In this sense, the evolution of installed capacities in the period 2020-2030 is presented in Fig.1.

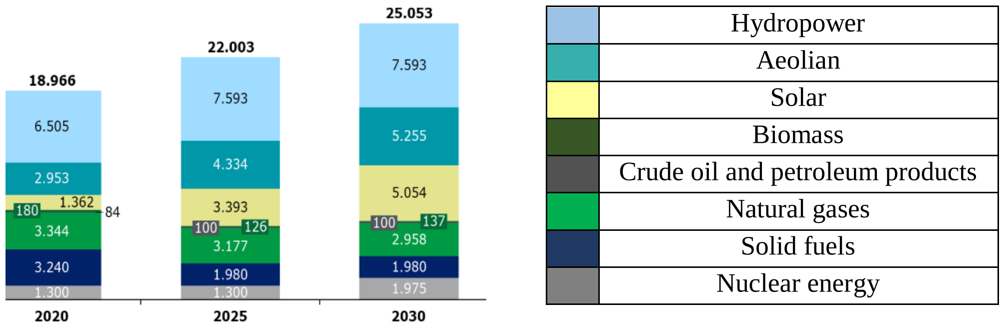


Fig.1. Indicative trajectory of net installed capacity, by source, [MW]
(Source: Deloitte calculations based on information
provided by the PNIESC Inter-institutional Working Group and COM recommendations)

In order to ensure energy consumption, installed capacity will increase by approximately 35% in 2030 compared to 2020, due to the installation of new wind (2,302 MW by 2030) and solar (3,692 MW by 2030) energy capacities, which will lead to an increase in domestic energy production, thus ensuring a higher degree of energy independence.

The positive impact can be seen in particular in the reduction of dependence on imports from third countries, from a level of 17.8% in 2030, representing one of the lowest levels of dependence on energy imports in the European Union.

It is also expected to replace several coal-fired units with natural gas-fired combined cycle units, to retrofit one nuclear unit, and to build at least one new nuclear unit by 2030.

The modeling of the Romanian energy system was based on the expected evolutions of policies and measures, in accordance with various other technical and economic factors and indicators. In this regard, the proposed policies determined a series of inputs and assumptions, as well as outputs of the modeling [4].

The model is a complex one that analyzes the links between various energetic and non-energetic parameters and their impact on the calculated indicators [11], [12].

In recent years, covering electricity consumption at the level of the system is proving to be more and more difficult to achieve from own energy resources, in order to give a correct picture of the operation of the National Electric Power System, but also to attract new investors in the area of production of electricity, the relevant Ministry and ANRE decided to remove from the records all the groups whose license was withdrawn/modified, the value of the power installed in the National Electric Power System being identical to the value of the installed power of all the groups included in the producers' licenses [6], [15].

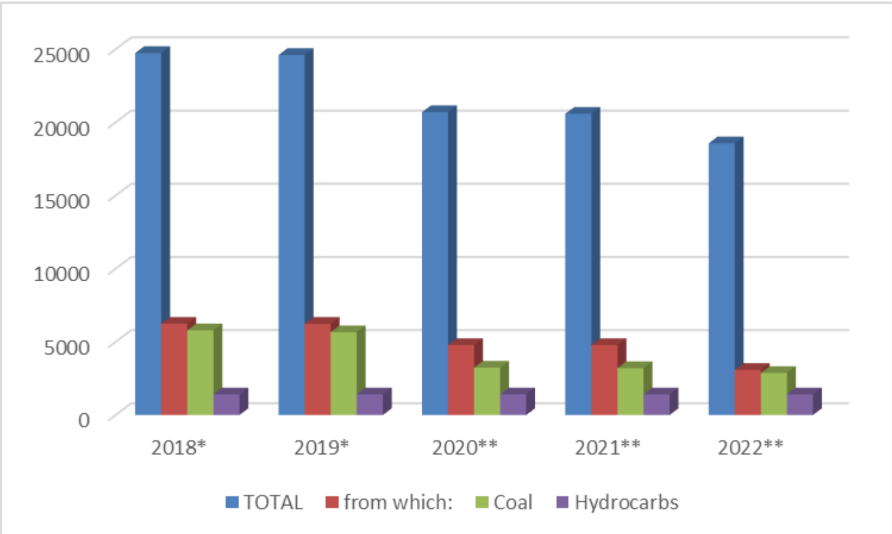


Fig.2. The power installed in the SEN [MW]

* Groups under conservation and groups withdrawn from operation for more than one year that are undergoing rehabilitation are not included. Also included are the groups in technological trials with a view to putting them into operation [8].

** Installed power in electricity production capacities in commercial operation (www.anre.ro)

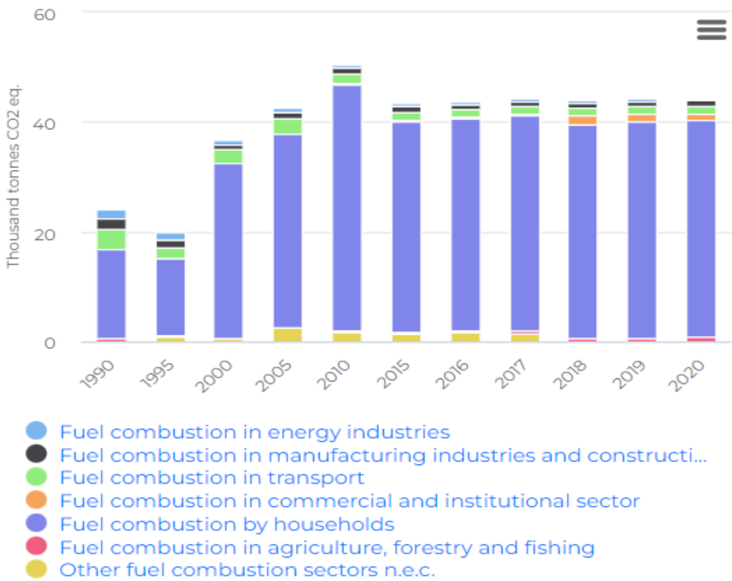


Fig.3. Greenhouse gas emissions intensity of energy consumption Romania (Source: Eurostat)

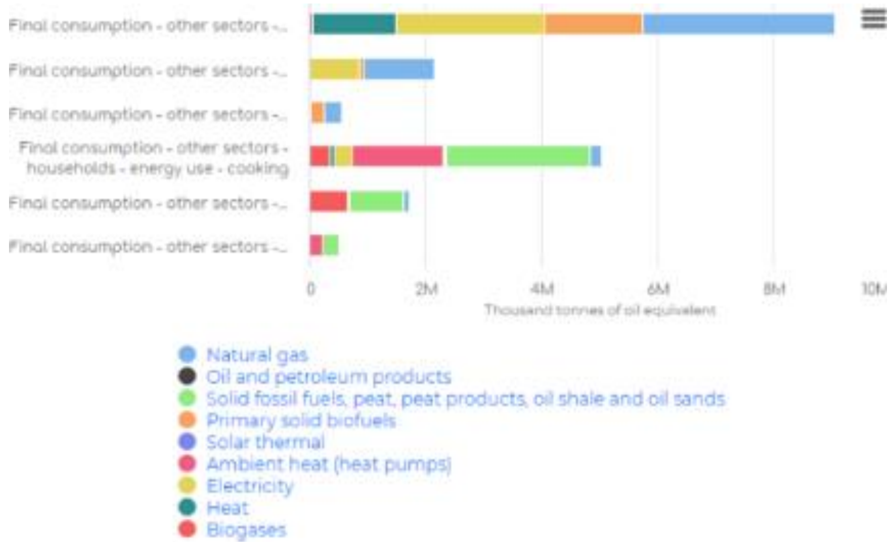


Fig.4. Disaggregated final energy consumption households quantities EU (Source: Eurostat)

The evolution of the energy sector in Romania in recent years has been sinusoidal, offering more market openness and the facilitation of diversity, better interconnection with neighboring states, but at the same time legislative and regulatory instability, the reduction of production capacities, the increase of dependencies on imports, the politicization of state-owned companies and the discouraging of new investment

On Romania's borders with Hungary, Bulgaria and Serbia, capacity allocation is carried out through market mechanisms, bilaterally coordinated in both directions, on the UIOSI principle ("use it or sell it"), Regional cooperation is an effective solution to energy supply crises [16].

Romania must maintain its position as an energy producer in the region and strengthen its role as an energy security provider in the management of stress situations at the regional level. Romania will continue the integration process in the European energy markets, making an important and profitable contribution to regional energy stability and security. The European approach to energy security policies is based on intra- and extra-community cooperation rules, norms and institutions. Romania currently has an energy security level score higher than the OECD average and better than its neighbors (Institute for 21st Century Energy 2013). In the EU Energy Security Strategy, the key to improving energy security lies in "improving cooperation at regional and European level in the functioning of the internal market and, secondly, in more coherent external action" [17].

3. THE ENERGY POTENTIAL OF GORJ COUNTY

Gorj county is, from an economic point of view, a mono-industrial county, the economy being based, for the most part, on the production of coal-based electricity, as well as on its related activities.

The main economic entity in Gorj County is the Oltenia Energy Complex, a coal-based energy producer that has approximately 12,858 direct employees and indirectly involves over 23,000 other employees in service companies and suppliers (production of assemblies and subassemblies, public food services, transport services, medical services, security and protection services, etc.), and represents about 12% of the total number of employees in this sector at European level (Source: Proposal of regulation of the European Parliament and of the Council establishing the Fund for a just transition) and approximately 40% of all employees in Gorj county (Source: AJOFM Gorj).

The Oltenia Energy Complex has a total installed capacity of 3,570 MW and an average annual production of 14 TWh and holds 22% of the electricity production market in Romania, energy produced as a result of mining activity from 9 (nine) nine extraction sites, of which 7 (seven) located on the territory of Gorj county.

CEO is a company of national interest, which was established by Government Decision no. 1024 of 12.10.2011 and was established through the merger of the following commercial companies:

- Craiova S.A. Energy Complex
- Rovinari S.A. Energy Complex
- Turceni S.A. Energy Complex

Oltenia S.A. National Lignite Company, and later, by payment, SC Power plants Group – SE Chișcani. The development strategy of Oltenia Energetic Complex SA has as its fundamental objective the production and supply of electrical and thermal energy, as well as the provision of services at exceptional standards for customers, in conditions of safety, accessibility and sustainability [7].

Fig.5. CEO activity

In the current context, marked by the emergence of increasingly severe environmental regulations in the energy field, Oltenia S.A. Energy Complex wants to consolidate its reputation earned on the competitive market in Romania, as a manufacturer that ensures SEN safety, by guaranteeing an energy production on safe, clean and efficient lignite, made in sustainable conditions by protecting and preserving the environment. CEO produces approximately 30% of the energy consumed in the system, having the following production capacities:

a) 10 energy blocks, with an installed capacity of 3,270 MW,

b) 2 energy blocks of 150 MW/160 Gcal on lignite, in cogeneration.

Oltenia S.A. Energy Complex can extract and deliver around 30 million tons of lignite per year, with the help of the following machines:

a) 69 large-capacity excavators (rotor excavators, of which 29 are modernized);

b) 46 dump trucks;c) 27 maşini de depozit;

c) 327 km conveyor belts;

d) 41 diesel, electric and hydraulic locomotives of 2100 HP, respectively 1250 HP;

e) 129 km industrial railway.

The main source of air pollution is the polluting substances from the combustion gases discharged through the desulphurization stacks. The main pollutants emitted into the atmosphere, contained in the gases resulting from the combustion of fuel together with the combustion air, in the hearths of the boilers, are: SO2, NOx, CO2, CO, unburned dust and particles and traces of heavy metals (Hg, Sb, As, Pb, Cr, Co, Cu, Mn, Ni) [9-11].

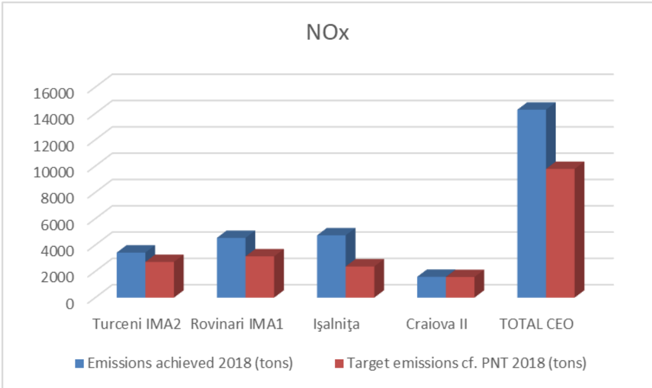


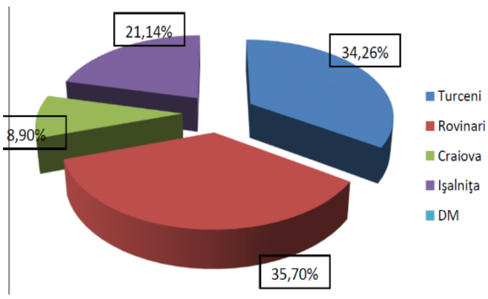
Fig.6. NOx emissions at CEO

According to GEO no. 196/2005, with subsequent amendments and additions, C.E.O. transferred in 2018 to the Environmental Fund Administration the following amounts as a result of pollutant emissions (SO2, NOx, dust) discharged into the atmosphere from fixed sources [2], [3].

The effects of the change in air quality, caused by the works within the mining operations, will materialize through the possible increase, in certain points of the mining perimeter, of the concentration of dusts, gases and smoke, resulting from the deployment of technology in the pits.

The main specific pollutants are represented by:

- suspended powders, settleable powders;
- combustion gases - machines, regardless of their type, operate with Diesel engines, the exhaust gases discharged into the atmosphere contain the entire complex of pollutants specific to the internal combustion of diesel: nitrogen oxides (NOx), non-methane volatile organic compounds (VOCs) , methane (CH4), carbon oxides (CO, CO2), ammonia (NH3), particles with heavy metals (Cd, Cu, Cr, Ni, Se, Zn), polycyclic aromatic hydrocarbons (PAH), sulfur dioxide (SO2) [1]. In 2018, Oltenia S.A. Energy Complex produced 17,232 (GWh), representing 22.82% Market share (%) [3], [9].



Turceni	413.511,22
Rovinari	430.882,00
Craiova	107.399,45
Işalniţa	255.308,17
DM	0

Fig.7. Amounts transferred by the CEO, as a result of pollutant emissions, AFM

According to the data from the National Integrated Plan in the Field of Energy and Climate Change (PNIESC), by 2030, the market share of coal-based energy producers will decrease from 25%, as it is currently, to 15%.

In this context, the Oltenia Energy Complex is to decrease the installed capacity based on lignite, by more than 45%, respectively from 3,570 MW to 1,605 MW. Implicitly, this decrease implies the closure of some coal mining perimeters, namely Husnicioara (Mehedinți County), Peșteana (Gorj County) and Lupoaia (Gorj County), but also a significant reduction in the number of personnel.

The restructuring plan foresees the closure of four of the 11 quarries that the company operates. In parallel, the company intends to invest in renewable energy production capacities, namely 8 photovoltaic parks, with a total installed capacity of 725 MW, located on closed slag and ash deposits. At the same time, the Oltenia Energy Complex is to rehabilitate and modernize a micro-hydro power plant with an installed capacity of 10 MW in SE Turceni and, last but not least, to build two natural gas power groups, with a total installed capacity of 1,325 MW.

The main sources of electricity are represented by the Turceni Energy Complex, with an installed capacity of 1980 MW, the Rovinari Energy Complex, with an installed capacity of 1320 MW, as well as the Târgu Jiu Hydroelectric Branch, with an installed capacity of 200 MW, which processes the energy potential of the waters within the Cerna, Motru, Tismana, Bistrița and Jiu hydrographic basins.

From the analysis of the territorial development of Gorj county, it shows that there are significant discrepancies between the county seat municipality of Târgu Jiu and the rest of the cities, but also between the urban environment and the rural environment, human resources, labor force, economic activities, services being concentrated in the urban environment, with especially in the county seat municipality.

From the point of view of urban settlements, in Gorj county there are municipalities and cities that do not meet some minimum criteria for the category in which they are placed, requiring urgent investments in the development of their urban infrastructure, in improving accessibility, social services and in supporting the business environment. The Paris Agreement on climate change, the policies and strategies promoted by the European Union, places particular importance on increasing the area of green areas in cities, reducing carbon dioxide emissions and energy consumption. The urban environment in Gorj county does not meet the community and World Health Organization standards for green spaces, currently only two localities exceed the European norm for green spaces in the urban environment of 26 sq m/inhabitant (the city of Novaci with 40.76 sq m/inhabitant and the city Țicleni with 40.06 sqm/inhabitant).

In terms of reducing energy consumption and the circular economy, Gorj County benefits from plans and programs to improve energy efficiency.

The energy efficiency improvement program for the municipality of Târgu Jiu provides a series of objectives in line with the economic potential of the city, investments from its own budget and financing based on credits or European funds, among which:

- reduction of the total consumption of thermal and electrical energy in municipal buildings;
- building energy production units for own consumption (photovoltaic energy, solar panels for obtaining hot water, wind energy);
- the introduction of provisions related to energy efficiency in the technical projects for new municipal buildings, so that they correspond to high energy efficiency standards;

- the purchase of electronics used in local administration that meet the economic efficiency requirements in force at European level;
- increasing the energy efficiency of rehabilitated buildings;
- reducing the fuel consumption of vehicles controlled by Târgu Jiu town hall (student transport, sanitation) by 10%;
- reducing energy consumption at the level of the population and economic agents by making citizens responsible; modernization and energy efficiency of homes by attracting European funds; creating an infrastructure for urban bicycle transport and promoting it within the community;
- promoting among the community the purchase and use of hybrid vehicles;
- increasing the level of awareness and accountability of citizens and economic agents regarding local energy problems and finding optimal energy efficiency solutions [1-3], [14];
- promoting eco-efficient behavior within the local community.

In the context of the current European decarbonization policies, CEO is considering the implementation of a Development and Decarbonization Plan that will allow it to make a transition as realistic and sustainable as possible towards efficient electricity production and with as few carbon emissions as possible, in this case, the transfer from coal-based capacities to those based on natural gas and renewable energy sources, contributing to ensuring energy security and reducing dependence on external energy resources. Energy security is the main pillar for Romania and achieving the transfer from coal to gas and renewables, according to a well-defined decarbonization plan in time and from a financial point of view, is crucial for reaching Romania's targets and objectives for the year 2030.

Maintaining production capacities at CEO in the period 2021-2025 is absolutely necessary to ensure Romania's energy security and the stability of the national electricity network, and the reduction of lignite capacities until the phase-out must be aligned with the increase of renewables in the system and commissioning of new gas plants, with the possibility of using green gases, to reach the energy and climate targets in 2030 and to prepare the energy system in Romania for climate neutrality in 2050, in accordance with the Green Deal [18].

4. CONCLUSIONS

Oltenia Energy Complex is an important producer on the electricity market, and in the current context, considering the increasingly severe environmental regulations in the energy field, it wants to consolidate its reputation earned on the competitive market in Romania, as a producer of safe, clean and efficient lignite energy, made in sustainable conditions by protecting and preserving the environment.

Based on the modeling carried out for the Romanian energy system, it is found that in recent years it is increasingly difficult to cover electricity consumption at the level of the system from its own energy resources, and Romania considers the security of energy supply from internal sources a primary objective for ensuring energy security national and aims to maintain a diversified energy mix, taking into account both the decarbonisation objective of the energy system, as well as ensuring its flexibility and adequacy.

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Annals of the University of Petroşani, Mining Engineering, 24 (2022)

DESIGNING WEB-ENABLED REMOTE MONITORING TOOLS FOR ELECTRIC POWER NETWORKS

MIRCEA RISTEIU[1], GEORGETA BUICA[2], MIHAELA ALDEA[3], FLORIN SAMOILA[4], ION BUTNARCIUC[5]

Abstract: The current paper is the result of research program dedicated to designing new tools and instruments in designing and optimizing electric power networks management. Starting from a deep state-of-arts in energetic domestic management and control, the paper underlines the main uncovered user's demands. The hardware- software proposed solution is using industrial smart meters and System-on-Chip implementation. The current solution allows electrical consumers to accurate analyze the quality of the energy in real-time status, using modern and flexible software instruments.

Keywords: Smart metering, System-on-Chip, Remote monitoring, Quality of energy, Web-enabled monitoring and control.

1. ENERGETIC EFFICIENCY IS PART OF OUR LIFE- HOW TO APPROACH IT?

The energetic efficiency is not only a deep eye on a bill. The amount of money we are paying is considered as big or small according with the allocated budget. Usually we do not care about the way the electrical energy is consumed. In the next figure we are showing a typical industrial consumer profile.

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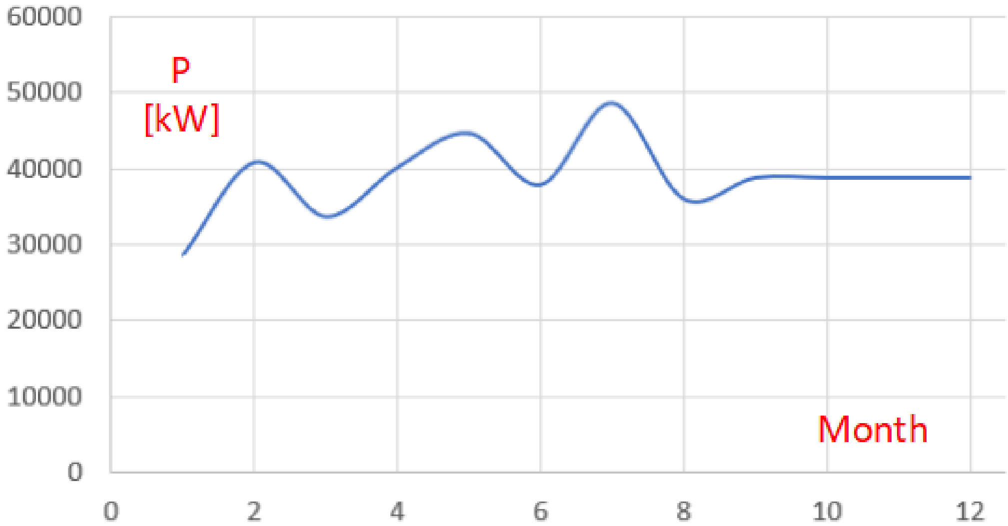

Fig.1. The most common profile of the monthly consumption (data provided by a local metallurgical company)

At the first look, this profile is not special, but at deep analysis, we understand that there is a demand of power, from minimum continuously supplying to the maximum values, around double value. It is big? Considering that the power must be contracted, and/or taking proper measures to ensure it, no matter it comes from an energy supplier or from solar plant, this amount of variation of power is quite difficult to manage it, especially because there is a need for very accurate monitoring and control.

Another example, with different analysis approach, with quite similar problem of monitoring and control- see the below figure.

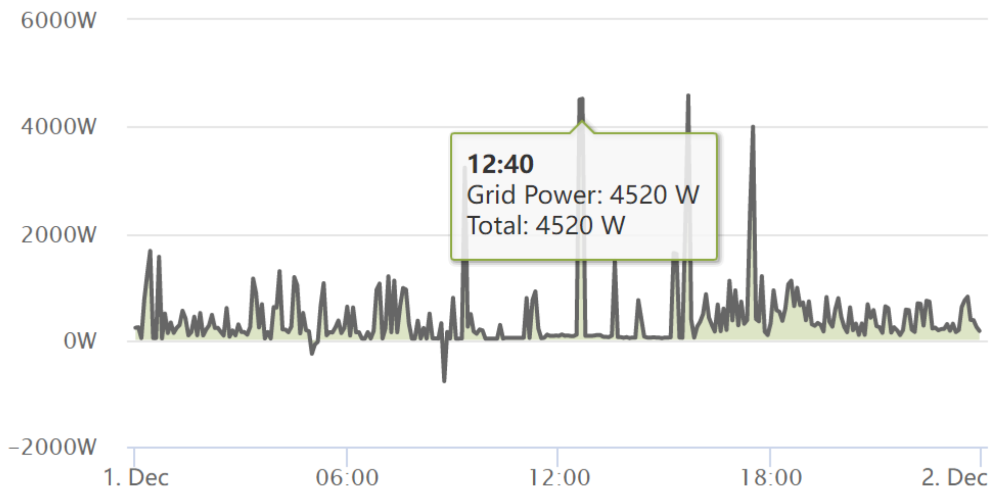

Fig.2. The domestic consumption profile (the data is provided by a local domestic consumer, and is taken from its monitoring interface)

In this case, first characteristic is: a very high variation of the demanded power- from zero to around 5000 W, instant power. The second characteristic is the ability of the grid to inject/to accept power from local producer: around 9.00 AM some power (-500W, according with local records of the domestic consumer) is injected to the grid. If no proper monitoring is implemented, this injected power to the grid is a disturbance and it is consistent taxed by the electricity provider.

The question is: is it convenient to implement such proper monitoring system? To answer to this question, we discuss here the medium-term records of energy (consumed/injected energy): today's energy- 2.46 kWh/0.38 kWh, monthly energy- 12.43 kWh/0.85 kWh, yearly energy- 2505.52 kWh/ 420.66 kWh. At simple calculus, the 20% of the energy is recorded as injected into the grid. The question is now: what about the contribution of this energy to the local consumption; how much it is?

According with the local regulations related to the prosumer contract, there is a need for a monitoring implementation in a way to understand the ration between exported energy and direct self-use, like in next figure.

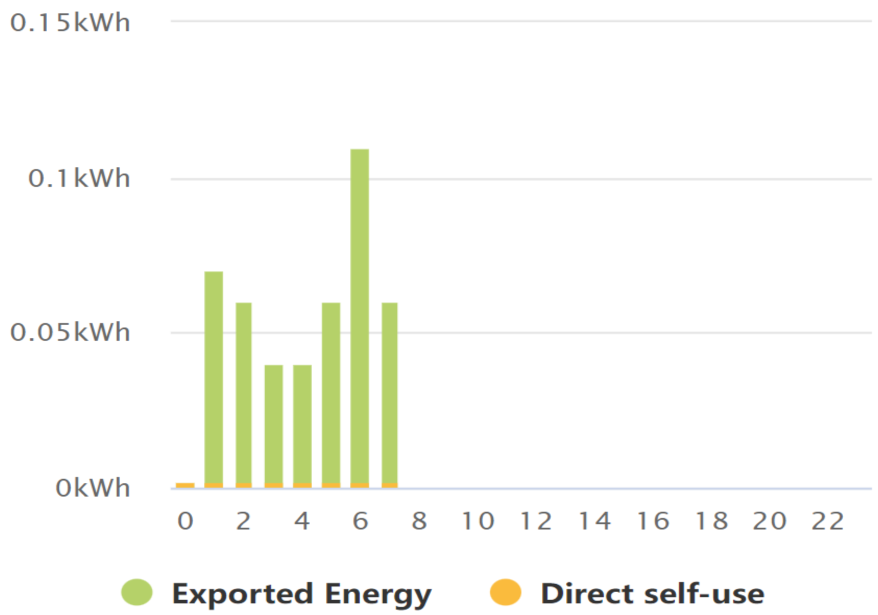

Fig.3. The representation of the two parts of the energy use from the prosumer's contract point of view (data is taken from the same domestic consumer, along a monthly record).

2. THE ANALYSIS OF THE STRUCTURE OF THE CONSUMERS

Another problem, which creates some local issues related to the quality of the supplied energy to the domestic consumer is the structure of the electrical devices that must be supplied correctly.

Next two figures show the records of some records.

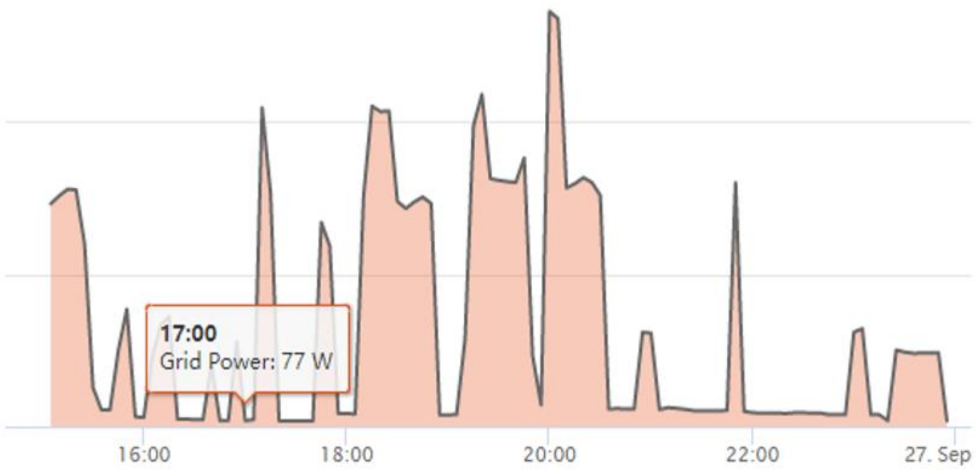

Fig.4. The graph record of the air conditioning (AC) system- data is taken from another domestic consumer

Fig.5. The graph record of the kitchen's electrical devices- the same domestic consumer

The data are important to understand the character almost chaotic of the demands. In such case, an accurate monitoring and control implementation is strongly demanded.

3. THE ANALYSIS OF TYPICAL MONITORING IMPLEMENTATIONS

Most of the monitoring implementations are required from the installation (commissioning) and maintenance point of views.

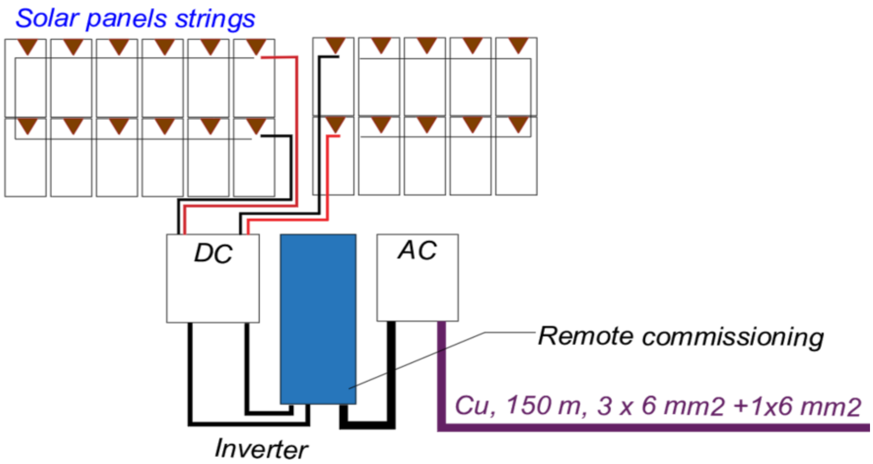

Fig.6. The inverter requires the setup according with local regulations [1]

This kind of monitoring system allow the user to understand the local behavior of the inverter, because it is recording only the production of the electrical energy. If the solar plant consists in many investors, the situation might look like in next figure.

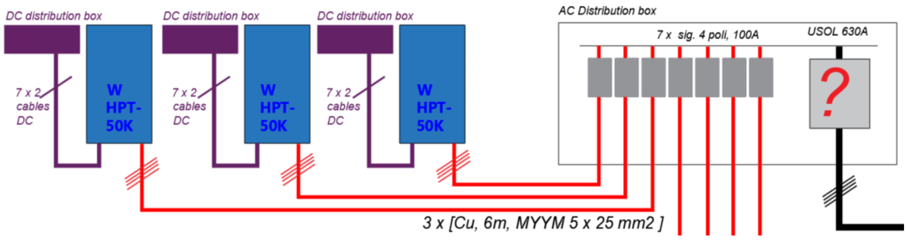

Fig.7. The inverters produce energy that is injected into the grid via USOL 630 device.

At the USOL 630A level, the question is how much energy is produced. The producers of this kind of inverters do not provide a solution for plant level monitoring.

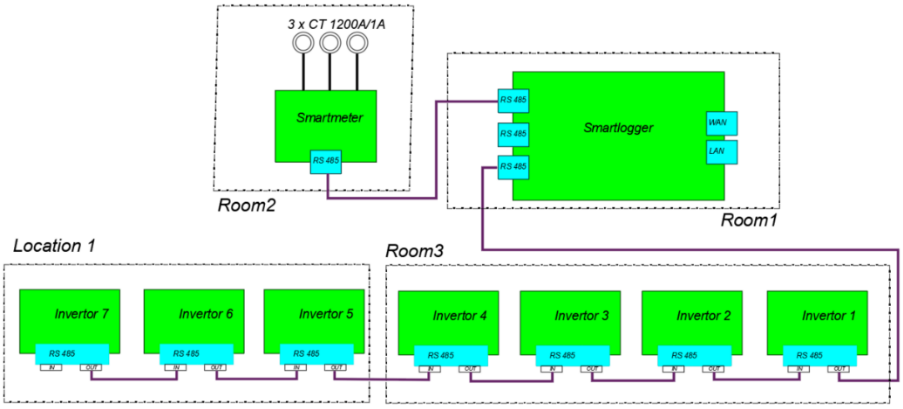

Fig.8. The inverters and the smart meter are connected together to a smart logger, for collecting the data from inverters [2], [3]

Another implementation is done by a different inverter's producer.

The implementation requires a dedicated connection to the company's cloud, without any safety rules in terms of control and the protection of data.

4. DESIGNING APPROACH OF A REMOTE MONITORING SYSTEM USING OPEN SOURCE PLATFORMS

4.1 Service- oriented approach in system architecture design

This method of designing starts from the services required to be used in the current context. Starting from a typical structure, shown in next figure, we analyze the main implemented services.

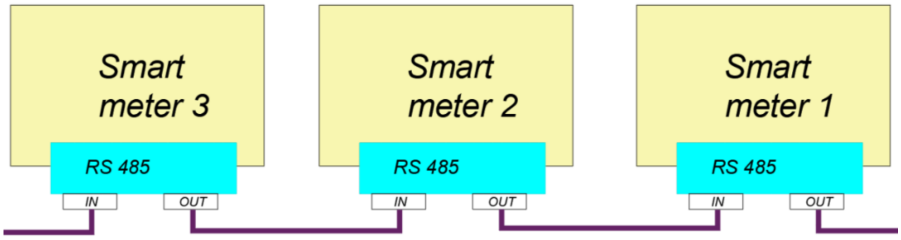

Fig.9. The chain of smart meters connected via RS 485 protocol

In the above structure, there are implemented two kind of services: smart measuring and data communication. The smart measuring will record in both direction the flow of power (see next figure), and in the implemented datalogger it stores the energy production and its direction (produced/injected). Then the dedicated communication service will group by meanings then sends data to a specified destination.

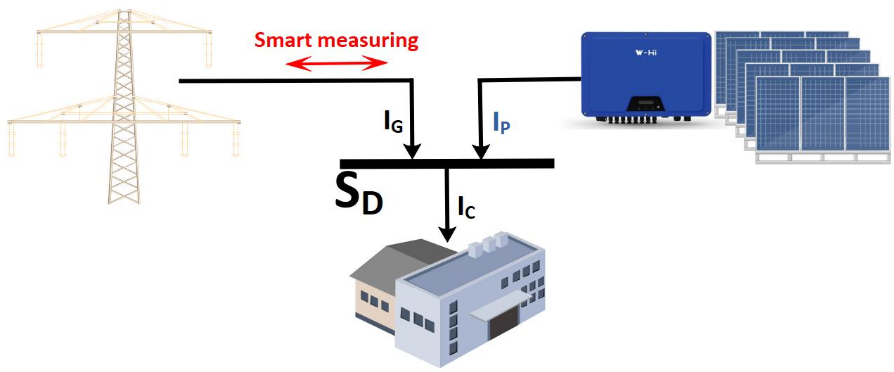

Fig.10. The location of the smart meter, for optimized management of electrical energy

4.2 The Modbus service approach for optimized monitoring

The Modbus communication protocol is a widely used industrial network protocol for machine-to-machine (M2M) communication. Modbus is based on architecture Master-Slave. According to this approach- see next figure-, a client (master) device is allocated in the network, which periodically sends requests to server (slave) devices in order to read or write their parameters. All requests are only initiated by master; therefore, slave devices cannot send data if a request hasn't been sent to them.

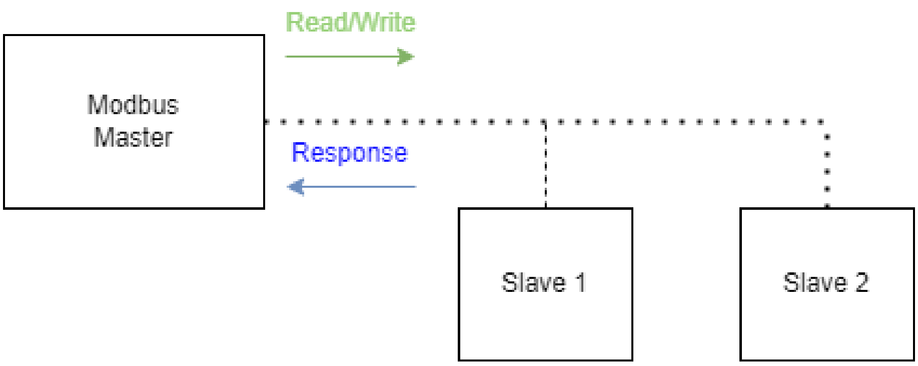

Fig.11. The typical querying method in energy management implementation [4]

On the same level of importance for applications is energy meters. This allows to measure the energy consumption of devices over a time interval. Their functionality is based on continuous measurement of the instantaneous voltage and current to get at output the used energy. There are two types of devices: electromechanical, based on electromechanical induction and electronic one which uses various ICs to accomplish this.

As energy industries developed, so did energy meters. Nowadays, smart meters are becoming an important part of systems allowing real time reading from any location, power outage notifications, power quality inspections and notification- see next figure.

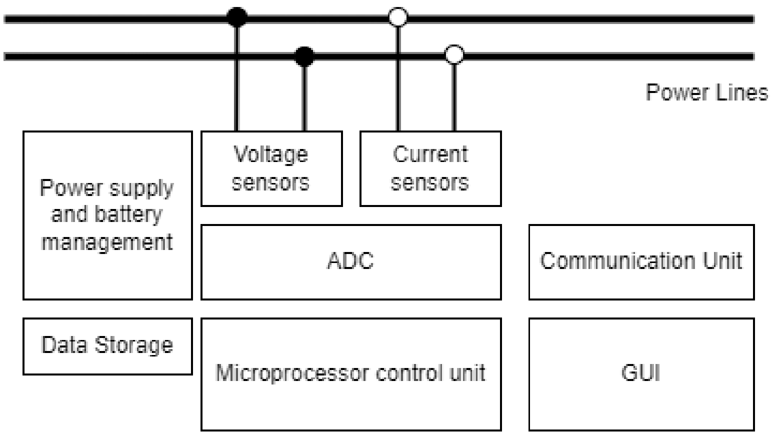

Fig.12. The link between different services (measuring and data communication) implemented in a computing system.

For the proposed application, it will be used the bi-directional smart meter, developed by Frer, NANO63H [5]. This device can measure main parameters of an electrical network like active and reactive energy counts. Being able to measure in both directions, NANO63H can be used to measure the grid electrical energy used by consumer and simultaneous the injected energy into the grid from photovoltaic panels for example. In order to access this data, we need to establish a communication through Modbus and send read request to our devices. The requested parameters are presented in figure below.

40429	01AC	kWh+ Sys 64 (Most Significant)	1Wh	R
40430	01AD			
40431	01AE	kWh+ Sys 64 (Least Significant)	1Wh	R
40432	01AF			
40433	01B0	kVArh+ Sys 64 (Most Significant)	1VArh	R
40434	01B1			
40435	01B2	kVArh+ Sys 64 (Least Significant)	1VArh	R
40436	01B3			
40437	01B4	kWh- Sys 64 (Most Significant)	1Wh	R
40438	01B5			
40439	01B6	kWh- Sys 64 (Least Significant)	1Wh	R
40440	01B7			
40441	01B8	kVArh- Sys 64 (Most Significant)	1VArh	R
40442	01B9			
40443	01BA	kVArh- Sys 64 (Least Significant)	1VArh	R
40444	01BB			

Fig.13. The Modbus registers table for optimized communication [6]

5. IMPLEMENTATION

5.1 Designing hardware open platform

The proposed system has been built around a System-on-Chip, with TCP/IP implemented stack- next figure shows the architecture.

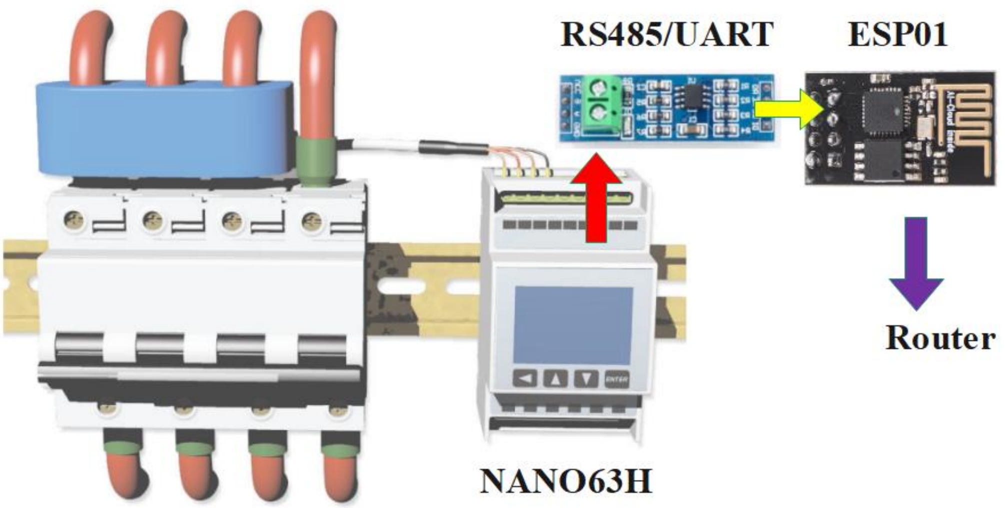

Fig.14. The designed architecture around the smart meter [7] and using SoC for web-enabled platform

In the above figure we are showing the main components- some additional conditioning and powering modules, which are standard, are not represented, for simplicity reason. The main modules- the RS485 converter and ESP01- are represented by them commercial representation, as they are well-known as open platforms.

On the other hand, the router is suggesting that, by using TCP/IP stack of the SoC, there is possibility to use the main actual facilities in terms of communication and security, because outside of the router's network, the rules are established by the Internet service provider.

5.2 Designing software open platform

We are using here the main facilities of the open platform concept in the software, because the main reason of this paper is to show the alternative developed solution. The below figure shows the main libraries invoked in our application. It is developed under Open Source Software (OSSL) license, with the possibility to get updated any changes into the used libraries. On the other hand, it uses additional files (the web-page interface with user's particularities).

On the other hand, because the SoC ESP01 doesn't contain the serial communication protocol implemented hardware.

In order to query the Modbus protocol, the serial protocol has been implemented software.

```
#include <ESP8266WiFi.h>
#include <WiFiClient.h>
#include <ESP8266WebServer.h>
#include <ArduinoJson.h>
#include "ModbusMaster.h"
#include "SoftwareSerial.h"

#include "index.h" //Our HTML webpage contents with javascripts

ModbusMaster node_meter;
SoftwareSerial rs485serial(0,2);  // RX,TX
```

Fig.15. The software contains OSSL libraries that allow managing Serial, Modbus and TCP/IP protocols.

The major tasks developed in the SoC (processing and communication) are developed as pseudo- multitasking processes- as parallel and asynchronous processes (C1/ C2)- like in next figure.

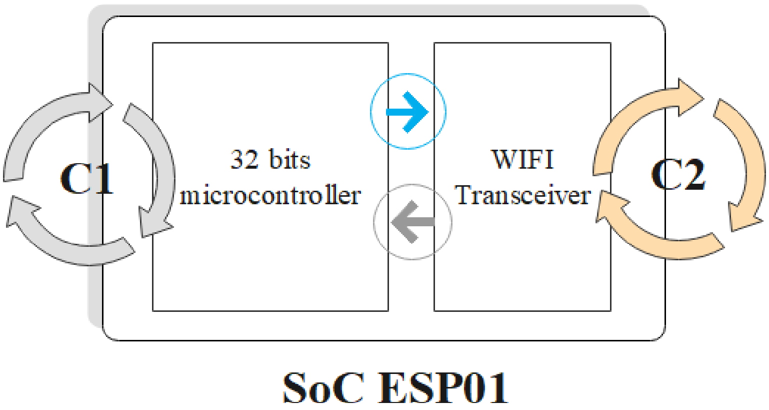

Fig.16. The processes inside of SoC are developed as asynchronous actions.

This implementation allows processes to be passed independently, without technical difficulties interaction.

5.3 Results

Because of high demand from the users, the interfaces have been developed for different actins- to query the data from the main electrical distribution point, and to show in real time the power balance when there is a contribution of the alternative energy power plant. Next figure shows these interfaces.

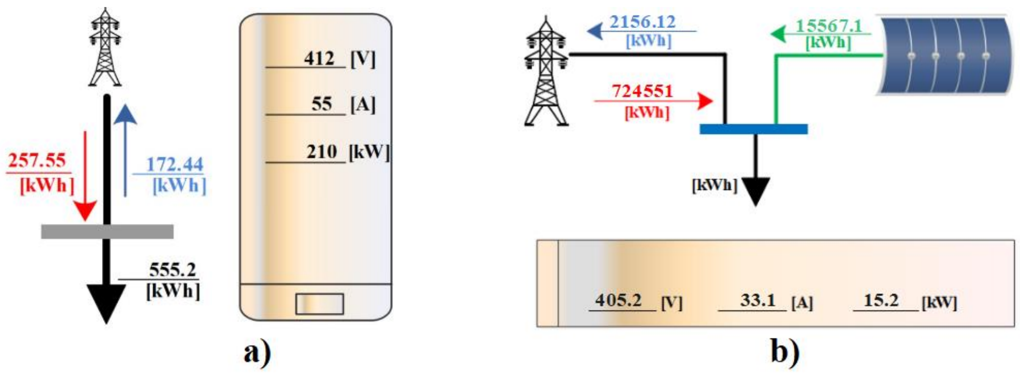

Fig.17. The web-enabled interface allows the main electrical parameters in the main distribution point (a) and as balance with solar plant contribution (b).

For the rest of results processing, a common database has been used. When we are interrogating it, depending by the data we want to retrieve, we obtain different kind of reports.

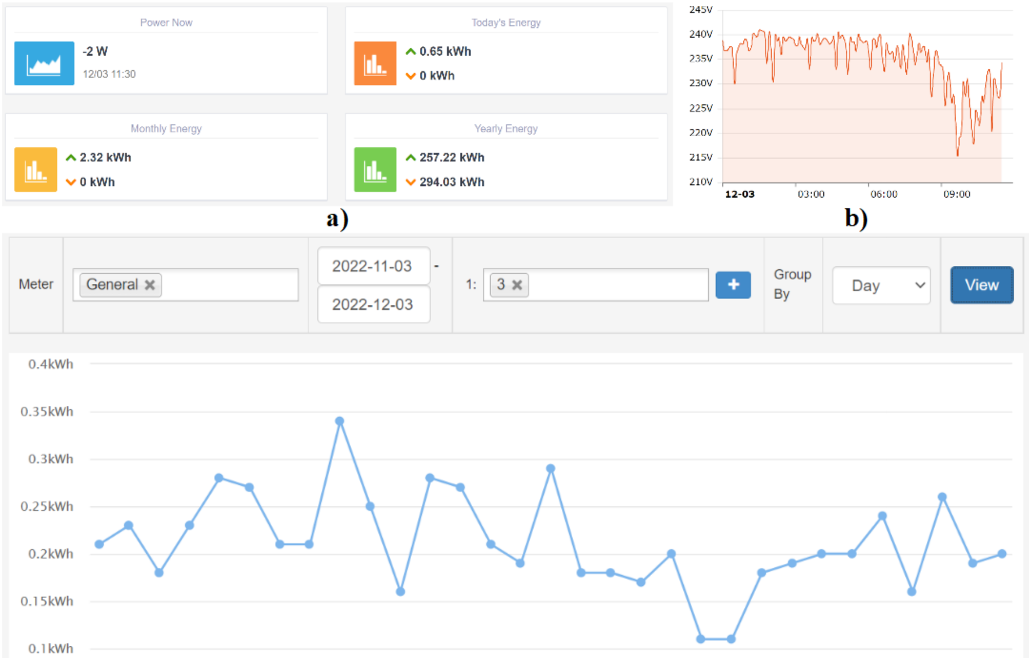

Fig.18. The resulting reports using the database software processor- brief results (a), quality analysis graph (b), and comparison report (c).

For all other imagined processing demands, the table format is also available.

6. CONCLUSIONS

A proposed system is fully developed and it is working without no interruption for 4 months. The smart meter provides the main legal, and user demanded data with the meter's reliability. The interface is developed and independent platform, providing data in local area network, and through a virtual private network in any web- accessible location.

In this way we have created an alternative solution to the solar systems developers, for ensuring the quality of services required by local regulations, and for GDPR response.

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PROCEDURE FOR THE STUDY OF ELECTRONIC DEVICES BY VIRTUAL INSTRUMENTATION

NICOLAE PĂTRĂȘCOIU[1], CECILIA ROȘULESCU[2]

Abstract: In this paper, we present the hardware and software structures for a laboratory stand used to interactive study electronic devices based on the physics functionality of these. The entire laboratory stand is created using various National Instruments. This equipment generates the input signals and also receives the electronic response signals. For various electronic circuits or devices, software applications can be created in the LabView graphical development environment, in particular, in this paper, the application is built for the study of semiconductor diode.

Keywords: p-n junction characteristic, MyDAQ, DiscoveryStudio, LabVIEW.

1. INTRODUCTION

The use of virtual instrumentation for both learning and research offers a number of advantages over hardware structures based on measuring devices with manual data logging, including:

- the generation of signals with very precise shapes and amplitudes and at very well-determined moments of time,
- automatic data retrieval and processing,
- graphical interfaces that allow users to effectively control the computer or device they interact with,
- virtual instruments through their interfaces offer the user:
  - ✓ clarity, that's means recognizable features and elements that are intuitive to interact with,
  - ✓ consistency which helps the users feel at ease and in control of their actions,
  - ✓ accessibility which makes all users feel comfortable, at ease, and in control when using a software product.

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The LabView is one of the most important means of creating the virtual instruments, is the abbreviation for Virtual Instrument Engineering Workbench and is a graphical programming language that allows teachers, scientists, and engineers in various fields to develop and implement interactive programs that will enable the acquisition of data from different equipment, analysis, and data processing and then displaying results with reports, graphs or charts. The LabView programming environment has many functions, libraries, and subprograms that allow the creation of highly complex programs that can be used in any branch of engineering [5].

The development of virtual laboratories that allow the training of students in various engineering fields using online technologies based on the LabView programming environment has preoccupied developers for over 20 years [3]. Thus, we meet virtual tools used to train students in the field of power electronics without them having to have the necessary physical equipment, all taking place in a simulated environment [4]. Hardware-in-the-loop simulators for teaching laboratories are also a useful learning aid [1].

For students and also for researchers is most important to repeat an experiment many times to understand all the basic concepts in unfolding the analyzed phenomenon or circuit and the use of virtual instrumentation offered by an experimental lab has revealed that students understand the concepts presented much better and their feedback is extremely encouraging in terms of the impact on them of this learning method [6].

There are various ways to create software applications for creating virtual laboratories using the LabView programming environment, so there are virtual tools that allow you to perform various simple experiments from analyzing different signals [2] to remote control of a DC motor [7].

Therefore, using LabVIEW can develop applications that can be accessed through a browser with minimum requirements of each computing system [8].

In this paper, we present an application written in LabVIEW used to draw the static characteristic of a rectifier diode. This application is included in a large project on the subject of using virtual instrumentation in studies of electronics devices and circuits.

2. HARDWARE STRUCTURE

In electronic devices and circuits studies is most important to know the compartment of these, which can be appreciated by performance characteristics. There are two types of performance characteristics of measuring instruments which are: static characteristics and dynamic characteristics. The static characteristics are used to measure quantities that slowly vary with time or are mostly constant with time and for electronic devices like diodes the current-voltage characteristic or IV characteristic is usually used.

a) Some theoretical consideration

For the rectifier diode it is known that the equation of the static characteristic deduced considering the density and mobility of the charge carriers is:

$$I_D = I_0\left(e^{\frac{q\cdot V_D}{k\cdot T}} - 1\right) \tag{1}$$

where:
I_D – the direct current flowing through the diode in direct polarization;
I_0 – the inverse current, the diode leakage current density in inverse polarization;
V – applied voltage across the terminals of the diode;
q – absolute value of electron charge;
k – Boltzmann's constant;
T – absolute temperature (°K).

The principle electrical diagram for drawing the diode characteristic for direct polarization is presented in Fig.1.

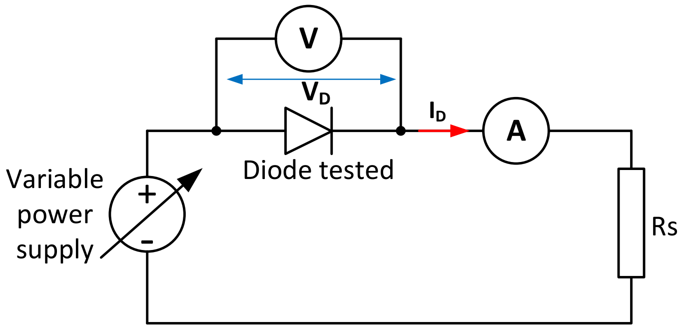

Fig.1. The principle electrical diagram

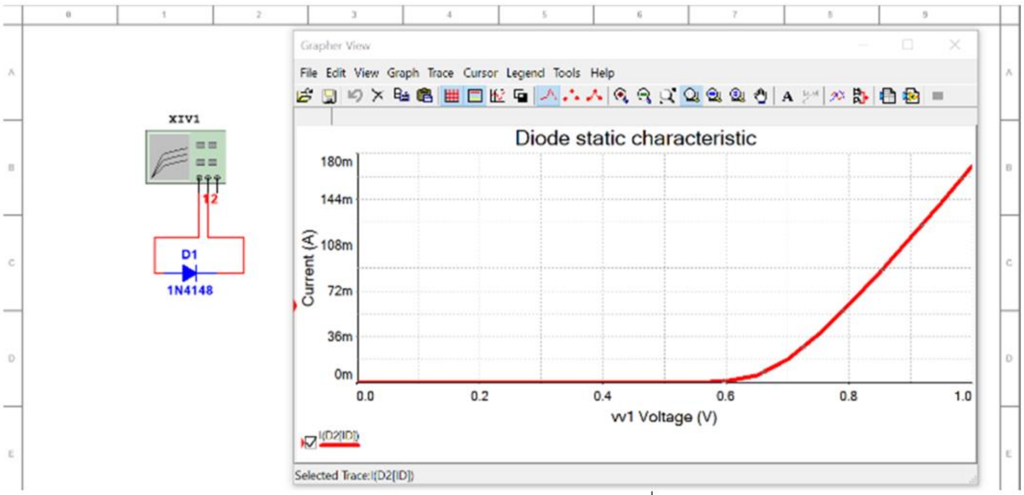

Fig.2. Static characteristic drawn in Multisim

The procedure for drawing the characteristic consists in modifying the voltage provided by the variable power supply and registering the pairs of current-voltage values. By interpolating them, the characteristic graph is drawn.

Based on these principle electrical diagram and procedure the static characteristic can be draw using a proper software application like NI Multisim how is shown in Fig.2

b) The experiment setup

For the realization of the experiment, was used specialized equipment produced by Agilent and National Instruments, as follows: Analog Discovery Studio for the implementation of the adjustable power supply function and the MyDAQ acquisition module for the implementation of the voltage and current measurement functions.

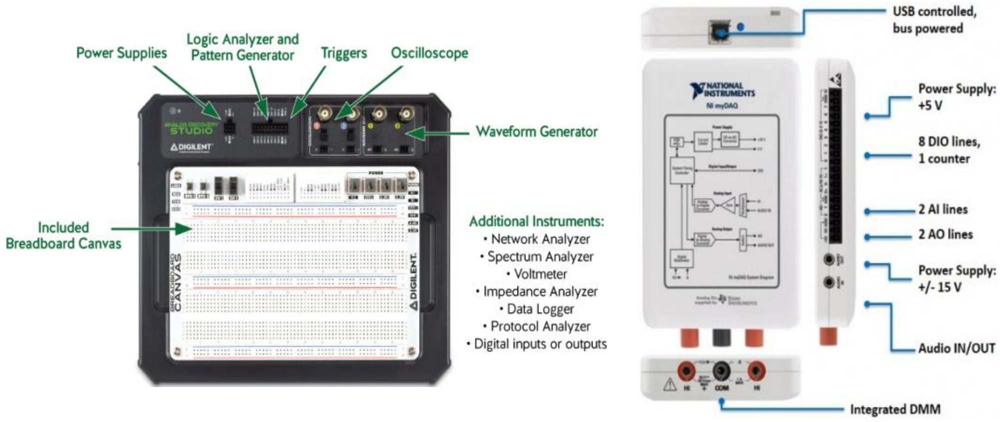

Fig.3. Equipment used in experimental assembly

The Analog Discovery Studio is a fully functional, portable test and measurement device that can turn any cross-functional space into a pop-up electronics laboratory. This equipment includes the Power Suppliers and other 13 instruments such as Oscilloscope, Logic Analyzer, Spectrum Analyzer, Waveform Generator, and more. The Analog Discovery Studio provides an entire stack of bench-top instruments with a convenient, replaceable, and breadboardable interface. For this application, one of the 3 available power sources is used, namely the Variable power supply for which the generation, with a resolution of 12 bits, of a voltage in the range (0 ... 5) V can be programmed.

MyDAQ is a data acquisition device that combines a comprehensive set of plug-and-play computer-based lab instruments with high portability and usage. This device is used for the virtual realization of the voltmeter by using the analog input AI0 in differential connection as well as the ammeter by using the current input of the included DMM multimeter.

The experimental electrical connections of the tested diode to the used device, Analog Discovery Studio module, MyDAQ module and software host computer are shown in Fig.4

The control of the power supply, as well as the acquiring and the processing of the measured values, are performed by resident software in the PC computer to which the used devices are connected via the USB bus.

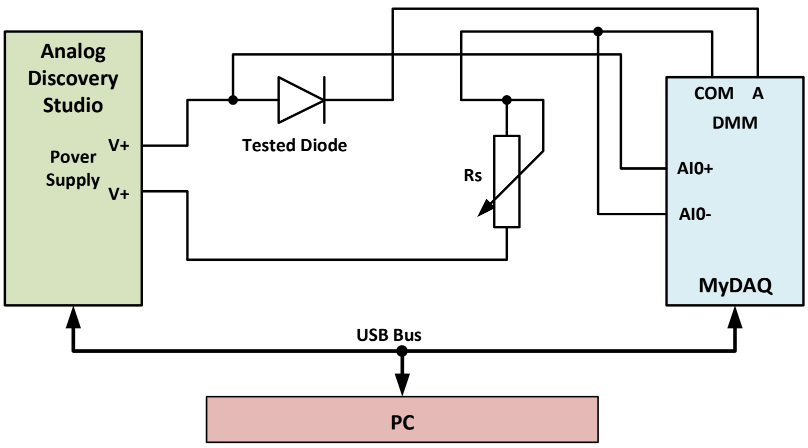

Fig.4. The experimental electrical connections

3. SOFTWARE IMPLEMENTATION

The virtual instrument that we propose in this paper is built in the LabVIEW graphical programming environment. This consists of the program through which is possible to draw the static characteristic of the electronic device based on the hardware experiment structure described above.

a) Algorithmic description of the virtual instrument

In Fig.5. is shown the realization algorithm for this experiment that involves setting the values of the DC voltage organized in an array and reading the resulting DC current.

For this experiment, a series of values is established, in the form of an array, of an independent parameter that is the voltage V_D across the diode. The acquisition of the current through the diode is made by adjusting the value of the V_{Di} until reaching the prescribed value through the mentioned table of values, also with specified tolerance.

The effective realization of a measurement supposes the fulfilment of the condition by which by adjusting the parameter $val[V_{Di}]$ the set value V_{Di} is reached, with the tolerance *tol* also established to it:

$$val[V_D i]=V_D i\pm tol \quad (2)$$

Once this condition is met, the other value that's mean $I_D i$ is read from the MyDAQ device through USB bus. All read values, including those of the considered parameter, are deposited in arrays $\{V_D i\}$ and $\{I_D i\}$ for a later use.

The number of loops, and thus implicitly the number of read values is determined by the size of the array initially established by setting the parameter values. The program reads the number of set values nV_D of the parameter and thus sets the number of loops through which the bus is read.

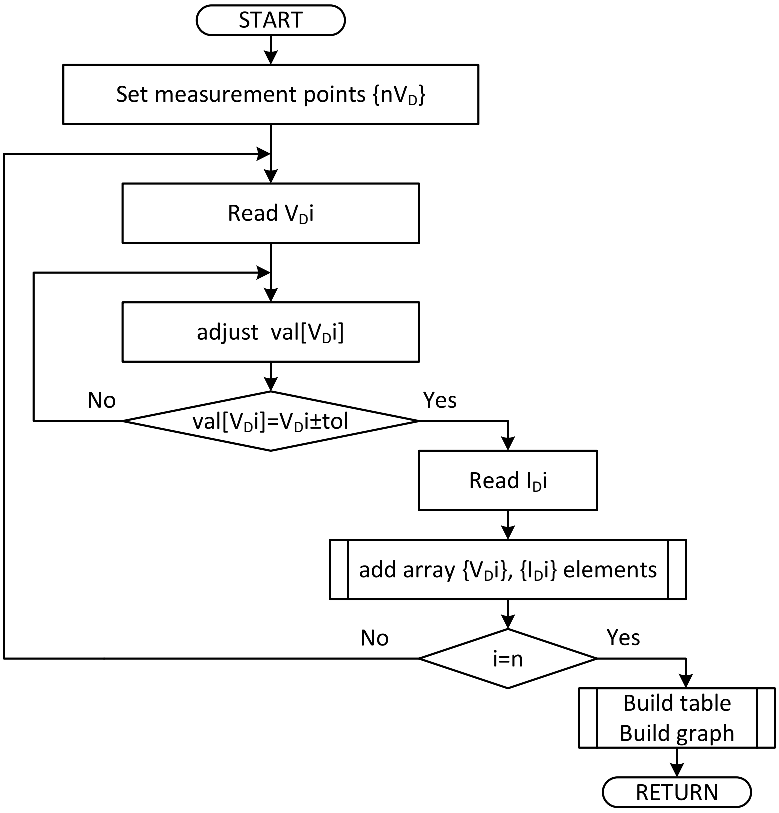

Fig.5 Algorithm of the experiment

Once determined the sets of values $\{V_{Di}\}$, $\{I_{Di}\}$ they can be used, depending on the application necessary, in this case for the construction of value tables and graphs of evolution of the voltage and current quantities.

b) Front Panel of the Virtual Instrument

The front panel of the virtual instrument represents the user interface and includes controls for generating commands and data as well as indicators for displaying the results obtained from data processing.

For this application the front panel, shown in Fig.6 and Fig.7, has two main windows through which the user sets the experiment steps and read the obtained results,

The front panel is divided into two windows used for: carrying out the procedure of raising the static characteristic and for displaying the obtained results, respectively. In these windows are used the following controls:

- two **Tab** controls through which the user can switch between the configuration of the experiment (Configurare experiment) or effective measurement (Masurare valori) windows, respectively the tabular (**Date**) or graphical display of the values (**Grafic**);

- two Boolean controls for the end of the process (RETURN) and respectively for the deletion of the values and the resumption of the acquisition and processing process (Clear table data);
- a **Ring** control for choosing the graph (Selectie grafic).

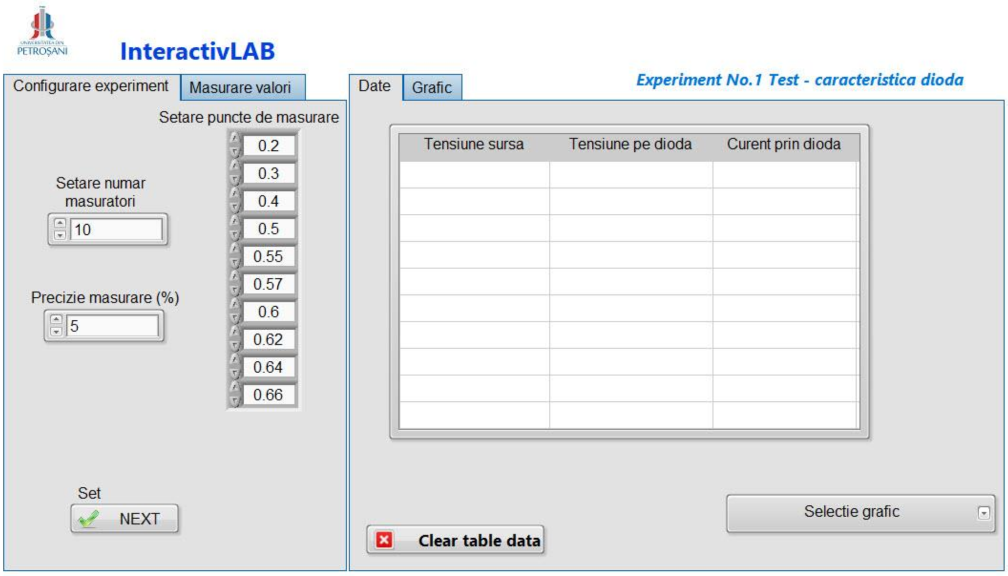

Fig.6. Experiment configuration front panel

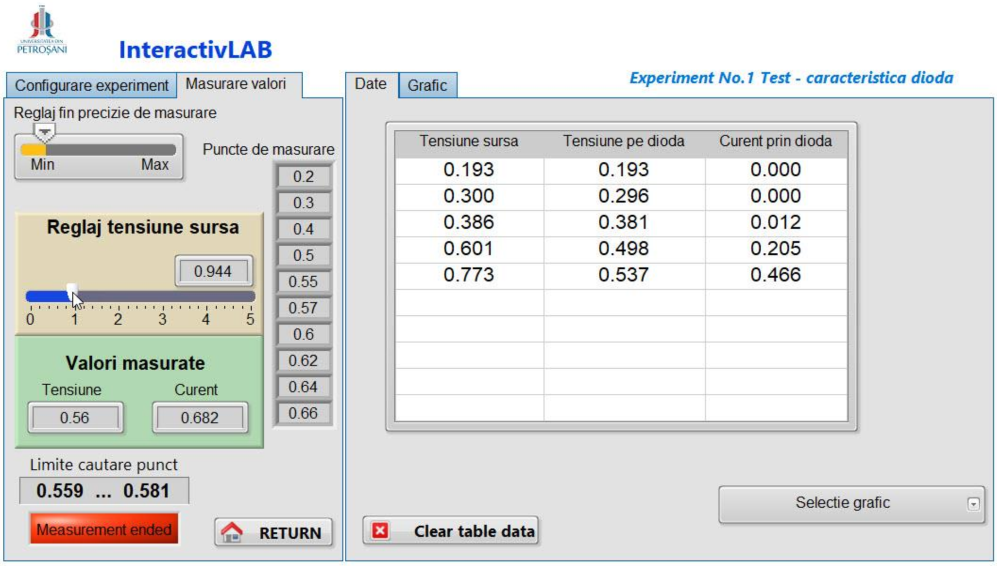

Fig.7. Experiment measurement front panel

Thus, through Configurare experiment, the number of points where the measurement will be made, the values of the set quantity, in this case, the voltage, and the identification precision of the dependent quantity, in this case, the current, are established. At the same time, depending on the number of points, the size of the table that will be completed with the measured values is measured

The next step is the proper experiment and the user has on the front panel, presented in Fig.7, a set of numerical type controls through which he will establish:

- the number of points based on which the static characteristic will be drawn;
- the set of values V_{Di} (Puncte de masurare) of the voltage on the diode in relation to which the set of I_{Di} values of the current through the diode will be measured;
- two **Slide controls** for the control of the supply voltage (V1 Reglaj tensiune sursa) and respectively for the choice of the tolerance *tol* (Reglaj fin precizie masurare) for establishing the V_{Di} values;

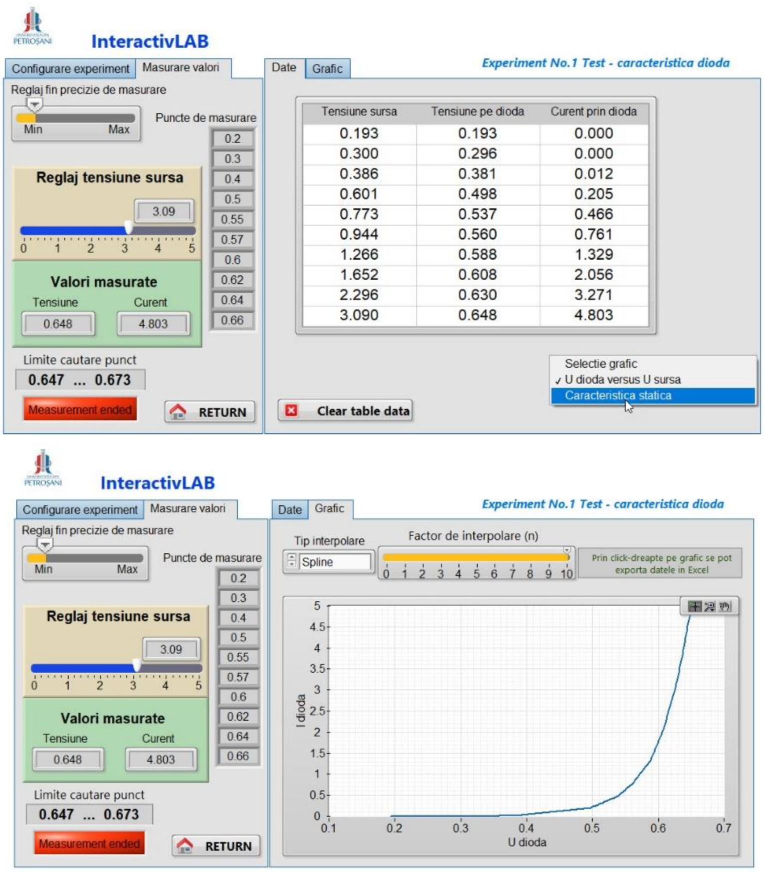

Fig.8. Screenshots of the front panel for measured data

To display the measured data and the processing results, numerical and graphical indicators are arranged on the front panel, depending on the window chosen by the user, as follows:

- the indicators Tensiune sursa, Tensiune pe dioda, and Curent prin dioda which will display the current values of these measured quantities;

- a tabular indicator that displays the values as they are acquired;
- a graphical indicator whose orthogonal axes can be set by choosing the sizes whose dependence is displayed.

In Fig. 8 are shown two screenshots obtained during the operation of the virtual instrument for measured and processed data.

All data measured during the experiment can be extracted from the graphic form of the static characteristic and exported and used in Excel, as shown in fig.9.

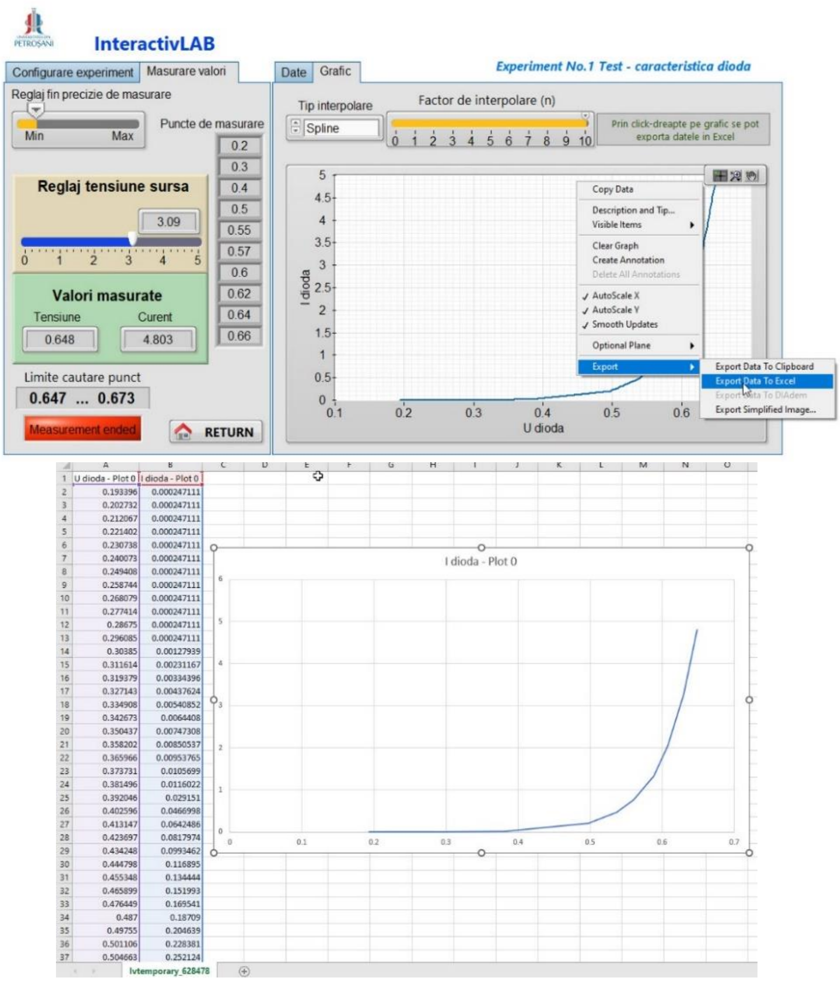

Fig.9. Export and use of data in Excel

c) Block Diagram of the Virtual Instrument

The block diagram represents the actual program based on which the virtual instrument works. It is made using programming structures, functions and operations available in LabVIEW libraries.

The block diagram of this application, shown in Fig.10 and Fig.11, determines the operation of the virtual instrument in a sequence of logical sequences made by using the Sequence structures.

Thus, a first such structure consists of two sequences through which the setting of the operating parameters of the instrument is performed, in the first sequence, and respectively the data acquisition and processing in the second sequence is performed.

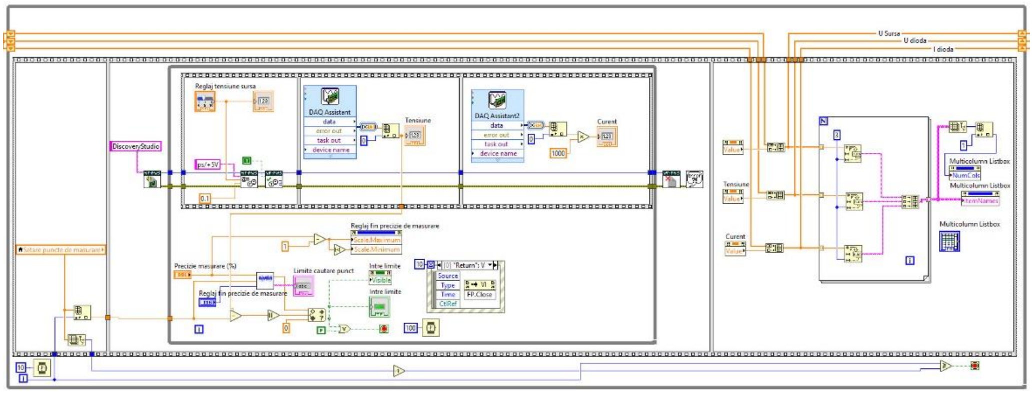

Fig.10. Block diagram of the virtual instrument

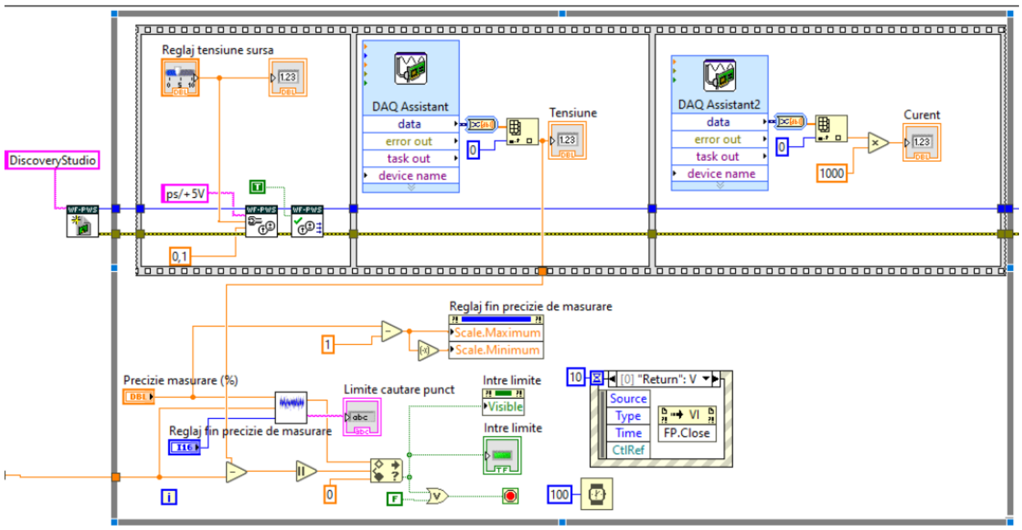

Fig.11. Data acquisition sequence

The end of the first sequence is made at the user's request, through the NEXT button, after completing the procedure for setting the operating parameters. Also the end of the second sequence is made at the request of the user, through the Return button and which becomes active only after acquiring the entire package of values $\{V_Di\}$ and $\{I_Di\}$. For both sequences, the stop conditions correspond to a While loop.

The operation of the program in the second sequence is also done through its sequencing in three sequences.

Thus in the first sequence, it is done simultaneously with the setting of the values of the vector $\{V_Di\}$ through the values of the supply voltage and the measurement of the corresponding values of the current through the diode resulting in the values of the vector $\{I_Di\}$.

In the second sequence in this part, the table of values is constructed by populating it with each pair of values after each reading.

In the third sequence from the same part of the program, the graph is built according to the user's options.

4. CONCLUSIONS

The results obtained and the operation of the virtual instrument by combining the two hardware and software components are prerequisites for the development of the instrument so that the functional study can be applied to various systems by the "black box testing" method. The concepts of the black box testing method come from the analysis of software applications that focus on testing systems mainly on their inputs and outputs and are based entirely on their requirements and specifications. It is also known as behavioral testing.

Even if this paper presents a minimalist example of system implementation, the paper has achieved its goal by highlighting the new concepts used as well as presenting new generation hardware equipment used.

The graphical interface of the entire program presented in this paper is very intuitive and can be used without problems in an extremely short time. The possibility of creating executable kits of the program together with the possibility of creating a web server dedicated to the entire system, will bring a special portability of the solution and will guarantee easy access to the entire suite of training resources of all those interested.

5. ACKNOWLEDGMENT

This work is part of the CNFIS-FDI-2022-0160 project financed from the funds of the Ministry of Education, which provides for the development of an interactive laboratory for the control through virtual instrumentation of the students' practical training activities, generically called InteractivLAB.

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ASPECTS REGARDING USEAGE OF THE HIGH VOLTAGE SOURCE IN ORDER TO VERIFY THE INSULATION SYSTEMS OF ELECTRIC MOTORS WITH THE TYPE OF PROTECTION INCREASED SAFETY USED IN POTENTIALLY EXPLOSIVE ATMOSPHERE

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Abstract: Evaluation of explosion-proof protected electrical equipment in scope of certification is extremely important considering the risk of explosion that has to be minimized in order to ensure life safety and health of workers and to prevent damaging of property and the environment, as well as free movement of goods when they meet the essential safety requirements at European level. Due to the fact that electric motors with type of protection Increased Safety, whose supply voltage exceeds 1000 V, presents a high risk of sparks occurring in windings, it is necessary to perform tests to verify that the insulation of the windings is adequate and does not lead to electric discharge (through electric springs or sparks) at winding levels. A very important test by which these aspects are verified is the overvoltage-ignition test, applicable to electric motors with increased safety protection type.

Keywords: electric equipment, increased safety, certification, explosive atmosphere.

1. INTRODUCTION

Explosive atmospheres can occur in various industrial fields, in installations in which flammable substances are processed, transferred or stored.

Using electric energy in potentially explosive atmospheres brings forward several particularities therefore the problems that appear during the design, construction and operation of electrical devices and installations brings forward numerous difficulties, their approach requiring special attention considering all the technical, economical and labour safety aspects [1], [5].

The risk of explosion may appear in all the fields of activity in which flammable substances are involved, such as gases, vapours, dusts, mists, which mixed with air may result in potentially explosive atmospheres [5].

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To prevent the ignition of explosive atmospheres, the electrical equipment used in such areas must be made with different types of protection so that it can not ignite the explosive mixture surrounding the electrical equipment [1], [4].

The type of protection means the specific measures applied to electrical equipment to avoid ignition of a surrounding explosive atmosphere [2].

For each type of protection applied to electrical equipment used in potentially explosive atmosphere, a wide range of type tests have been developed so that they can be used safely [2].

The evaluation of explosion-protected electrical equipment with type of protection increased safety is carried out by means of tests and verifications performed on the basis of the reference standards (SR EN 60079-0 - which includes the general requirements for all explosion-protected electrical equipment and the standards specific to the types of protection involved in the manufacture of the equipment). In the case of increased safety protection type, the specific standard is SR EN 60079-7 [2], [3], [6].

In order to verify explosion protection, the representative samples made available by explosion-protected equipment manufacturers are tested under the most unfavourable conditions that may occur in operation.

Most of the equipment used in technical installations in potentially explosive atmospheres (refineries, fuel depots, gas stations, dyestuffs, etc.) are electric motors, which in most situations act on various other elements.

2. ELECTRICAL TESTS CARRIED OUT ON ELECTRIC MOTORS WITH TYPE OF PROTECTION INCREASED SAFETY

The "e" increased safety type of protection implies equipment that does not produce electric arcs, sparks or excessive temperatures on any of the interior or exterior parts of the equipment, because of that it is necessary that these phenomena to be avoided [3], [7].

Because electric motors with increased safety type of protection (eb), whose supply voltage exceeds 1000 V, pose a high risk of sparks occurring in windings (due to the choice of an inadequate method of winding insulation), it is necessary to perform tests to verify that winding insulation is adequate and does not lead to electric discharge (by electric arcs or sparks) at winding levels [7].

This sparking risk in the winding occurs at weak insulation spots when the charge in the weak spot becomes too high. This weak spot is excessively stressed during the operation of the electric motor or during the high-voltage test. This weak spot cannot resist this increased stress. As a result there is a partial breakdown in this location. This partial breakdown is referred to as partial discharge. However, the remaining insulation can still resist the increased voltage stress so that there is not a complete breakdown [4], [9].

The tests by which these aspects are tested are the impulse ignition test and the overvoltage-ignition test, applicable to electric motors with type of protection increased safety.

Insulation systems and connecting cables shall be tested in an explosive test mixture as presented in Table 1. They shall be subjected to 10 voltage impulses of not less than three times peak phase to earth voltage and with a voltage rise time between

0,2 μs and 0,5 μs and with a time to half value which is at least. No ignition of the explosive test mixture shall occur [7].

Insulation systems and connection cables shall be tested in an explosive test mixture, with a sinusoidal voltage of at least 1.5 times the rated r.m.s. line voltage for at least 3 min. The maximum rate of voltage rise shall be 0.5 kV/s. The voltage shall be applied between one phase and earth with the other phases earthed. No ignition of the explosive test mixture shall occur [3], [8].

Table 1. ***Explosion test mixtures***

Equipment group	**Test mixture in air v/v**
II C	(21 ± 5) % hydrogen
II B	(7.8 ± 1) % ethylene
II A	(5.25 ± 0.5) % propane

3. USE OF THE HIGH VOLTAGE SOURCE IN ORDER TO VERIFY THE INSULATION SYSTEMS OF ELECTRIC

Within our laboratories were performed overvoltage-ignition test for stator insulation systems on electric motors used in potentially explosive atmosphere, as exemplified in Figure 1.

Fig.1. Insulation system subjected to overvoltage test in explosive mixtures

To carry out these tests were used specific testing equipment like: Oxygen analyser SERVOMEX 2200, high voltage source Sefelec. The tests were carried out with an explosive mixture whose characteristics correspond to the requirements (concentration 22 % hydrogen, test temperature 22°C).

Fig.2. High voltage source Sefelec used to test the insulation systems of electric motor

Pre-start purge may be adopted for Ex e, N or n motors at risk of incendive sparking, and is designed to purge clean air through the motor enclosure to remove any residual potentially flammable gas. Its purpose is to prevent the risk of explosions due to rotor sparking during starting; air flow sensors and pre-start timers may monitor this purge process before allowing the application of the HV electrical supply, or control may be achieved by procedures. Once the motor is started, no further pre-purge flow is provided [8].

A suitable purge connection point should be provided by the manufacturer. The purge gas supply is provided by the user, from a fixed supply or from portable gas bottles. (Nitrogen is sometimes used instead of using clean air) [6, 11].

Fig.3a. High voltage sources display (during test)

Ignition risks owing to stator sparking may also occur when the motor is running; this phenomenon has only been acknowledged relatively recently.

Note that pre-start purge does not offer any protection, but suitable special measure might be to pressurise the motor enclosure continuously in order to prevent the ingress of a potentially flammable atmosphere; this arrangement should be interlocked with pre-start and post shut-down timers and pressure/flow measurement, but may not fully comply with the standard for Ex p apparatus [6].

After performing the test in explosive mixtures, it turned out that the windings of the motor correspond to the requirements of the type of protection increased safety. (Fig. 3a, Fig. 3b)

Fig.3b. High voltage sources display (the test has been completed)

4. CONCLUSIONS

In this paper was revealed the importance of the tests carried out on electric motors used in potentially explosive atmosphere and the aspects that should be considered when starting the motors. The modernization of the test stands will lead to the increase of the quality of the tests, finally resulting in an increased level of safety and health at work for the workers who operate in the industries with danger of explosive atmosphere.

With the high voltage source which we purchased last year we can perform more accurate tests, in explosive mixtures. This way we have increased the testing capacity of the laboratory and we increase the quality of the tests.

Medium voltage electric motors with increased safety type of protection present a fairly high risk of explosion, also because of the sparking phenomenon that can occur in the stator windings (including partial discharges). These phenomena shall be avoided by the construction of the motor and especially of the insulation system of the stator winding. Motors with type of protection increased safety "eb" can work in zone 1, and when the motor is stopped, inside the housing explosive mixture may enter. When starting the motor, overvoltage can be generated, much higher than the rated voltage, and if windings are not properly insulated, sparking may occur. For this reason it is important that the motors are tested in accordance with the requirements in force.

To prevent the risk of explosions due to rotor sparking during starting the motor can be purge with clean air or with a gas which is not explosive as it is done on the pressurised electric motors.

In this paper was revealed the importance of the tests carried out on electric motors used in potentially explosive atmosphere and the aspects that should be considered when starting the motors. The modernization of the test stands will lead to the increase of the quality of the tests, finally resulting in an increased level of safety and health at work for the workers who operate in the industries with danger of explosive atmosphere.

In order to protect people who work in explosive environments, it is important that equipment operating in such areas to comply with the requirements in force, and be properly maintained by personnel who know the principles of explosion protection.

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THERMAL ENDURANCE TESTS PERFORMED AS PART OF THE CERTIFICATION PROCESS ON EQUIPMENT USED IN POTENTIALLY EXPLOSIVE AREAS

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Abstract: Evaluation of explosion-proof protected electrical equipment in scope of certification is extremely important considering the risk of explosion that has to be minimized in order to ensure life safety and health of workers and to prevent damaging of property and the environment, as well as free movement of goods when they meet the essential safety requirements at European level. The purpose of this paper is to present aspects regarding the importance of thermal endurance tests performed on the electrical equipment used in potentially explosive atmosphere. The paper also presents laboratory facilities for performing the thermal endurance test.

Keywords: thermal test, flameproof enclosure, increased safety, certification, explosive atmosphere.

1. INTRODUCTION

Using electric energy in potentially explosive atmospheres brings forward several particularities therefore the problems that appear during the design, construction and operation of electrical devices and installations brings forward numerous difficulties, their approach requiring special attention considering all the technical, economical and labour safety aspects [4], [7], [11].

The risk of explosion may appear in all the fields of activity in which flammable substances are involved, such as gases, vapors, dusts, mists, which mixed with air may result in potentially explosive atmospheres [5], [8], [12].

In order to increase the occupational health and safety level in potentially explosive atmospheres generated by flammable gases or explosive dusts we have to prevent the ignition of explosive atmospheres. In order to do this the electrical equipment used in such areas must be made with different types of protection so that it can not ignite the explosive mixture surrounding it [4], [9].

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The type of protection means the specific measures applied to electrical equipment to avoid ignition of a surrounding explosive atmosphere [1], [17].

For each type of protection applied to electrical equipment used in potentially explosive atmosphere, a wide range of type tests have been developed so that they can be used safely [1], [10].

In addition to type tests, on the equipment the thermal endurance test must be performed.

2. THERMAL ENDURANCE TESTS PERFORMED ON EQUIPMENT USED IN POTENTIALLY EXPLOSIVE ATMOSPHERE

The enclosure of the equipment, due to unfriendly conditions in which they operate, can be damaged quite easily. In order to preserve the type of protection of the equipment it is very important that their enclosures remain intact in the event of an accidental impact.

During the certification process, the equipment is subjected to an impact test to determine the resistance of the enclosure. According to the standardized requirements before carrying out these tests, the equipment enclosure must be subjected to thermal endurance tests. This test is performed using the climate chamber, specifically designed for testing enclosures [1], [6], [18].

The thermal endurance to heat shall be determined by submitting the enclosures or parts of enclosures in non-metallic materials, on which the integrity of the type of protection depends, to tests according to Table 1 [2].

Table 1. ***Thermal endurance test***

Service temperature Ts	**Test condition**	**Alternative test condition**
Ts ≤ 70 °C	$672\ ^{0}_{+30}$ h at (90 ± 5) % RH, at Ts + 20 ± 2 K (but not less than 80 °C test temperature)	
70 °C < Ts ≤ 75 °C	$672\ ^{0}_{+30}$ h at (90 ± 5) % RH at Ts + 20 ± 2 K	$504\ ^{0}_{+30}$ h at (90 ± 5) % RH at (90 ± 2) °C followed by $336\ ^{0}_{+30}$ h dry at Ts +20 ± 2 K
Ts > 75 °C	$336\ ^{0}_{+30}$ h at (90 ± 5) % RH at (95 ± 2) °C, followed by $336\ ^{0}_{+30}$ h dry at Ts + 20 ± 2 K	$504\ ^{0}_{+30}$ h at (90 ± 5) % RH at (90±2) °C followed by $336\ ^{0}_{+30}$ h dry at Ts +20 ± 2 K

At the conclusion of the test according to Table 1, the enclosures or parts of enclosures in non-metallic materials that were tested shall be subjected to (20 ± 5) °C at (50 ± 10) % relative humidity for 24 0 +48 h, and then immediately followed by the thermal endurance to cold test [2], [13], [16].

The test values given in Table 1 include two test conditions. The conditions shown in the 2nd column were used in previous editions of this standard and allow previously obtained test results to remain valid for this edition.

The conditions shown in the 3rd column have been added to allow testing at temperature/humidity conditions that are more readily achieved, although at an increased test time [1], [14].

It is generally acknowledged that glass and ceramic materials are not adversely affected by the thermal endurance to heat test, and testing may not be necessary [1].

The thermal endurance to cold shall be determined by submitting the enclosures and parts of enclosures of non-metallic materials, on which the type of protection depends, to storage for 24 h 0+2 + in an ambient temperature corresponding to the minimum service temperature reduced according to standardized requests [1], [3], [15].

It is generally acknowledged that glass and ceramic materials are not adversely affected by the thermal endurance to cold test, and testing may not be necessary. [1], [3], [19]

3. RESULTS OBTAINED

During the process of certification of a equipment used in potentially explosive atmosphere, at National Institute for Research and Development in Mine Safety and Protection to Explosion – INSEMEX laboratories are performed thermal endurance tests. The equipment is tested in the climatic chamber.

Fig.1. Climatic chamber

After the equipment was submitted to thermal endurance to cold and to heat, it was tested for resistance to impact. Following this test, the equipment did not suffer deformations or cracks, so it can be safely used in explosive atmosphere for which it was designed. This test is essential in the process of certification of equipment used in explosive areas.

Fig.2. Lamps subjected to thermal endurance tests

Table 2. ***Results of the resistance to impact test***

Equipment subjected to resistance to impact test.	The height from which the equipment is hit	Impact energy (m*g*h)	Results
Lamp used in potentially explosive atmosphere	0.4 m	1 kg*9.8m/s^2*0.4m =3.92 Joul	The equipment has not been deformed or cracked

Following numerous applications for product certification received by INSEMEX, it has been decided to purchase a larger climate chamber to test a wide range of products.

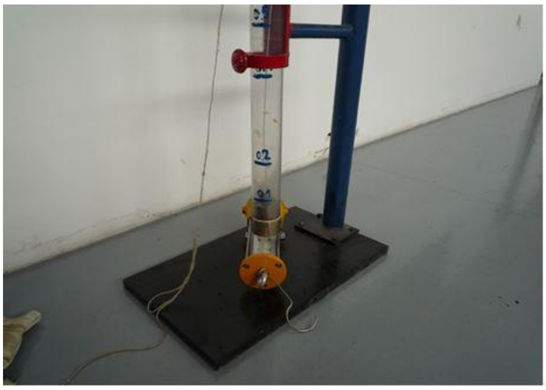

Fig.3. Lamp subjected to resistance to impact test

4. CONCLUSIONS

To protect people who work in explosive environments, it is important that equipment operating in such areas to comply with the requirements in force, and be properly maintained.

According to the requirements in force, in the process of certification of Ex equipment call of them must be tested in order to verify if the explosion protection characteristics are maintained at their level. In this paper was revealed the importance of thermal endurance tests performed on equipment used in potentially explosive atmosphere. Also after the studies made in the laboratories, it became necessary to acquire a large climate chamber, which will be done within this year.

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EXTRAPOLATION COMPUTATIONAL VIRTUAL SYSTEM BASED ON LABVIEW FOR SQUIRREL CAGE THREE-PHASE ASYNCHRONOUS MOTOR TESTING

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Abstract: The study of the no-load characteristics of squirrel cage three-phase asynchronous motor was made by applying balanced voltages to the stator terminals at the rated frequency with the rotor uncoupled from any mechanical load. Current, voltage and power are measured at the motor input. The losses in the no-load test are those due to core losses, winding losses and friction. The no load test of three-phase induction motor is performed on induction motor (1.1kW) when it is running without load. This test tells the magnitude of constant losses occurring in the motor. The testing was performed using a measurement acquisition software (LabVIEW) and the squirrel cage three-phase asynchronous motor will be controlled using the MHI software.

Keywords: acquisition software, real data measurement, open-circuit testing, induction motor, loss measurement.

1. INTRODUCTION

The three-phase induction motor carries a three-phase winding on its stator. The rotor is either a wound type or consists of copper bars short-circuited at each end, in which case it is known as squirrel-cage rotor [1]. The three-phase current drawn by the stator from a three-phase supply produces a magnetic field rotating at synchronous speed in the air-gap. The magnetic field cuts the rotor conductors inducing electromotive forces which circulate currents in them. The no-load test on a squirrel cage AC motor gives information with respect to exciting current and no-load losses. It is normally performed at rated frequency by applying balanced phase voltages to the stator terminals.

The three-phase induction motor behaves as a transformer whose secondary winding can rotate. The basic difference is that the load is mechanical. Besides, the

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reluctance to the magnetic field is greater on account of the presence of the air-gap across which the stator power is transferred to the rotor. The no-load current of the motor is sometimes as high as 30 % to 40 % of the full-load value [2,3].

From the diagrams, in correspondence to the current rated value, we obtain respectively: I0, iron losses Pfe, mechanical losses Pm and power factor cosϕ.

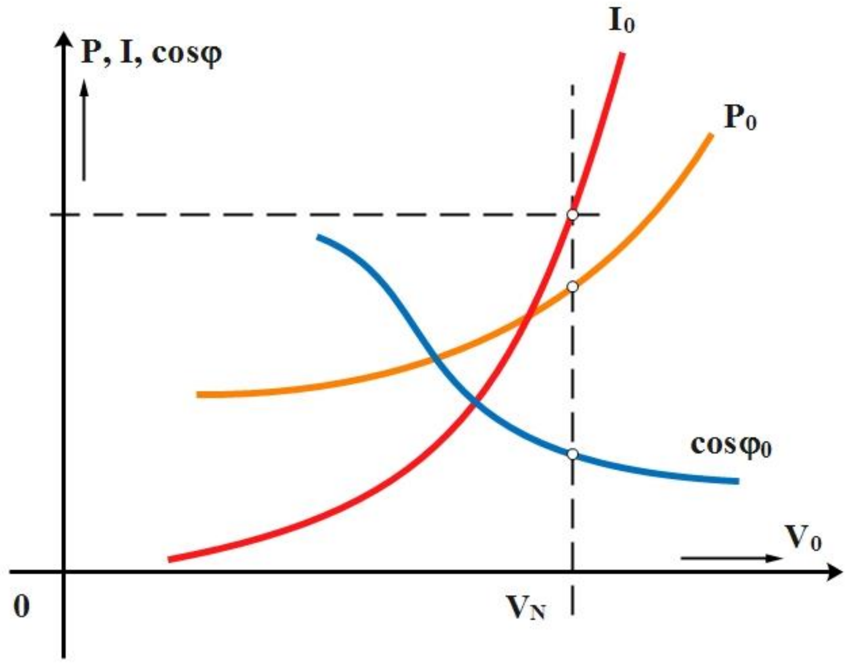

Fig. 1. The characteristic curve for the no load test of the squirrel cage AC motor

The no-load rotational losses (winding, friction, and core losses) will be seen in the no-load measurement.

Given that the rotor current is negligible under no-load conditions, the rotor copper losses are also negligible. Thus, the input power measured in the no-load test is equal to the stator copper losses plus the rotational losses.

The Pm + Pfe = f (V0) curve is nearly a parabola, presented in figure 3, shifted with respect to the X-axis by a Pm quantity. Following the variations of V0, in fact, the mechanical losses do not change, because they are related to the speed that remains sensibly constant.

On the other hand, the iron losses do change (because, changing the voltage means to change nearly by the same amount the magnetic flux that is generated) and, as between iron losses and induction there is a square proportionality, the graph that shows them will have a parabolic behavior.

The separation between Pm and Pfe is, therefore, possible through a graphical way, when the cross point between the curve and the Y-axis has been determined. That point cannot be experimentally measured because, with too reduced supply voltages, the asynchronous motor will tend to stop.

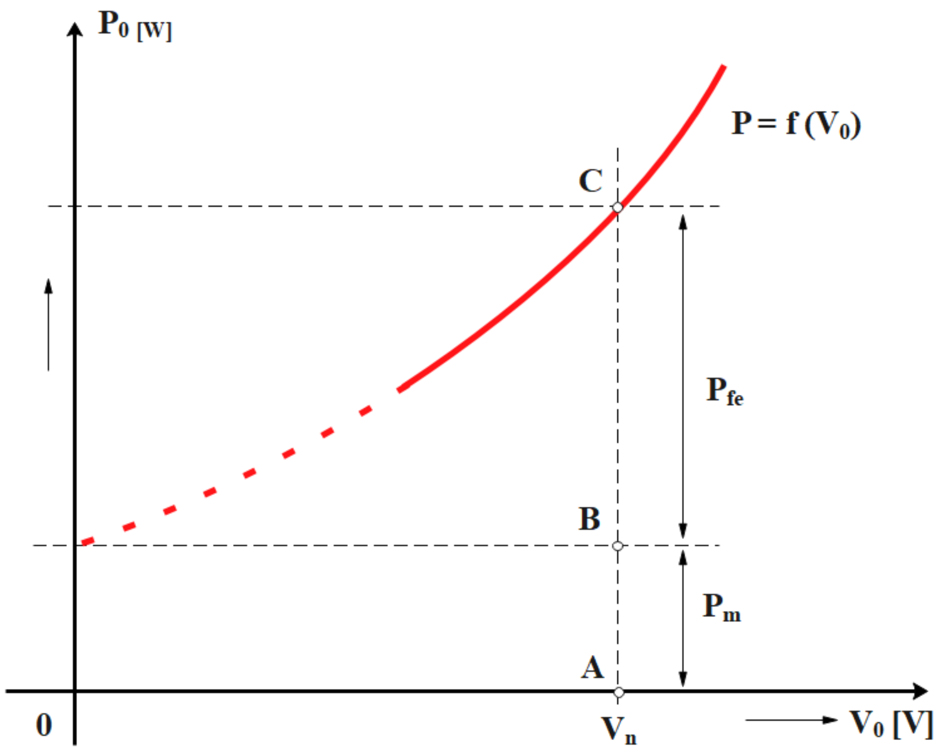

Fig. 2. Characteristic curve for determining the mechanical losses and the iron losses of the squirrel cage AC motor

The cross-point, therefore, has to be determined by graphical extrapolation on the amount of the curve that has been measured: to reduce the difficulty of this operation, it can be useful the fact that in the cross-point the curve is tangent to the X-axis.

At the rated voltage Un it is possible to obtain:

AB = mechanical losses Pm (W)

BC = iron losses Pfe (W)

2. CONCEPTUAL NO-LOAD OPERATION

Figure 3 shows the circuit diagram for measuring the electrical parameters needed for drawing the characteristic curves for no-load operation using a delta configuration of the stator windings. Figure 4 is used to perform the test using star configuration of the stator windings. This test describes the operating conditions in the magnetic circuit of the motor, and it is important because it makes available several elements that are useful both for the drawing of the circular diagram (I0 and cosϕ0) and for the calculation of the conventional efficiency (Pm and Pfe). It consists in supplying the asynchronous motor with its nominal voltage, leaving the rotor free to rotate without any resistant torque [4].

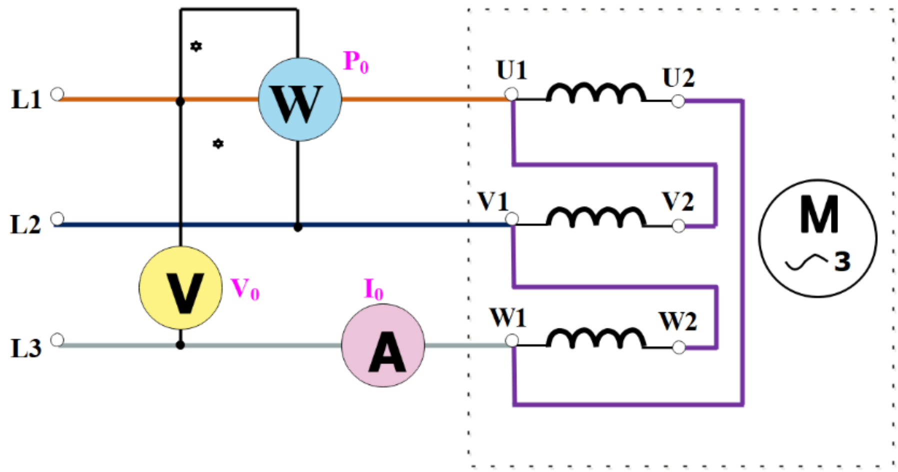

Fig. 3. Circuit diagram for the no load test of the squirrel cage AC motor (delta)

The set up for no load test of squirrel cage three-phase asynchronous motor is shown in the figures 3 and 4. The machine is started in the usual way and runs unloaded from normal voltage mains. On the mains side suitable instruments are connected between supply mains and motor terminals to measure power, line current and line voltage.

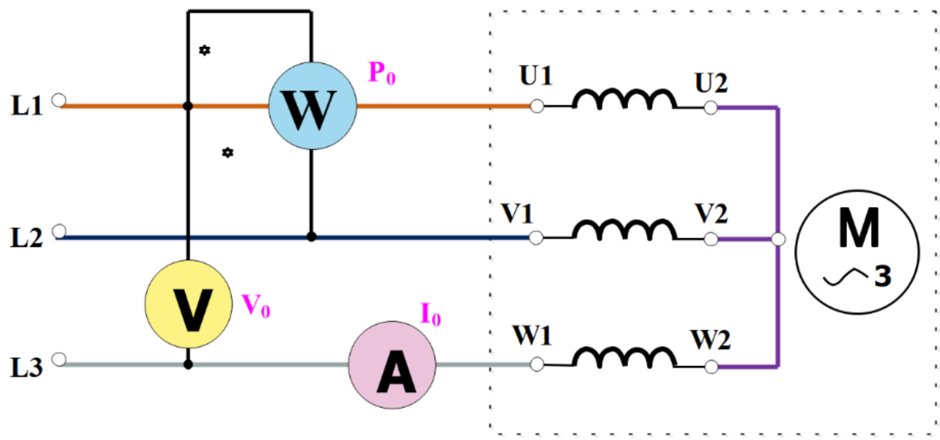

Fig. 4. Circuit diagram for the no load test of the squirrel cage AC motor (star)

The no-load electrical parameters can be measured using the ammeter A and the voltmeter V. In this schematic diagram, the AC stator configuration is presented. The electrical power has been measured with a three-phase wattmeter. As the asynchronous motor is, due to its construction and operating conditions, a symmetrical machine under every load condition, in figure 3 only one wattmeter, voltmeter and ammeter are indicated.

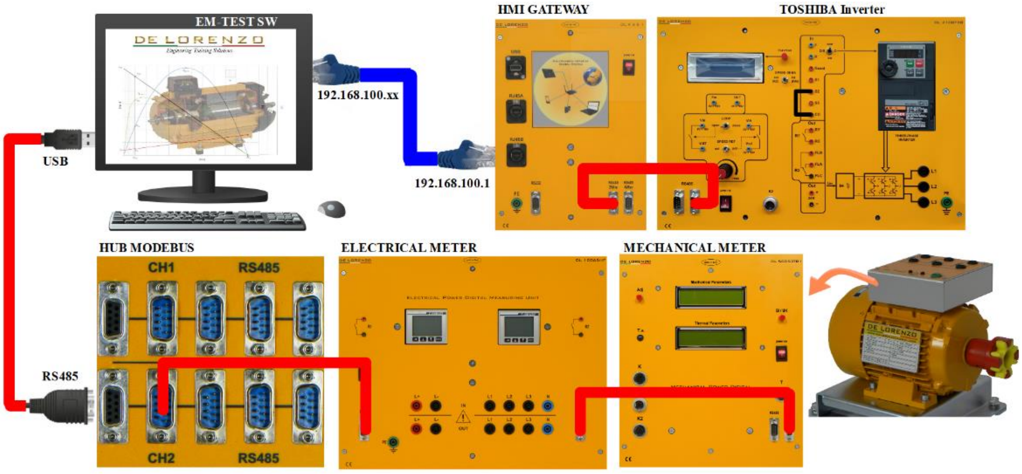

Fig. 5. MODBUS communication diagram for dynamic analysis

3. DINAMIC NO-LOAD TEST OF SQUIRREL CAGE THREE-PHASE ASYNCHRONOUS MOTOR

Figure 6 shows the measurement and control interface. Using the HMI software START the power supply to power the induction motor. By gradually increasing the voltage until the voltage reach 1.1*Un. The machine is started in the usual way and runs unloaded from normal voltage mains. On the mains side suitable instruments are connected between supply mains and motor terminals to measure power, line current and line voltage.

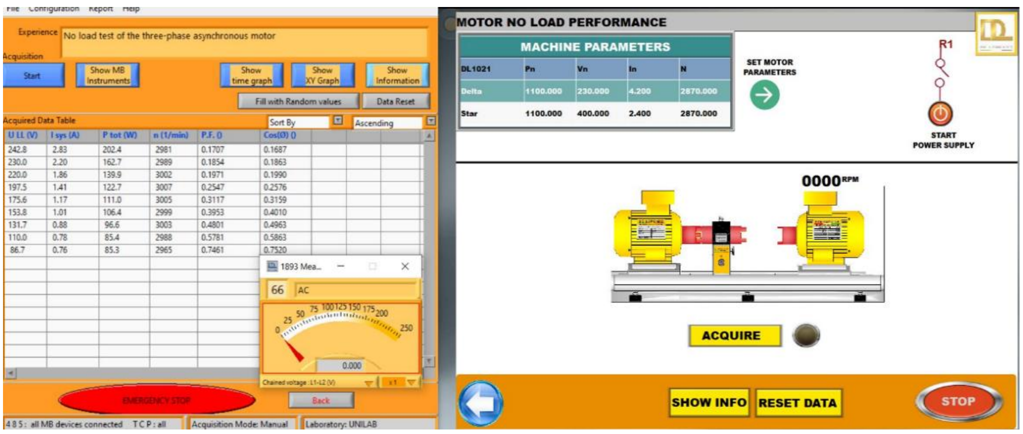

Fig. 6. Dynamic analysis using HMI control and LabVIEW

Figure 7,8 shows the curve that is used to determine the values Pm and Pfe using the extrapolation method, when the motor stator is in delta.

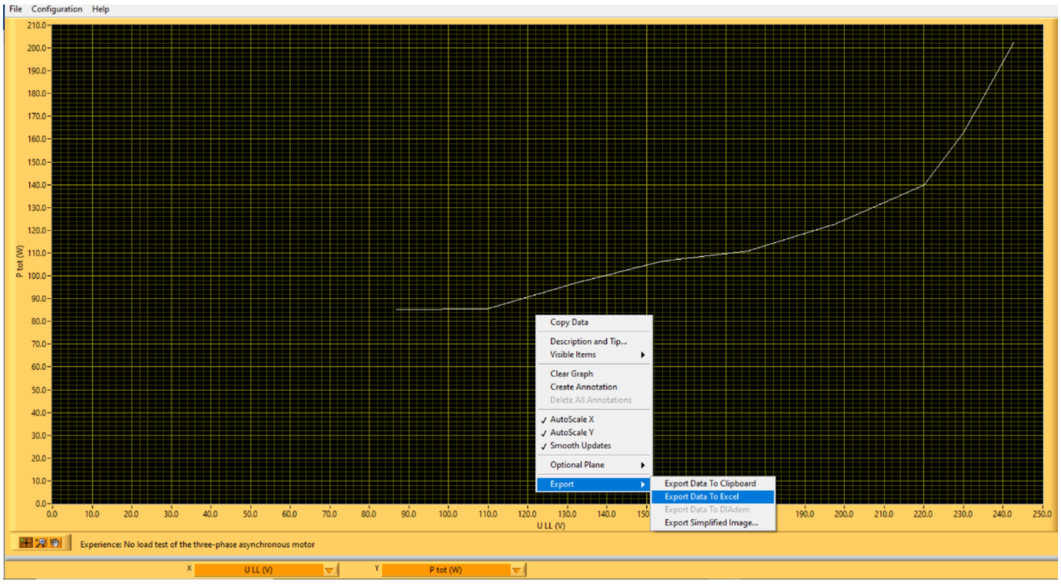

Fig.7. Squirrel cage AC motor no-load power measurement (delta)

Since the motor is not loaded so input power absorbed by the motor is providing losses only. Losses are occurring in iron core of the stator as well as the rotor which are called core losses. A small amount of copper loss is also occurring in stator winding. This can be neglected since the stator current is very small.

The point where it intersects, is the zero applied voltage. When applied voltage is zero the core losses and stator copper losses are zero.

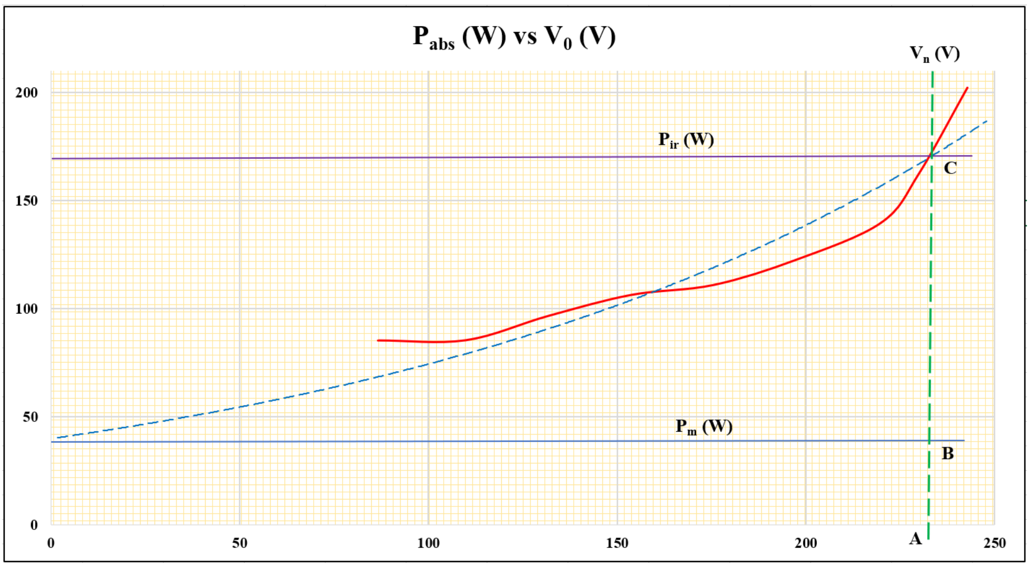

Fig. 8. DELTA configuration: The experimental characteristic curve for extrapolation of the Pm + Pfe

Figure 9,10 shows the curve that is used to determine the values Pm and Pfe using the extrapolation method, when the motor stator is in star [5]. To obtain the characteristic curves of the AC motor tested under no-load conditions was selected on the horizontal axis the no-load voltage and on the vertical axis the active power.

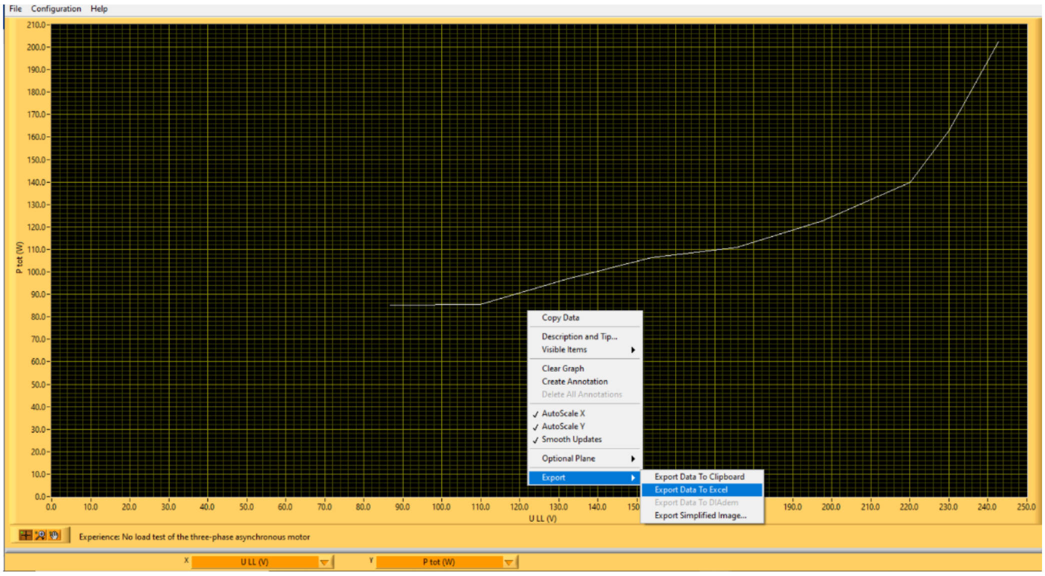

Fig.9. Squirrel cage AC motor no-load power measurement (star)

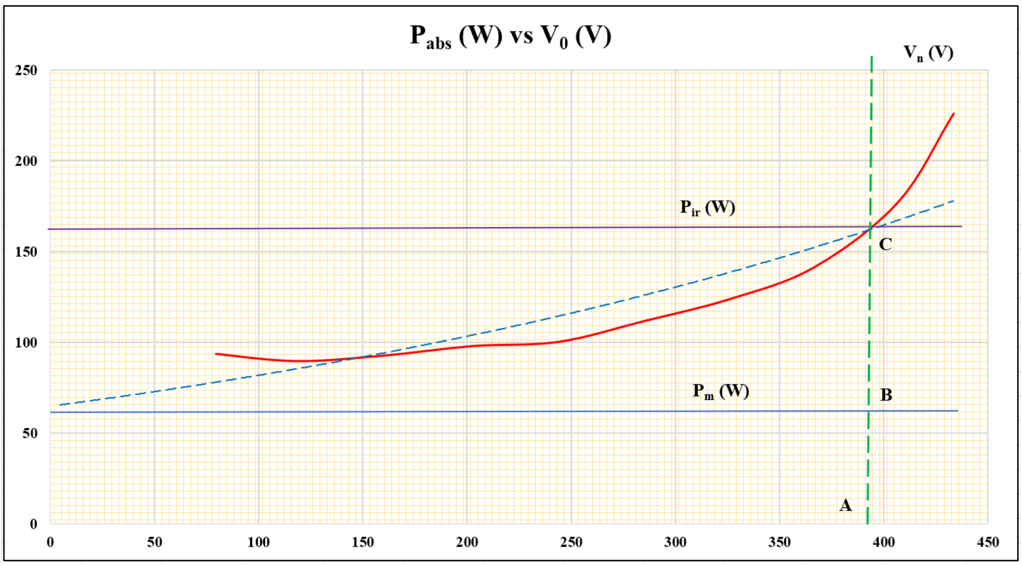

Fig. 10. STAR configuration: The experimental characteristic curve for extrapolation of the Pm + Pfe

Successful design of electrical machines hinges on a knowledge of the likely temperature rise within the machine. The ability to predict an accurate temperature distribution, in turn, requires a knowledge of the iron loss distribution, thermal characteristics of the materials, and the cooling conditions. Other methods are proposed to evaluate accurately the iron loss density distribution in the stator of an induction motor by measurement of temperature gradients in the machine [6,7].

4. CONCLUSIONS

The no-load test of the induction motor calculates the rotational (these losses are such power loss which occurs due to friction and windage) losses of motor and deliver knowledge about the magnetization current of the motor. By performing specifically tests the losses in an AC can be identified and these losses are converted into heat that raises the temperature of the machine and lowers its efficiency. Determination of the conventional efficiency can be done by indirect tests using the classical calculation method or by using a software approach.

Using an HMI, the motor was controlled and supplied up to the rated voltage and the active power was measured for different values of the input voltage.

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STUDY ON THE REDUCTION OF SO2 EMISSIONS IN COAL-FIRED POWER UNITS

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Abstract: This paper presents the harmful effects produced by SO_2 resulting from the burning of fossil fuels (coal, natural gas, fuel oil), on the environment, human health, soil, buildings and constructions, but also outlines the possiblities of reduction of SO_2 emissions by applying the technology of burning in fluidized layer.

It also summerizes the main causes that lead to the appearance of acid rains, fog formation, smog, and other harmful effects of such emmisons in the environment

Keywords: emissions, acid, technology, pollution, SO2.

1. IMPACT OF THE ENERGY SECTOR ON THE ENVIRONMENT

In Romania, the energy sector has contributed as a major factor of environmental degradation through the development of power plants on lower coal. Pollution in this sector can be caused by the process of primary energy production, transmission, conversion and consumption. The energy sector contributes to the emission into the atmosphere of significant amounts of sulphur dioxide (SO2), carbon monoxide (CO), carbon dioxide (CO2), nitrogen oxides (NOx), fine particles, as well as to the discharge of waste water [1], [2].

The reduction of the impact of the energy systems on the environment and the implementation of the norms stipulated in this field imposed by the European Union regulations, will be achieved through: rehabilitation and modernization works, greening of the slag and ash heaps, continuous monitoring of the environmental quality in the area of the major energy objectives, rehabilitation of polluted soils and their reintroduction into the agricultural circuit, reduction of pollutant emissions to refineries and minimization of losses, ecological recovery of some oil production and processing areas by reducing the risks in such operations.

The specific measures to be adopted for the protection of the environment are as follows:

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- making investments in the area of environmental protection;
- compliance of thermal power plants with the conditions imposed by Directive 2001/80/EC on the limitation of emissions into the air of certain pollutants (SO2, NOx and dust) from large combustion plants, Directive 96/61/EC on integrated pollution prevention and control and Directive 99/31/EC on the landfilling of industrial waste;
- stepping up the use of the flexible mechanisms provided for in the Kyoto Protocol and directive 2003/87/EC on co2 emissions trading.

The energy sector, on the entire production - transport - distribution - consumption chain, produces approximately 90% of the polluting emissions in Romania. The main pollutants resulting from the combustion of fossil fuels with an impact on the air are dusts (ashes, coal particles, slag, earth, soot, etc.); sulphur oxides (SO2 and SO3); nitrogen oxides (NO and NO2); carbon oxides; tars; hydrocarbon; organic acids, etc.

2. EFFECTS OF POLLUTION BY SULPHUR OXIDES

Sulfur oxides have harmful action on the human body, on overall biological environemnt as well as on metal and stone constructions.

The most significant damage caused by SO_2 to plants happens during the day, when the photosynthetic activity is maximum, the phytotoxic action of SO_2 consisting in the destruction of chlorophyll [4], [7].

Sulphur dioxide (SO_2), produced mainly by coal combustion (but also present as result of other proccesses, for example in diesel engine emissions), combines with water in the atmosphere and causes acid rains that destroy vegetation and affect buildings.

Sulfur oxides have a direct action on plants, contributing to the modification of water and soil. Sulfur oxides, together with nitrogen oxides, are considered the main causes of acid rains, rains that can cause destruction of forests over large areas.

The harmful effect of sulphur dioxide on the vegetation is greatly amplified by its synergism with nitrogen dioxide (NO_2).

Depending on the concentration and the period of exposure sulfur dioxide has various effects on human health. Exposure to a high concentration of sulfur dioxide over a short period of time can cause severe respiratory difficulties. Especially it affects people with asthma, children, elderly and people with chronic respiratory diseases [1].

Fig.1. Effects of SO_2 on vegetables

Sulfur dioxide visibly affects many plant species (figure 1), the negative effect on their structure and tissues is discernible by naked eye.

Some of the most sensitive plants are pine, vegetables, red and black acorns, white ash, alfalfa, blackberries.

In the atmosphere, it contributes to the acidification of precipitations, with toxic effects on vegetation and soil (figure 2). The increase in the concentration of sulfur dioxide accelerates the corrosion of metals, due to the formation of acids. Sulfur oxides can erode stone, masonry, paints, fibers, paper, leather and electrical componentsc [2].

Fig.2. Effects produced by SO_2

The pollution affects soil by changing the pH, the degree of saturation of the bases and the humus content (figure 3). Sulphur dioxide SO_2 and Sulphur trioxide SO_3, in addition to other harmful effects, they contribute to excessive acidification of the soil, slow dehydration and carbonization of dead organic substances and reducing the nutritional resources of microorganisms in the soil.

Fig.3. Soil affected by SO_2

By accumulating pollutants in the soil, acidification of the trophic complex occurs, weakening of the microbial activity, reduction of the supply of mineral substances, decomposition into primary elements by disappearance of clay as binding factor, the latter effect being also amplified after strong rains.

In the cultivated plants, lead, zinc, cadmium, copper, iron, etc., can appear either by root absorption or transferred through the leaves [3].

3. SOME CONSIDERATIONS ABOUT BURNING COAL IN A FLUIDIZED LAYER

A fluidized layer is a biphasic system in which a gas, evenly distributed using a distribution grill (grate or insufflation nozzles) is expelled from the bottom up, through a mass (bed) of solid particles, so that they float in the gas current and are in a permanent agitation (figure 4). The components are: 1 - air chamber, 2 - grate 3 - heat exchanger, 4 - primary air, 5 - coal flow, 6 - limestone dust, 7 - starting burner, 8 - fluidized layer, 9 - ash cooler, 10 - secondary air, 11 - screen pipes, 12 - flue gas exhaust channel, 13 - ash discharge.

The behavior of this biphasic medium, in which solid particles can move relative to each other, is similar to that of a boiling liquid, hence the name is sometimes known as kettle layer.

Inside the fluidized layer, which reaches the height of (3-4) m, the coal particles are kept in a chaotic movement, collide with each other, as well as with the walls of the pipes of the heat exchanger or of the firebox. As a result of these collisions, the ash layer formed after burning at the surface of the particles is shaken, thus facilitating the access of oxygen to the reaction surface, which greatly assists with the increase of the burning speed of the particles, as well as the increase of the convection coefficient of the gases to the walls of the heat exchanger pipes [5], [6].

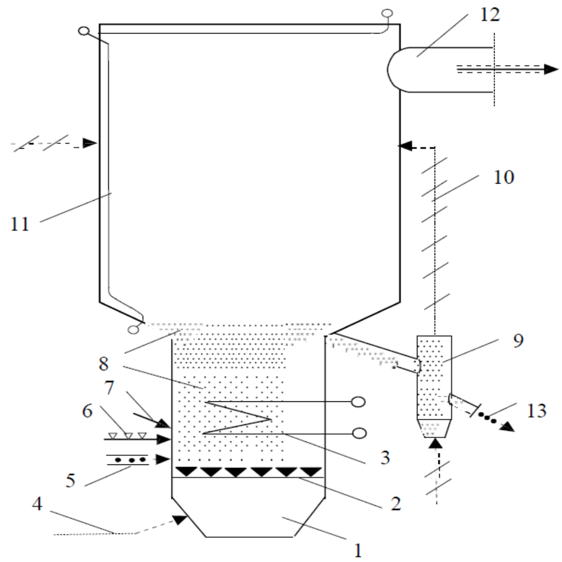

Fig. 4. The scheme of an outbreak with a stationary fluidized layer

In principle, the process consists of burning the particles of activated charcoal, in an oxidizing current, distinguishing two limit situations, determined by the value of the air insufflation rate:

- burning in stationary or dense fluidized layer (BSF);
- burning in circulating fluidized layer (BCF).

There is also a process of desulphurization of flue gases, carried out in two stages. At the first stage, calcium carbonate calcination occurs (1):

$$CaCO_3 \rightarrow CaO + CO_2 - 183kJ/mol \quad (1)$$

And in the second stage, the sulphation of calcium oxide takes place based on the following two reactions (2), (3):

$$2SO_2 + O_2 \rightarrow 2SO_3 \quad (2)$$

$$CaO + SO_3 \rightarrow CaSO_4 \quad (3)$$

These reactions may also be presented in the form of:

$$2CaO + 2SO_2 + O_2 \rightarrow 2CaSO_4 + 486\ kJ/mol \quad (4)$$

The reaction (4) of sulphation of calcium oxide is exothermic. Industrial practice has shown that by dosing limestone in the ratio Ca/S = 2.5 ÷ 3.5, the problem of simultaneous desulphurization of the flue gases was partially solved, the degree of desulphurization reached being about 50% in the best case [3].

The temperature control in the fluidized layer can no longer be ensured only by providing an immersed gas-water heat exchanger, but it is necessary to resort to a substoichiometric combustion, simultaneously with gray recirculation. This leds to the emergence of solid fuels combustion plants in circulating fluidized layer (Figure 5.).

4. SCHEME OF A FIREBOX WITH A CIRCULATING FLUIDIZED BED

The diagram of a hearth with circulating fluidized bed shown in figure 5 contains the following elements: 1 – air chamber, 2 – grill, 3 – primary air, 4 – coal, 5 – calcium carbonate, 6 – starting burner, 7 – heat exchanger heat, 8 - screen pipes, 9 - cyclone, 10 - flue gas exhaust channel, 11 and 13 - channel for ash return to the hearth, 12 - regulating valve, 14 - external heat exchanger for ash cooling, 15 – ash grate, 16 – secondary air, 17 – ash discharge channel, 18 – secondary air.

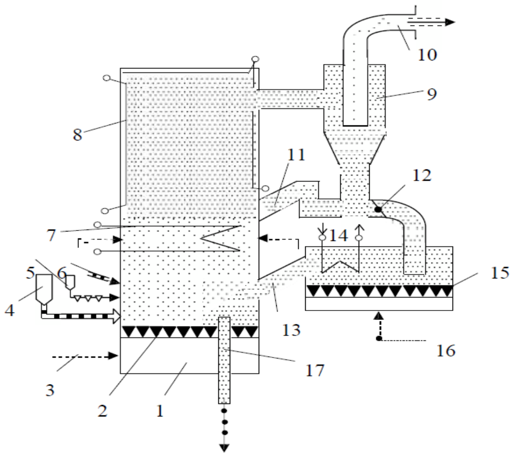

Fig.5. Scheme of an outbreak with circulating fluidized layer

a. The possibility of using various qualities of coal, from the inferior to the superior, of coal mixtures or even of household or other waste. Ignition and combustion stability is high, and unburnt losses do not exceed (1 ÷ 2) %. Coal burning is self-thermal, i.e. without hydrocarbon support, for lignites with Hi > 5000 kJ/kg, even at partial loads.

b. The polluting emissions are minimal, due to the possibility of advanced desulphurization (up to about 80 ÷ 85%) of the flue gases with the help of absorbent substances ($CaCO_3$, CaO, $CaCO_3$ MgCO3) and the blocking of the thermal mechanism for the production of nitrogen oxides as a result of the relatively low temperature in the focus (below 900^0C);

c. The preparation of coal is summary and is done by simply crushing it.

The dimensions of the coal granules (φ = 0 ÷ 20mm) for the BCF are much larger than in the case of the BSF for which the φ = (0 ÷ 7) mm, or in the case of sprayed combustion when φ 0.1 mm. Therefore, an important energy saving is made when grinding coal, but also decreases the investment and operating expenses related to the non-existence of coal mills.

The flue gases, cleaned of dust, are relaxed in the gas turbine, after which they are cooled in the economizer, preheating the boiler water supply. To comply with the rules on the maximum concentration of dust at emission into the atmosphere, before being discharged onto the stack, the gases are again dedusted, either by using an electrostatic precipitator or by running them through filter bags made of textile materials [6].

5. CONCLUSIONS

The main component of fog is the substance formed by sulfur particles, along with varous quantities of nitrogen-containing substances, which in some areas may equal the amount of sulfur. Other components include graphite in the form of fine ash or organic aerosols.

The main reactants in a process of photochemical smog formation are nitrogen oxide and unburned hydrocarbons, which are emitted into the air as pollutants, from internal combustion engines and from other sources.

Land, vegetation and stretces of water are the surfaces on which the acid deposits accumulate. Acid rain is a form of pollution of both water and air. Acids in the air, produced by power plants and other sources, fall on earth in various surface areas.

The main effect of air pollutants on metals is surface corrosion, which leads to material loss on the surface and alteration of the electrical qualities of metals.

The effects of pollutants on humans are an important problem, because after several seriousincidents, air pollution can have a significant effect on health, especially on children, the elderly or sick people.

Sulfur dioxide visibly affects many plant species, the negative effect on their structure and tissues being noticeable by naked eye. In humans and animals, even in lower concentrations, it causes irritation of the respiratory system, and, in higher concentrations it causes bronchial spasm. Also, sulfur dioxide causes disorders of carbohydrate metabolism and enzymatic processes.

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MODELING AND SIMULATION OF LIGHTING OF A ROAD WITH 2 STRIPS PER DIRECTION TO EN 13201: 2015 STANDARD

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Abstract: When providing solutions for lighting of streets, the parameters must comply with some predefined standards. One of these standards is the standard for EN 13201:2015. Performance requirements - This part of this European Standard that defines performance requirements which are specified as lighting classes for road lighting aiming at the visual needs of road users, and it considers environmental aspects of road lighting.

Keywords: lighting, street, photometric distribution, poles, simulation.

1. INTRODUCTION

In the case of outdoor lighting, there are no side surfaces that limit the analyzed space and therefore the calculation can be performed by the point-by-point method, starting from the photometric curves of the lighting sources used [2], [4], [11], [15].

The lighting system must be sized separately for the roadway and the sidewalk.

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It is necessary to know the data on the density of vehicles, the type of road cover, the width, both for the road and for the sidewalk, the type of sources used, clamping height, etc. [1], [5], [9].

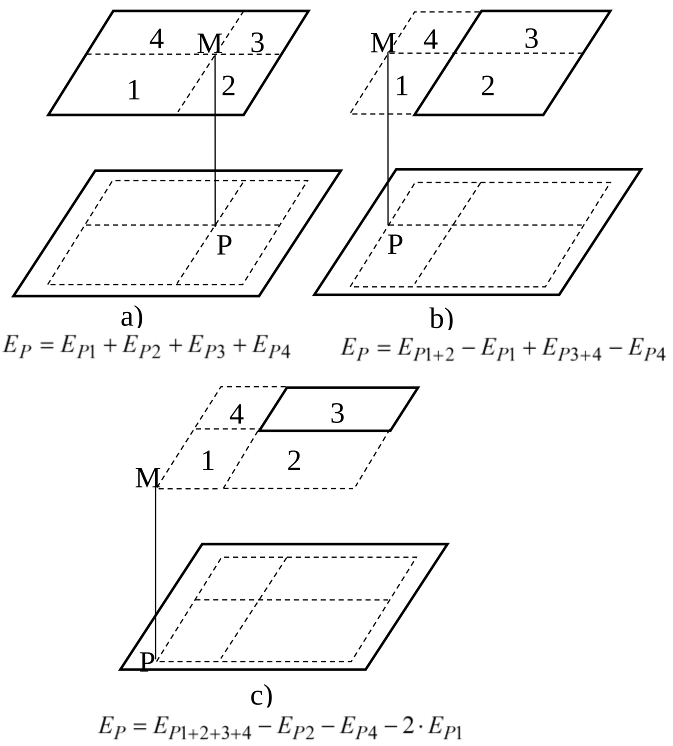

Fig.1. Calculation of rectangular lighting sources.

Narrow streets are lit with light sources placed on one side (Fig. 2) or in the middle of the street. For wider streets, lighting is usually used on both sides (2a and 2b). The dimensioning of the lighting installation for sidewalks is done based on the imposed values of the lighting level, indicated according to the circulated area and the importance of the artery. Light sources can be considered point-like and the calculation is done by the point-by-point method [3], [8], [12].

The sizing of the lighting installations on the road is made on the basis of the imposed values of the lights and taking into account the overlapping of the contributions of the different sources [2], [4], [12].

For the simple case of a light source the luminance at point P_i results from the relation:

$$L_{Pi} = p_t \cdot q_{Pi} \cdot E_{Pi} \tag{1}$$

where:

$p_t = p_l \cdot p_a$ is the holding factor of the light source (the product of the holding factor of the lamps p_l and the holding factor of the luminaire p_a),

q_{Pi} – luminance coefficient (known size, depending on source type and angles) α and β),

E_{Pi} – lighting level in point P_i .

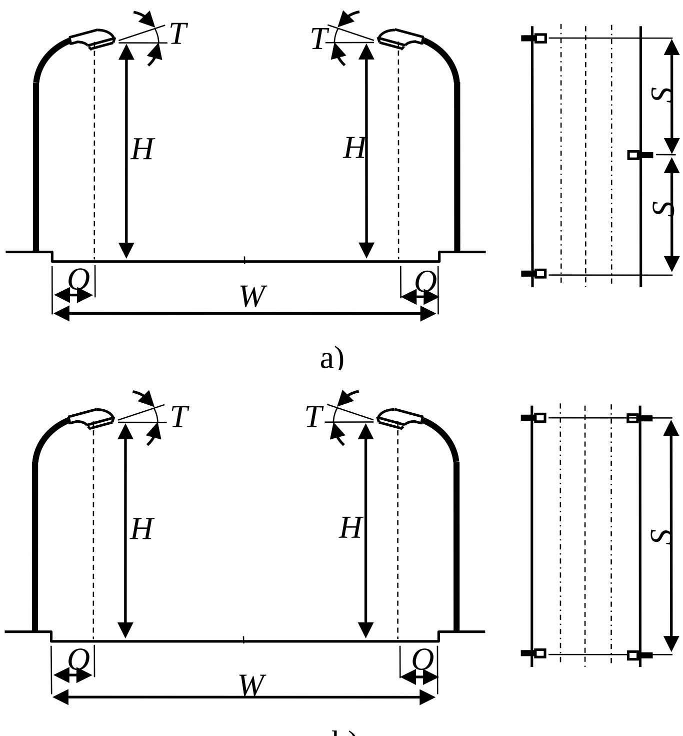

Fig.2. Bilateral street lighting:
a) alternate arrangement; b) face-to-face arrangement.

Equation (1) can also be written in the form:

$$L_{Pi} = p_t \cdot q_{Pi} \cdot \frac{I_{c\gamma} \cdot \cos^3 \gamma}{H^2} \quad (2)$$

The light intensity $I_{c\gamma}$ of the light source, in the direction is known from the photometric curve indicated by the luminaire manufacturer for the standard 1000 lm source [6], [16].

$$I_{c\gamma} = \left(I_{c\gamma}\right)_{1000} \cdot \frac{\phi}{1000} \quad (3)$$

where ϕ is the luminous flux of the source used, and $(I_{c\gamma})_{1000}$ is read from the curve indicated by the manufacturer.

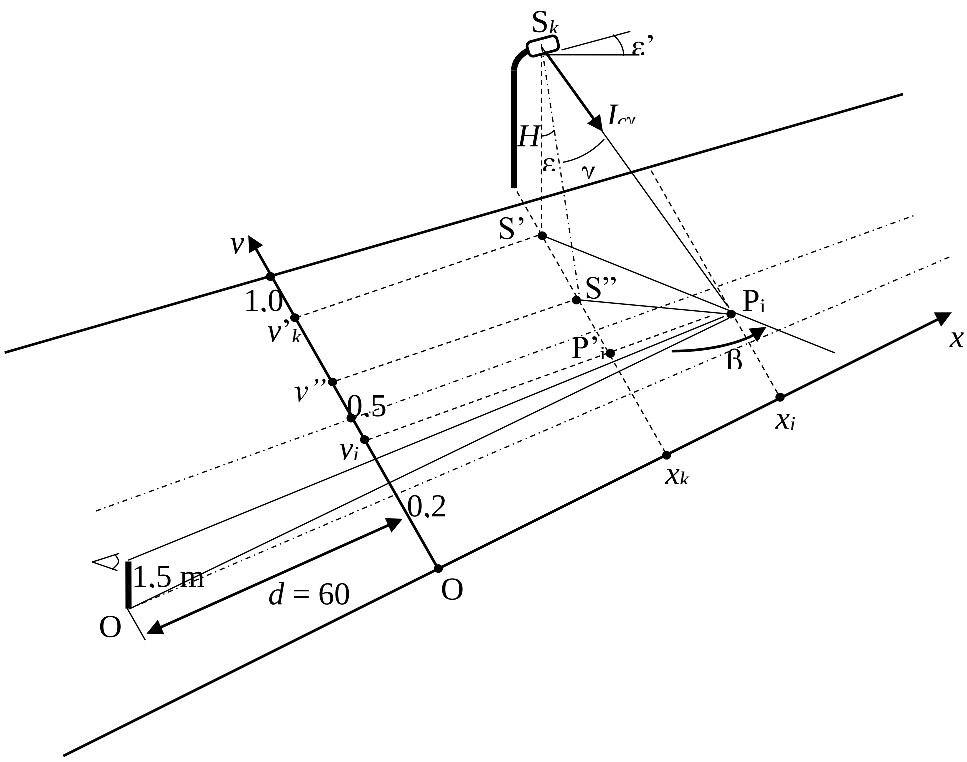

Fig.3. Calculation of outdoor lighting installations

In the general case, where there are multiple light sources, the total light $(L_{Pi})_{\text{total}}$ it results by summing up the contributions of the *n* light sources:

$$(L_{Pi})_{\text{total}} = p_t \cdot \sum_{k=1}^{n} r_k \cdot I_{c\gamma k} \cdot \frac{1}{H_k^2} \tag{4}$$

In relation (4) it was considered that all sources have the same maintenance coefficient p_t and the expression of the reduced luminance factor was noted with r_k:

$$r_k = q_{Pi} \cdot \cos^3\gamma \tag{5}$$

Low luminance factor values are tabulated for each source and different angle values α, β şi γ.

The choice of light sources is made on the basis of relation (4), by an iterative calculation. The obtained solution is verified from the point of view of the longitudinal non-uniformity factor, of the transversal non-uniformity factor and of the global non-uniformity factor, for an interval between two successive pillars, on the same side [7].

2. METHODOLOGY

For the existing in site situation, was used a certain Phillips luminaire with the following technical data:

Article No.	S466 LEDXION K09129
P	218.0 W
Φ_{Lamp}	31200 lm
$\Phi_{Luminaire}$	25238 lm
η	80.89 %
Luminous efficacy	115.8 lm/W
CCT	4000 K
CRI	99

Fig.4. Nikkon luminaire technical data

The luminaire has the following photometric distribution:

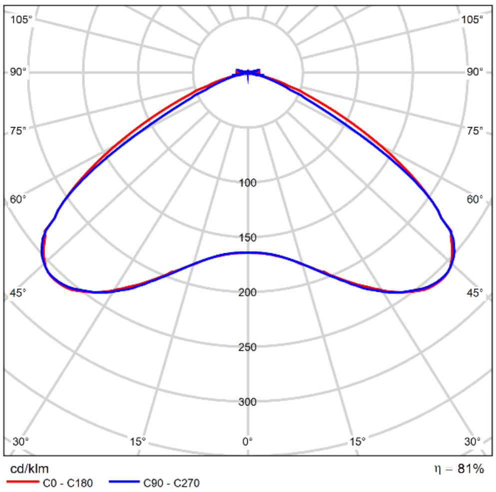

Fig.5. Nikkon luminaire photometric distribution

The image shows that the luminaire is well suited for this kind of application, street lighting requiring a special lens or LED distribution inside the luminaire body that can provide a light spread like in the picture above [13].

As shown in the figure, at an angle of around 45 degrees, the maximum intensity.

Using Dialux Evo, a simulation was made with the following settings:

Pole distance	15.000 m
(1) Light spot height	8.000 m
(2) Light point overhang	0.000 m
(3) Boom inclination	0.0°
(4) Boom length	0.600 m
Annual operating hours	4000 h: 100.0 %, 218.0 W
Consumption	29213.3 W/km
ULR / ULOR	0.00 / 0.00
Max. luminous intensities Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.	≥ 70°: 68.3 cd/klm ≥ 80°: 10.5 cd/klm ≥ 90°: 1.67 cd/klm
Luminous intensity class The luminous intensity values in [cd/klm] for calculation of the luminous intensity class refer to the luminaire luminous flux according to EN 13201:2015.	G*3
Glare index class	D.5

Fig.6. Lamp and pole setting – LED street lantern (4000K) Both sides opposite

As the data in the figure presents, the pole distance of real site is 15m with a pole height of 8m. No inclination of the luminaire was used, but the boom length (the arm of the pole) was 0.6m.

Designation for the color rendering index of a luminaire or a lamp acc. The general color rendering index R_a (or CRI) is a dimensionless figure that describes the quality of a white light source in regards to its similarity with the remission spectra of defined 8 test colors to a reference light source – usually the Sun. The higher the CRI factor, the better for the eyes [4], [10].

The light output ratio describes what percentage of the luminous flux of a free radiating lamp (or LED module) is emitted by the luminaire when installed. Unit: %

Body temperature of a thermal radiator that serves to describe its light color. The unit is Kelvin [K]. The lesser the numerical value the redder; the greater the numerical value the bluer the light color. The color temperature of gas discharge lamps and semi-conductors are termed "correlated color temperature" in contrast to the color temperature of thermal radiators [14].

Allocation of the light colors to the color temperature ranges according to EN 12464-1: Light color - color temperature [K] warm white (ww) 4000 K.

3. THE 3D SITE CREATION

Using a special set of tools in Dialux Evo, one particular part of the program allows the user to create an editable street site, having the possibility to add median space, bycicle lanes, green spaces, sidewalks, emergency lanes [17]. The setting was recreated according to the real site of an expressway with a median space between the two ways.

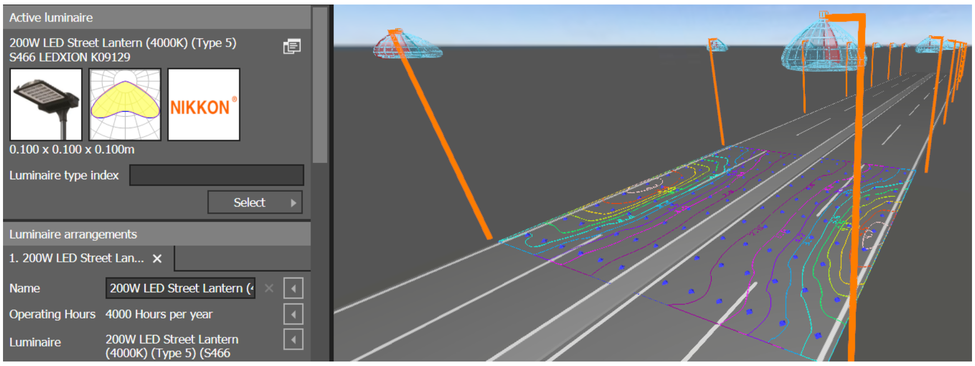

Fig.7. 3D rendering of the 4 lane street, valuation site and colour map

	Symbol	Calculated	Target	Check
Roadway 2 (M4)	L_{av}	3.31 cd/m²	≥ 0.75 cd/m²	✓
	U_o	0.78	≥ 0.40	✓
	U_l	0.77	≥ 0.60	✓
	TI	2 %	≤ 15 %	✓
	R_{EI}	0.92	≥ 0.30	✓
Roadway 1 (M4)	L_{av}	3.31 cd/m²	≥ 0.75 cd/m²	✓
	U_o	0.78	≥ 0.40	✓
	U_l	0.77	≥ 0.60	✓
	TI	0 %	≤ 15 %	✓
	R_{EI}	0.92	≥ 0.30	✓

A maintenance factor of 0.67 was used for calculating for the installation.

Fig. 8. The results for energy efficiency indicators

	Symbol	Calculated	Consumption
Street 1	D_p	0.029 W/lx*m²	-
200W LED Street Lantern (4000K) (Type 5) (both sides opposite)	D_e	8.3 kWh/m² yr,	1744.1 kWh/yr

Fig.9. Energy consumption automatic calculation

With an average annual working time of 4000 hours, the annual consumption calculated for this luminaire is averaged to 1750 kWh.

	Symbol	Calculated	Target	Check
Roadway 1 (M4)	L_{av}	3.31 cd/m²	≥ 0.75 cd/m²	✓
	U_o	0.78	≥ 0.40	✓
	U_l	0.77	≥ 0.60	✓
	TI	0 %	≤ 15 %	✓
	R_{EI}	0.92	≥ 0.30	✓

Fig.10. Results for valuation field

The illuminance is not tied to an object surface. Surface (lm/m² = lx). It can be determined anywhere in space (inside or outside). The illuminance is not a product feature because it is a recipient value. Luxometers are used for measuring illuminance.

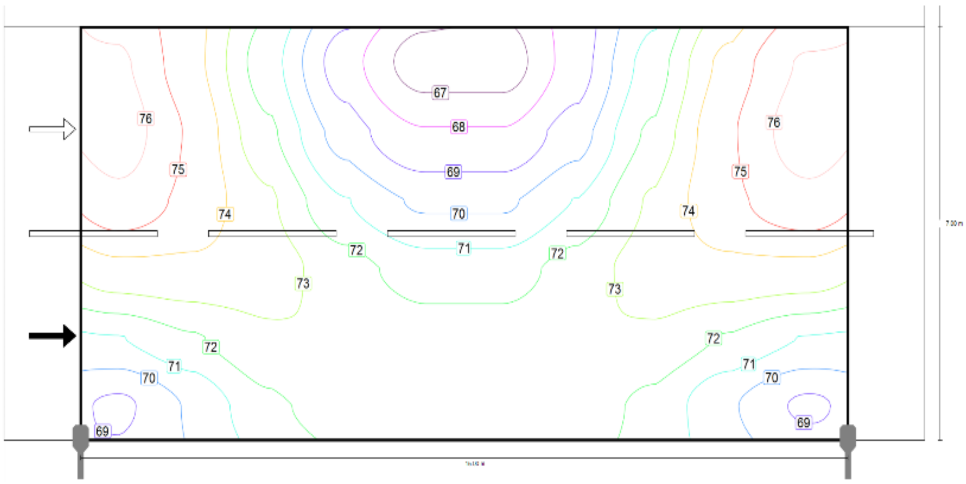

Fig.11. The light distribution of the luminaire

As seen in this color map, the illuminance at the surface of the road, has very little fluctuations, the deviation from the average being insignifiant. This is due to the fact that the light distribution of the luminaire is specifically created for this kind of applications.

4. CONCLUSIONS

To implement a luminaire swap from old sodium type to LED type is a much more easily task to simulate beforehand and draw a conclusion. AS the software has shown, all the parameters were met successfully (green checked) with this kind of LED luminaire, making it a good solution for that particular setting of the road and poles.

The design procedure of a lighting installation also requires the knowledge of the parameters involved in the described model, their tolerances and variability. The annual energy consumption indicator determines the power consumption during the year, even if the relevant lighting requirements change during the night or seasons.

These indicators may be used to compare the energy performance of different road lighting solutions and technologies for the same road lighting project. The energy performance of road lighting systems with different road geometries or different lighting requirements cannot be compared to each other directly, as the energy performance is influenced by, amongst others, the geometry of the area to be lit, as well as the lighting requirements.

This paper specifies the lighting classes set out in EN 13201 and gives guidelines on the selection of the most appropriate class for a given situation. To do this, it includes a system to define appropriate lighting classes for different outdoor public areas in terms of parameters relevant to guarantee the aims presented in introductions. The decision on whether a road should be lit is defined in the national road lighting policy. This varies by country or municipality.

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Annals of the University of Petroşani, Electrical Engineering, 24 (2022)

ECONOMETRIC ANALYSIS BETWEEN TOTAL ENERGY CONSUMPTION AND CO2 EMISSIONS IN EUROPE AND ROMANIA

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Abstract: The transition to an economy with low CO2 emissions aims at a sustainable and high-performing energy sector, both nationally and at European level, in which, through the services offered to consumers, to be seen both a reduction in the bills we pay and an increase of the quality of life. Based on these considerations, in this article analyzes the correlation between total energy consumption in Europe and Romania and CO2 emissions.

Keywords: CO2 emissions, energy consumptions, econometric analysis, least squares method (LSM).

1. INTRODUCTION

One of the most current and discussed problems facing Europe (and not only) is the energy crisis. Against the background of the war provoked by Russia against Ukraine, on the taking of some not very happy governmental decisions, regarding the closure (in some countries in Europe) of some thermal power plants (see the case of Romania), as well as by the restrictive measures taken by the European Union against Russia, all this led to an extremely difficult year 2022 from an energy point of view.

Thus, according to World Energy & Climate Statistics [5], in the context of the global pandemic, global energy consumption returned with an increase of 5% in 2021, after a decrease of 4.5% in 2020. The biggest increase of energy consumption was achieved in China, with 5.2% compared to 2020, followed by the USA and India with 4.7%. And in Europe, total energy consumption increased in 2021 by 4.5% compared to the previous year, after in 2020 it decreased by 6.8% compared to 2019.

Figure 1 shows the diagram of the total global energy consumption in the period 1990-2021. As can be seen, the Asian continent has the largest increase in total energy consumption, followed by North America and Europe.

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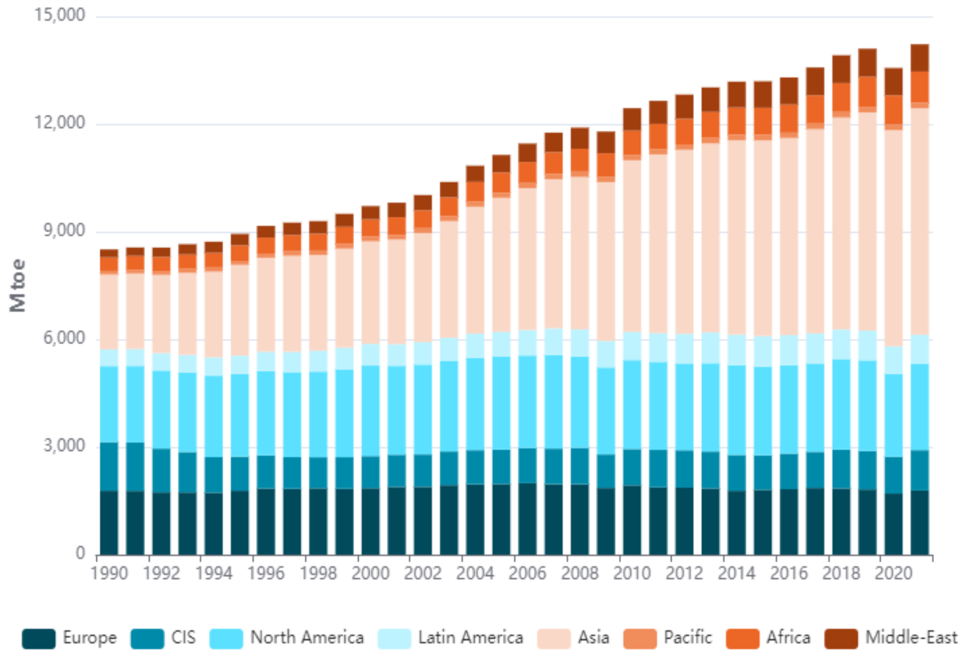

Fig. 1. Total energy consumption in world
Source: Enerdata. World Energy & Climate Statistics – Yearbook 2022 [5]

In the European Union, in order to overcome or improve the energy crisis, a series of measures have been adopted regarding the reduction of energy consumption. Thus, the "Plan of measures proposed by the EU" [6] proposes, among other things, the mandatory reduction of electricity consumption at peak hours, the regulation of the commercial margin for low-cost energy producers who make high profits, the over taxation of oil and gas companies, securing financial sources to ensure liquidity for energy companies, etc.

In Romania, total energy consumption increased in 2021 by 6.25% compared to the previous year. Regarding the measures taken by the government at the national level to reduce energy consumption [7], there are the replacement of light bulbs with LED ones, the reduction of external and internal lighting in common spaces, the disconnection of devices from the power source when they are not in use, establishing an optimal microclimate in office spaces by reducing temperatures to 21 degrees C. etc.

In this article, the total energy taken into account includes coal, gas, oil, electricity, heat and biomass.

Another stringency problem facing humanity is that of CO2 emissions from fossil fuels. Figure 2 shows the diagram of CO2 emissions worldwide, emissions from the burning of fossil fuels (coal, oil and gas).

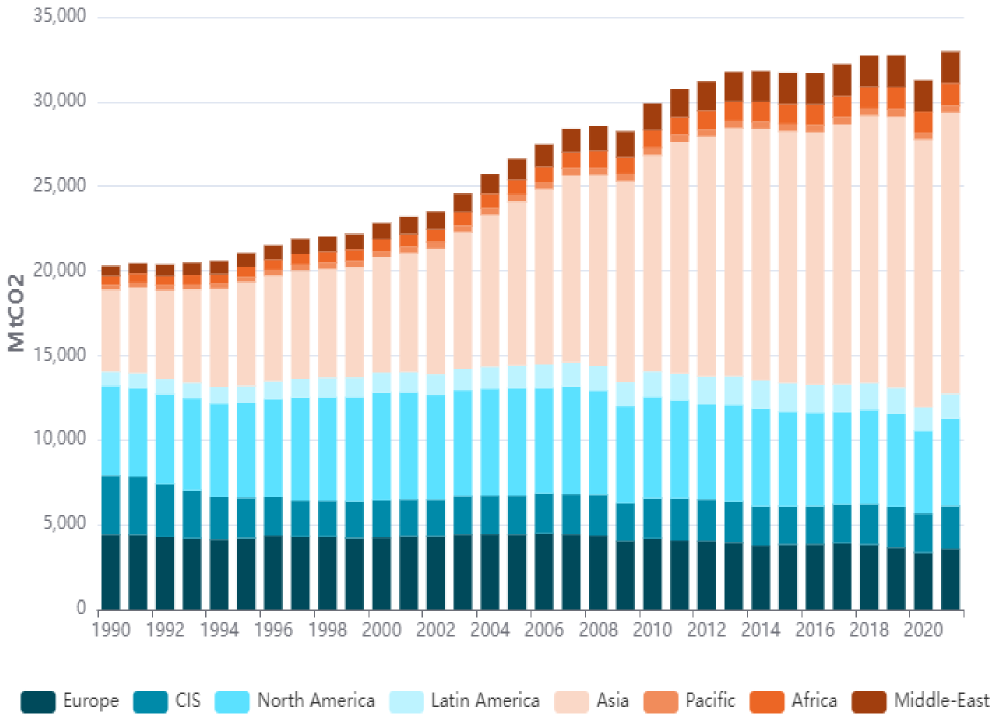

Fig. 2. CO2 emissions from fuel combustion

Source: Enerdata. World Energy & Climate Statistics – Yearbook 2022 [5]

Thus, worldwide, CO2 emissions returned by 5.4% and reached the record level of 33 GtCO2. In Europe, CO2 emissions increased by 7.1% in 2021 compared to the previous year. Against the background of the global economic recovery, in the last year under analysis, countries such as Germany, France, Italy and the Netherlands contributed to more than 70% of the increase in CO2 emissions [5].

However, according to the International Energy Agency (IEA), the EU's total CO2 emissions are expected to fall in 2022, despite the fact that emissions from burning coal will be higher. The increase in the use of coal in the EU would be only temporary and the new renewable projects that will be connected to the grid next year will increase the renewable production capacities by approximately 50 GW [8].

Unfortunately, Romania is among the EU countries with the highest increases in CO2 emissions. In Romania, CO2 emissions increased in 2021 by 4.5% compared to the previous year.

According to Eurostat [9], in 2021, Romania is among the countries whose CO2 emissions have increased more than the European average. These increases (over 50%) were caused by the increase in the use of solid fossil fuels.

Increases were also recorded in countries such as Bulgaria, Estonia, Slovakia, Poland or Spain. The only countries in which CO2 emission decreases were observed are Portugal (-5.5%) and Finland (-1.5%).

2. LITERATURE REVIEW

Being a topical subject, the specialized literature is rich, with a number of authors carrying out interesting studies on the energy sector.

Authors such as Salari et. all [2], investigates the relationship between carbon dioxide (CO2) emissions, energy consumption, and GDP in the US over the period 1997-2016. The results obtained by the authors of this study show that there is a long-term relationship, with a positive impact on CO2 emissions at the state level, of the total energy consumption, non-renewable, industrial and residential, for both static and dynamic models. On the other hand, the study shows that renewable energy consumption has a negative relationship with CO2 emissions. Based on this study, decision makers will be able to use the findings to define applicable policies to reduce CO2 emissions in the US.

Yang, et. all [1], in their paper investigates the impact of economic growth on CO2 emissions at the subsector level by employing an endogenous finite mixture model, taking renewable energy consumption as a concomitant variable and using data from 25 manufacturing subsectors in 38 countries, from 2000 to 2014.

Stoicuta O. and Stoicuta N. [3], in their paper performs the econometric analysis of the main official indicators for monitoring Romania's objectives, in accordance with Directive 2009/28/EC. In this sense, within the Eviews program, econometric models are made regarding the share of renewable energy sources in the total energy consumption used in heating/cooling; the share of energy from renewable sources in the fuel consumption used in the field of transport, as well as the share of energy from renewable sources in the final gross energy consumption.

On the other hand, Stoicuta N. and Stoicuta O., in the article [4] analyzes the evolution in time of the total electrically energy production and categories of power stations in Romania for a period of 26 years (1992-2017).

3. ECONOMETRIC ANALISYS

Starting from all the considerations above, this article analyzes the dynamics of the level of CO2 emissions according to the total energy consumption, both at European and national level, for the period 1990-2021. Also, the impact of total energy consumption on CO2 emissions from burning solid fuels is monitored. Thus, in the following table, the data series were collected for the two sizes analyzed. No changes were made to the data series, it was taken from the World Energy&Climate Statistic-Yearbook 2022 website [5].

Thus, the two econometric models to be analyzed are presented in the following:

Table 1. ***The data series of the two quantities analyzed***

Year	Total energy consumption in Europe [Mtoe]	Total energy consumption in Romania [Mtoe]	CO2 emissions in Europa [MtCO2]	CO2 emissions in Romania [MtCO2]
1990	1780	62	4418	162
1991	1777	51	4395	135
1992	1737	46	4261	124

1993	1735	46	4183	118
1994	1728	43	4138	113
1995	1781	47	4197	117
1996	1844	48	4343	121
1997	1835	45	4269	112
1998	1850	41	4275	98
1999	1833	36	4205	85
2000	1854	36	4246	87
2001	1888	37	4306	93
2002	1890	38	4302	93
2003	1938	40	4423	97
2004	1960	39	4435	96
2005	1970	39	4420	92
2006	1990	40	4469	96
2007	1964	40	4430	93
2008	1964	40	4344	92
2009	1859	35	4041	78
2010	1934	35	4175	75
2011	1875	36	4064	82
2012	1866	35	4043	79
2013	1846	32	3945	70
2014	1779	32	3776	69
2015	1808	32	3833	69
2016	1825	33	3848	68
2017	1859	33	3901	71
2018	1847	34	3820	72
2019	1817	33	3659	70
2020	1701	32	3338	66
2021	1787	34	3575	69

Dynamic Model 1. *Econometric analysis of the correlation between CO2 emissions and total energy consumption at European level*

$$CO2E\_EU_t = a_1 T + a_2 T^2 + a_3 CTE\_EU_t + a_4 CTE\_EU_t^2 + a_5 + \varepsilon_{1t} \quad (1)$$

where it was noted with:

- ✓ $\left(CO2E\_EU_t\right)_{t=\overline{1,T}}$ represents CO2 emissions at European level, measured in MtCO2 (output variable);

- ✓ $\left(CTE\_EU_t\right)_{t=\overline{1,T}}$ represents the total energy consumption at European level, measured in Mtoe (input variable);
- ✓ $t=\overline{1,T}$ the time period analyzed, between the years 1990-2021;
- ✓ T the number of terms in the series;
- ✓ ε_1 represents the residual variable.

Analyzing the two series of data and taking into account their characteristics, in the following table, various descriptive indicators specific are calculated.

Table 2. ***Descriptive indicators - Dynamic Model 1***

	Mean	Median	Std. Dev.	Skewness	Kurtosis	Sum Sq. Dev.
CTE_EU	1847.531	1846.5	76.60792	0.119405	2.294718	181932
CO2E_EU	4127.406	4201.0	284.6242	-0.950319	3.232963	2511340

Dynamic Model 2. *Econometric analysis of the correlation between CO2 emissions and total energy consumption at national level*

$$CO2E\_RO_t = b_1T + b_2CTE\_RO_t + b_3 + \varepsilon_{2t} \qquad (2)$$

where it was noted with:

- ✓ $\left(CO2E\_RO_t\right)_{t=\overline{1,T}}$ represents CO2 emissions at national level, measured in MtCO2 (output variable);
- ✓ $\left(CTE\_RO_t\right)_{t=\overline{1,T}}$ represents the total energy consumption at national level, measured in Mtoe (input variable);
- ✓ $t=\overline{1,T}$ the time period analyzed, between the years 1990-2021;
- ✓ T the number of terms in the series;
- ✓ ε_2 represents the residual variable.

And in this case, the main descriptive indicators of the two analyzed data series are calculated.

Table 3. ***Descriptive indicators - Dynamic Model 2***

	Mean	Median	Std. Dev.	Skewness	Kurtosis	Sum Sq. Dev.
CTE_RO	39.06250	37.50000	6.743874	1.420950	5.312877	1409.875
CO2E_RO	92.56250	92.00000	22.94304	1.045566	3.858429	16317.88

The graphs of the dependencies between CO2 emissions and total energy consumption, both at the European and national level, in the period 1990-2021, are represented in the following figure (graphs made in Eviews1.11).

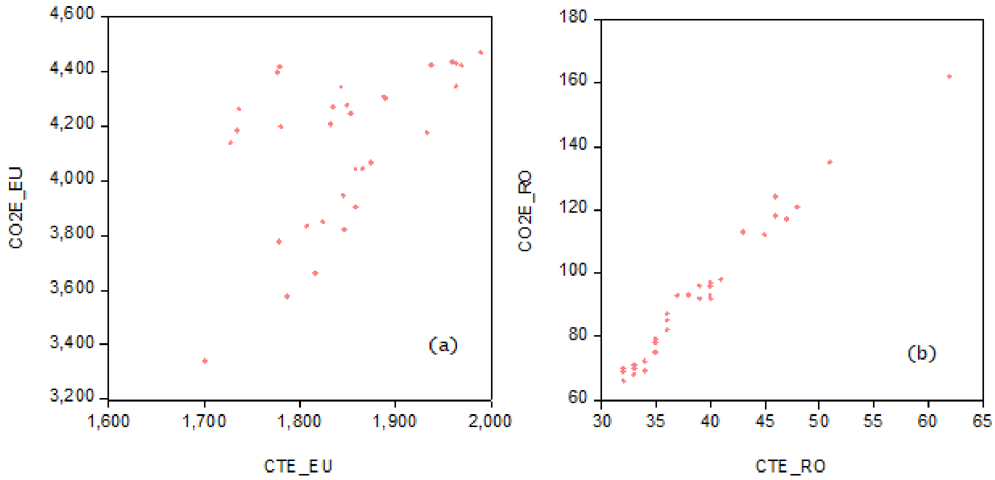

Fig. 3. Graph of the dependence between CO2 emissions and total energy consumption (a) Europe; (b) Romania

As can be seen, the first dynamic model has a non-linear trend, the data cloud being quite scattered, and the second dynamic model is one with a linear trend. Following the distribution of the points in the plane, the expressions of the two mathematical models approximating the analyzed data series are represented in relations (1) and (2).

Taking into account the above, in the next paragraph we will do the econometric analysis of the two models, starting from the results obtained in Eviews 11.1. I mentioned that the two models are obtained following the distribution of points in the plane.

Also, the results obtained for these two dynamic models give the best results, this conclusion being obtained by comparison with other models, but which were not introduced in the article.

4. RESULTS AND DISCUTION

In this paragraph, we will analyze from an econometric point of view the two models defined in relations (1), respectively (2). Thus, the parameters $a_1, a_2, ..., a_5, b_1, b_2, b_3$ of the two models are determined using the least squares method, their values being found in Table 4 for the first model, respectively in Table 5 for the second model.

Within these tables, the values of the main statistical indicators are also calculated, based on which the hypotheses specific to the econometric models will be analyzed in what follows.

Table 4. ***Estimation of parameters of Dynamic Model 1***

Dependent Variable: CO2E_EU		
Method: Least Squares (Gauss-Newton / Marquardt steps)		
Date: 11/25/22 Time: 13:50		
Sample: 1990 2021		

Included observations: 32				
CO2E_EU=a1*T+a2*T^2+a3+a4*CTE_EU+a5*(CTE_EU)^2				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
a_1	-1026.489	623.4858	-1.646371	0.1113
a_2	0.249449	0.155404	1.605164	0.1201
a_3	1054947.	624575.1	1.689063	0.1027
a_4	2.258844	4.049475	0.557811	0.5816
a_5	9.31E-05	0.001087	0.085670	0.9324
R-squared	0.983767	Mean dependent var		4127.406
Adjusted R-squared	0.981362	S.D. dependent var		284.6242
S.E. of regression	38.85710	Akaike info criterion		10.30026
Sum squared resid	40766.61	Schwarz criterion		10.52928
Log likelihood	-159.8042	Hannan-Quinn criter.		10.37617
F-statistic	409.0693	Durbin-Watson stat		1.682839
Prob(F-statistic)	0.000000			

If we following the values of the parameters $a_1, a_2, ..., a_5$ in the table above, it can be observed that the linear trend of CO2 emissions for the analyzed period determined the decrease in the level of these emissions, and the total energy consumption at the European level, has a positive influence on the dynamics of CO2 emissions.

On the other hand, if we following the values of the statistical indicators in Table 4, the following results are obtained:

- ✓ The high values of the coefficient of determination R^2 (R-squared), respectively of the adjusted demining coefficient Adjusted R-squared (close to 1) show the fact that the dynamic model 1 approximates very well the data series of the two analyzed variables;
- ✓ To verify the hypothesis of autocorrelation of the errors, the calculated value of the Durbin-Watson statistic is compared with the table values of the same statistic. In this case, for a significance threshold of 5% and for a number of 32 observations, the values from the table of the Durbin-Watson statistics are $d_1 = 1.37$ and $d_2 = 1.5$. Since the double inequality condition $d_2 < DW < 4 - d_1$ is satisfied, that is, we can conclude that the series of residuals is independent, that is, the residuals are not correlated with each other;
- ✓ To verify the hypothesis of the homoscedasticity, following the application of the White test, a calculated value of the Fisher statistic $F_{calc} = 1.67$ is obtained. This value is compared with the tabulated value $F_{0.05;1;30} = 4.171$ of the same statistic for a significance threshold of 5%. As the inequality $F_{calc} < F_{0,05;1;30}$ we can say that this hypothesis is verified;
- ✓ Regarding the performance of this model, the three indicators based on information theory were calculated. Thus, the three criteria Akaike, Schwartz

and Hannan-Quinn have sufficiently small values so that we can say that the analyzed model is a good one;

- ✓ Also, to test the validity and quality of this model, the analysis of variance is applied. The calculated value of the F statistic (found in Table 4) is greater than the tabular value of the F statistic, i.e. $F_{calculat} = 409.0693 > F_{0,05;1;30} = 4.171$. Therefore we can say that the analyzed model is correctly specified;
- ✓ Another observation is that the high value of the F statistic shows that the dynamics of CO2 emissions is well appreciated by the level of energy consumption.

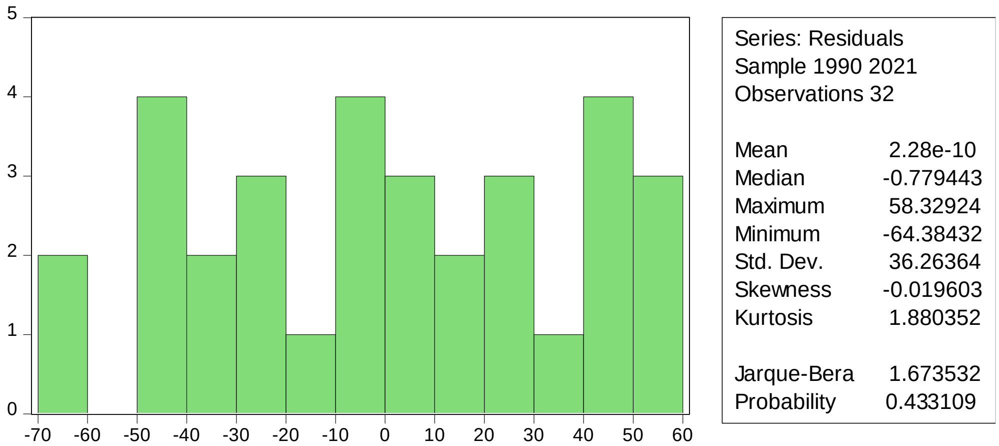

Fig. 4. The normality test from the Dynamic Model 1

In Figure 4 are represented the values of the coefficient of asymmetry (skewness) and flattening (kurtosis) and the Jarque-Bera indicator value $JB = 1.67$. Comparing the value of this statistic, with the value of the statistics $\chi^2_{2;0,05} = 5.991$, for 32 observations and a significance level of 5%, is observed that this hypothesis $JB < \chi^2_{2;0,05}$, of the normalization of residues is satisfied.

The calculated value of this test is compared to the tabulated value of the statistic $\chi^2_{2,\alpha}$, for a significance threshold of $\alpha = 5\%$, namely $\chi^2_{2;0,05} = 12,338$. If $JB = 0,078 < \chi^2_{2;0,05} = 12,338$ then the residue normalization hypothesis is accepted.

As far as Romania is concerned, based on the dynamic model 2 represented in relation (2) and the values of the characteristics and statistical indicators calculated in Table 5, we can make almost the same observations as those obtained in the case of the first Model.

In other words, we can say that model 2 checks the assumption of autocorrelation of the residuals. Also, the hypothesis of homoscedasticity is verified, knowing that the calculated value of the F statistic, obtained after applying the White test, is $F_{calc} = 2.63$.

Regarding the performance of this model, one can observe the very low values (close to zero) of the three indicators Akaike, Schwartz and Hannan-Quinn.

Table 5. ***Estimation of parameters of Dynamic Model 2***

Dependent Variable: CO2E_RO				
Method: Least Squares (Gauss-Newton / Marquardt steps)				
Date: 11/25/22 Time: 13:40				
Sample: 1990 2021				
Included observations: 32				
$CO2E\_RO=b_1*T+b_2*CTE\_RO+b_3$				
	Coefficient	Std. Error	t-Statistic	Prob.
b_1	-0.612673	0.077469	-7.908664	0.0000
b_2	2.638781	0.107760	24.48758	0.0000
b_3	1218.201	158.9236	7.665323	0.0000
R-squared	0.991525	Mean dependent var		92.56250
Adjusted R-squared	0.990940	S.D. dependent var		22.94304
S.E. of regression	2.183785	Akaike info criterion		4.489056
Sum squared resid	138.2986	Schwarz criterion		4.626469
Log likelihood	-68.82490	Hannan-Quinn criter.		4.534605
F-statistic	1696.358	Durbin-Watson stat		1.571405
Prob(F-statistic)	0.000000			

In other words, analyzing the values of the parameters in Table 5, it is observed that the linear trend of CO2 emissions at the national level, for the analyzed period, determined a decrease in the level of these emissions. And as far as Romania is concerned, total energy consumption has a positive influence on the dynamics of CO2 emissions.

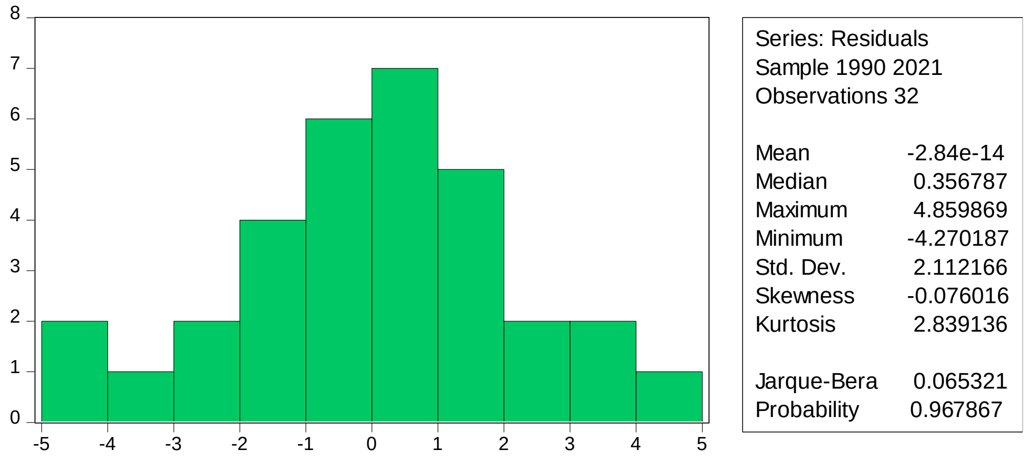

Fig. 5. The normality test from the Dynamic Model 2

In Figure 5 are represented the values of the coefficient of asymmetry (skewness) and flattening (kurtosis) and the Jarque-Bera indicator value $JB = 0.06$. Comparing the value of this statistic, with the value of the statistics $\chi^2_{2;0,05} = 5.991$, for

32 observations and a significance level of 5%, is observed that this hypothesis $JB < \chi^2_{2;0,05}$, of the normalization of residues is satisfied.

The actual and adjusted values, are also, plotted in tandem with the residual values. The graphs are made in the Eviews 11.1 software package.

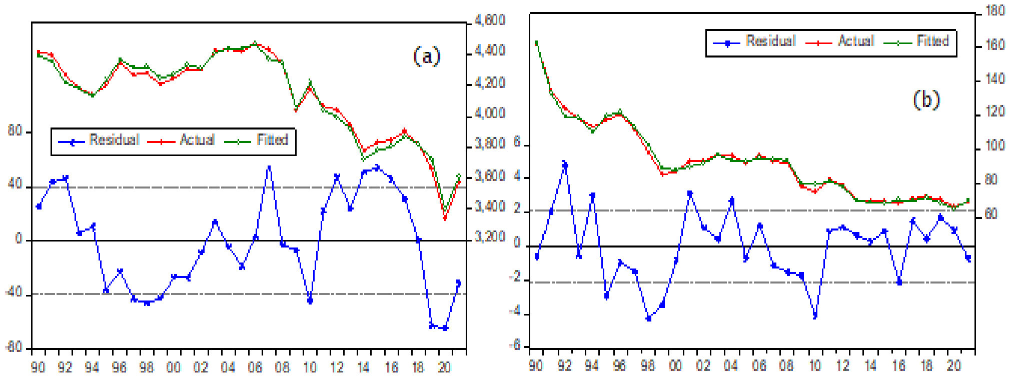

Fig. 6. Graph of the dependence between CO2 emissions and total energy consumption (a) Europe; (b) Romania

As can be seen, in both figures, the graphs of the values approximated by the two models are very close to the graphs of the real values of the two variables analyzed both at the national and at the European level.

5. CONCLUSIONS

Following the analysis of the two models applied in this work, it can be concluded that the linear trend of CO2 emissions both at the national and European level, for the analyzed period, determined decreases in the level of CO2 emissions. On the other hand, the total energy consumption, in both analyzed cases, has a positive influence on the dynamics of CO2 emissions.

Starting from these conclusions, strategic objectives can be formulated, both at national and European level in the field of the climate change and the energy, through the policies and measures applied to different sectors. In order to reduce CO2 emissions, both the EU and other European states have set ambitious objectives that aim to reduce these CO2 emissions by up to 55% by 2030.

Romania's target is to reduce these emissions by 12.7% until 2030 [10]. However, taking into account the current economic and social situation, these objectives are difficult to achieve, especially for Romania, which is on the vicinity of war of theUkraina.

On the other hand, the current energy crisis deepens even more the achievement of these objectives.

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CONSIDERATIONS ON METHODS TO INCREASE THE EFFICIENCY OF PHOTOVOLTAIC PANELS

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Abstract: A great advantage of using solar energy, compared to other forms of energy, is that it can be produced without affecting the environment through pollution. Another advantage of using solar energy is the fact that it is free, autonomous, inexhaustible, ecological (non-polluting), the installation does not require any kind of maintenance and is not influenced by price increases. This paper deals with the issue of increasing the efficiency of photovoltaic panels in generation of electricity. As a result of our documentation and research, we present a comparative overview of the maximum power point track methods, proposing the use of artificial intelligence, especially artificial neural networks.

Keywords: photovoltaic cell, MPP, solar cell model.

1. INTRODUCTION

Photovoltaic panels use a free and infinite source of energy, that is the energy from the sun. When the sun's rays reach the earth's surface, they contain approximately 2,000 times more energy than the total energy consumed on the globe in one year [1].

Recent statistics show that electricity generated from renewable energy sources covered over a quarter (28.8%) of the gross electricity consumption in the European Union, over half of the electricity used in Portugal (52.6%), Lithuania (52.2 %) and Denmark (51.3 %) coming from renewable energy sources. Estonia, Belgium and Poland recorded the fastest increases in the share of electricity generated from renewable energy sources.

The increase in the amount of electricity generated on the basis of solar energy came to exceed geothermal energy in 2008, and from only 1.5 TWh in 2005, it reached a level of 107.9 TWh in 2021. Over this period, the percentage represented by solar energy from the total renewable energy generated in the EU-27 increased from 0.3% to 18.2% [11].

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2. MODELLING THE OPERATION OF PHOTOVOLTAIC CELLS

The most used models for the operation of photovoltaic cells are those with single and double diodes. The described circuit of a simple diode takes into account the phenomena involved in the real operation of the photovoltaic (PV) cell. The current source connected in parallel with a semiconductor diode models an ideal cell, to which are added the two electrical resistances that model the current and voltage losses (Fig. 1).

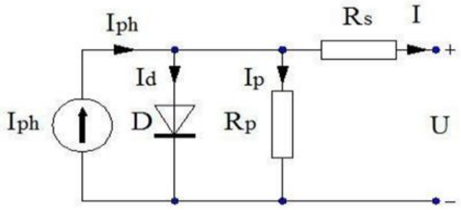

Fig.1. Simple diode model of a PV cell

The current produced by the source I_{ph} depends on the intensity of the solar radiation, the absorption coefficient of the wavelength of the solar radiation and the characteristic of diffusion and recombination of electrons in the material. Part of this current passes through the diode, a fact that models the phenomenon of recombination of charge carriers inside the solar cell. The small resistance of the edges of the solar cell leads to a new current loss highlighted by the existence of a parallel resistance R_p in the circuit, generally having a high value [10].

The double diode model takes into account the variation of the ideal coefficient of the semiconductor diode. At high voltage values, the recombination phenomenon of the charge carriers takes place mainly in the surface regions and in the doping regions, with an ideal coefficient close to the unit value. At low voltage values, recombination takes place mainly in the region of the junction, and the ideal coefficient approaches the value of two. Recombination in the junction area is modelled by adding a diode in parallel with the first one (Fig. 2).

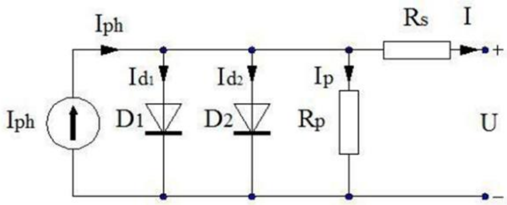

Fig.2. Double diode model of a PV cell

The electrical power provided by a photovoltaic cell is not sufficient for most domestic or industrial applications, so the photovoltaic cells are connected in series to increase the voltage value at the terminals and a panel (module) is made. The modules are connected either in series to increase the voltage even more, or in parallel to increase the current through the circuit and form the photovoltaic fields.

In the case of the series connection of photovoltaic cells, according to Kirchhoff's first theorem, the current drawn by each PV cell is the same, also equal to that at the terminals of the group. According to Kirchhoff's second theorem, the voltage at the terminals of the group is equal to the sum of the voltages at the terminals of each individual cell. Thus, the resulting I-U characteristic is obtained by arbitrarily choosing a value of the current and the sum of the voltages on the cells.

The voltage generated by a PV cell - approx. 0.5 V - is not sufficient for usual applications and several identical photovoltaic cells are connected in series or in parallel to obtain higher voltages. In certain applications mixed connections (series - parallel) of PV cells are used. Typically, PV generators are formed by the mixed interconnection of several PV modules. A PV module is formed by connecting a corresponding number of identical PV cells in series. For example, the BP 585 module of the British Petroleum company consists of a series connection of 36 PV cells, while the M220 module of the Solarwat company consists of 60 cells in series. Low-power PV generators are made by series interconnection of several PV modules, a configuration called a string of PV modules. Higher power PV generators are made up of several strings connected in parallel. For a mixed grouping of PV cells or modules, the names of area, array or photovoltaic matrix (by translating the English term array), or PV generator are also used.

If PV cells, constructively identical, are illuminated differently, such as the situation where one of the cells is shaded, or dirty, the short-circuit currents of the cells are different, so the currents at the terminals of each cell are different. The series connection, however, imposes the same current at the terminals of each cell, so part of the higher short-circuit current (that of the more illuminated cell) will close through the parallel diode, ensuring equality between the current at its terminals and that at the terminals of the shaded cell. The current of the series group will be imposed by the cell that has the lowest short-circuit current (the shaded cell), which limits the current of the entire group and implicitly the power generated by it [2].

For low terminal voltages (below 0.54 V), the power delivered by the shaded cell is negative, that is, with the on-state values adopted for U and I, it is actually absorbed. On the other hand, the total power is positive. Therefore, in this voltage range, the shaded cell consumes power from the brighter cell. Not only that it does not produce energy, the shaded cell also consumes part of the energy produced by the other cells.

For low values of the voltage at the terminals of the series group - in particular in short-circuit mode - the shaded cell consumes energy from the other cells. This energy is dissipated in the form of heat leading to the overheating of the shaded cell, i.e., to the appearance of a hot spot of the group. If the group contains many cells, the energy that must be dissipated is high, and overheating of the shaded cell can lead to its destruction and putting the module out of operation.

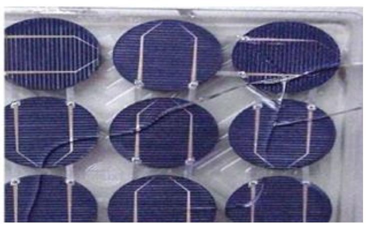
Fig.3. Bypass diode

To avoid overheating the shaded cell, a diode is connected in parallel with each cell, called a bypass diode (Fig. 3), which in normal mode is reverse polarized and does not intervene in the operation of the cell. The voltage that reversed biases the shaded cell, directly biases the bypass diode connected to it. In this way, the group current, which would otherwise have been strangled by the shaded cell, bypasses it through the bypass diode, which also limits the voltage on the shaded diode and implicitly the power dissipated by it.

It is not economical to connect a bypass diode in parallel with each cell of the module. A compromise solution is the connection of a bypass diode in parallel with a group of cells, usually consisting of half of the cells of the module. If one of the cells in a group becomes non-functional, the bypass diode connected in parallel with that group becomes directly biased thus supporting the failed cell.

In the case of parallel connection (Fig. 4), all cells have the same terminal voltage, and the group current is the sum of the currents at the terminals of each individual cell. Shading or failure of one of the grouping cells does not disable the grouping, as it happens in the case of the serial connection. No additional protective measures are therefore required. A point of the I-U characteristic of the group is obtained by arbitrarily choosing a value for the terminal voltage and then summing the corresponding currents of the individual cells.

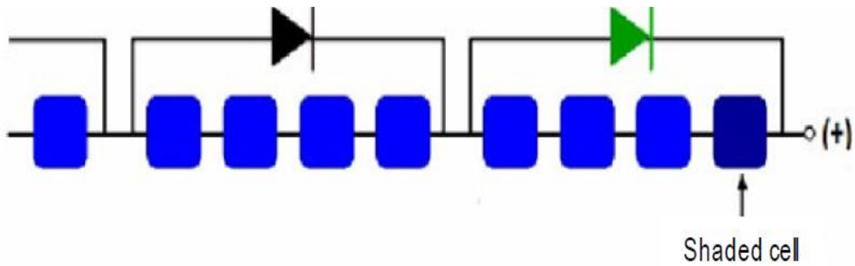

Fig.4. Parallel connection of photovoltaic cells

Although the shading effect of some of the cells of the parallel connection does not have the same effect as in the case of the series group, the power losses in the series and parallel resistors influence the way in which the power generated is distributed on the cells of the group.

3. COMPARATIVE OVERVIEW OF METHODS TO INCREASE THE EFFICIENCY OF PHOTOVOLTAIC PANELS

The voltage-current characteristic (U-I) of a photovoltaic module depends mainly on the intensity of the solar radiation and the temperature of the cells. For different meteorological parameters there is an operating characteristic of the photovoltaic generator. At the intersection of the U-I characteristic with the load characteristic at the PV generator terminals, the operating point is found, which generally differs from the maximum power point (MPP), at which the system can operate, when the optimal power transfer is achieved between the generator and the load [3]. Consequently, the MPP depends on the operating conditions of the photovoltaic generator, but also on the electrical characteristics of the load at the terminals. The goal of maximum power point tracking (MPPT) systems is to keep the operating point as close to the MPP as possible. In order to achieve the maximum power transfer between the PV generator and the receiver, a DC-DC converter is interconnected (Fig. 5). The DC-DC converter achieves the continuous adaptation of the load to the PV generator by using a control signal in modulated pulses.

The way to find the MPP is through repeated tests, that is, by changing the voltage at the generator terminals and by comparing the electrical power delivered in this case with the power from the previous step.

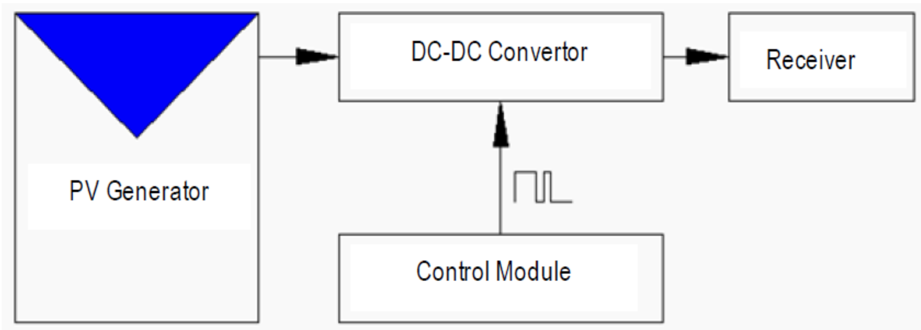

Fig.5. Adaptation of the resistive load user to the PV generator

There are several types of MPP tracking algorithms in the literature, and among the most used are the P&O (Perturb & Observe) algorithm, the Open and Short Circuit Method, the Incremental Conductance Algorithm and others [4]. Although these methods are widely used, they have disadvantages such as slow response to rapid variations in solar radiation intensity, oscillations around the MPP, or even tracking in the wrong direction.

In Fig. 6 we represented the P&O algorithm and the related logic diagram.

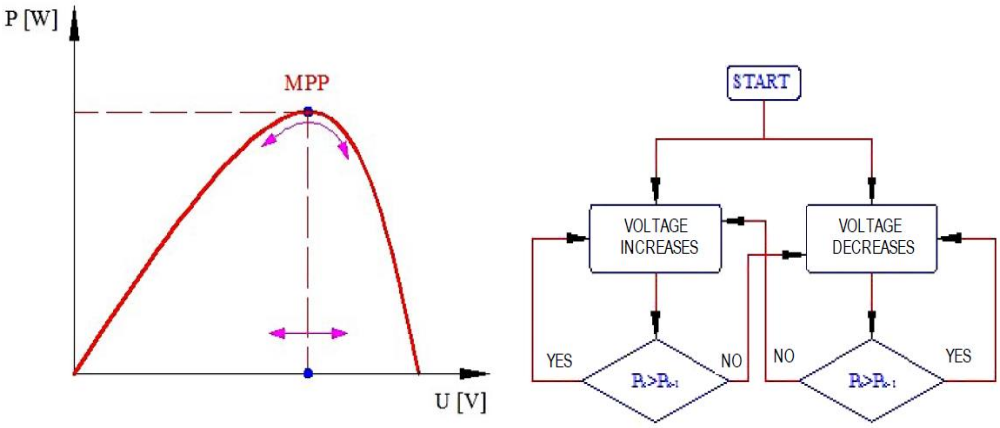

Fig.6. MPPT Perturb & Observe Algorithm

This algorithm is very simple and easy to implement. The way to find the MPP is through repeated tests, that is, by changing the voltage at the generator terminals and by comparing the electrical power delivered in this case with the power from the previous step. If the power from the current step is greater, the change of load continues in the same direction, and if it does not change in the opposite direction. This way of finding the MPP leads to oscillations around the MPP, even under stationary operating conditions, and in the case of sudden variations in the intensity of the solar radiation can even lead to tracking the MPP in the wrong direction

Another algorithm more commonly used in MPPT systems is "Incremental conductance". It is based on tracking the value of the derivative of the power with respect to the voltage, as shown in Fig. 7.

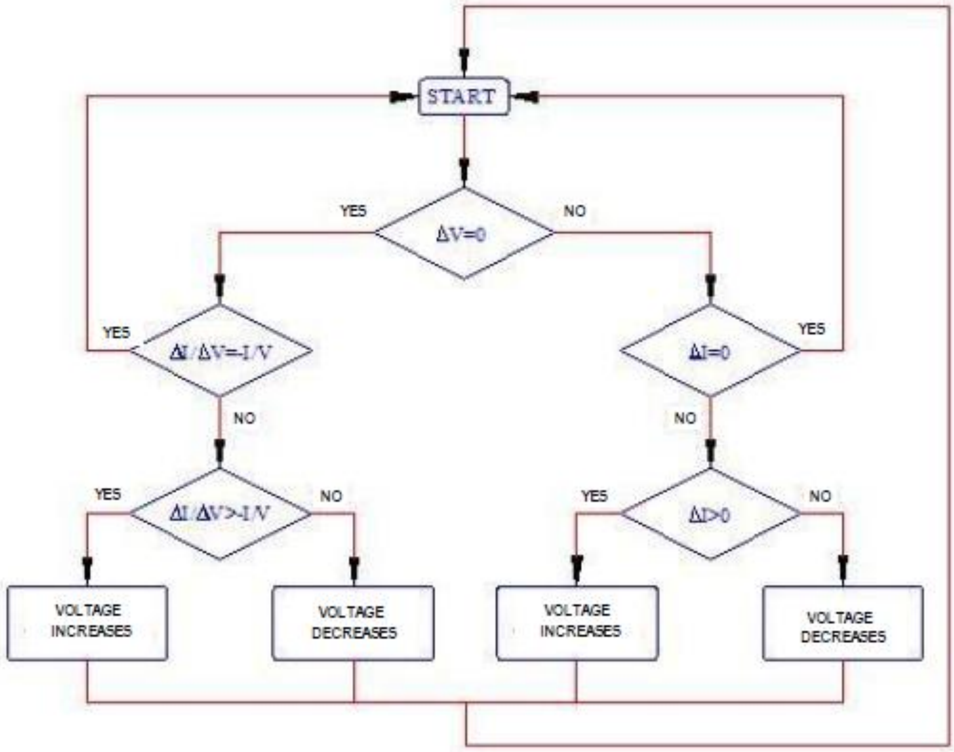

Fig.7. "Incremental Conductance" MPPT algorithm

Unlike the previous one, this algorithm does not present oscillations in operation nor the possibility of wrongly tracking the direction of the MPP, but it requires important computing resources and can influence the frequency of the current and the alternating voltage produced.

Research in this field is oriented towards two directions: either the optimization of already existing algorithms, or the development of new methods and algorithms. Regarding the first alternative, we can mention Taftich's work [5], in which an MPPT model based on measuring the voltage at the generator terminals is presented. The algorithm combines a non-linear method with the P&O algorithm. The results show a 17% increase in MPP tracking efficiency. The improvement of the P&O algorithm was also studied in Hua's work by modelling the transfer function and using multiple control signal models of the MPPT [6]. Another way to make MPPT systems more efficient is to create new algorithms. In general, they are based on the use of artificial intelligence techniques, especially artificial neural networks [7].

The applications of neural networks are very varied, but the prediction and control of processes is one of the most elaborated and together with genetic algorithms they can estimate the future state of a process, such as that of producing electricity using photovoltaic panels. [8]

The disadvantage of analytical models (single and double diode) is that they require numerical methods to solve the implicit equations, needing time and sufficient memory space. With the evolution of computers and the IT field in general, this problem has become much easier to solve. However, artificial intelligence techniques represent an alternative. [9]

Neural networks can learn from examples, are fault tolerant in the sense that they can handle incomplete data sets or signals with a significant noise component, can solve nonlinear problems, and once trained can make predictions and generalizations at a high computational speed. They have been successfully used in various applications of system control, robotics, shape recognition, medicine, weather forecasting, energy systems, optimization problems, signal processing, social and human sciences, etc. An important application is found in the modeling and identification of systems.

The applications of artificial neural networks (ANNs) in the field of renewable energy systems are among the most diverse: modeling of a solar steam generator, solar water heating systems, HVAC (Heating, ventilation, and air conditioning) systems, prediction of solar radiation and wind speed, modeling of the operation of photovoltaic cells, tracking algorithms of MPP etc.

In the case of photovoltaic panels, the parameter prediction refers to meteorological data - solar radiation intensity and atmospheric transmittance (clarity index) - necessary for the design of these installations or to internal variables of the system such as the electrical voltage, the current flowing through the circuit, the internal resistances of panel etc.

4. CONCLUSIONS

Although they are much studied and implemented, photovoltaic panels still present aspects that deserve to be taken into account. In this paper we tried to highlight the methods to increase their energy efficiency.

The problem with photovoltaic panels is related to the efficiency of converting solar energy into electricity. Also, the operating point of a panel, which is found at the intersection between the operating curve of the panel and the curve of its load at the terminals, is generally different from the maximum power point at which the panel can operate. There are thus several types of maximum power point tracking algorithm, but besides the fact that they show oscillations in steady state, they can even work wrongly in case of sudden changes in meteorological parameters. At the same time, the case of shading, which involves important energy losses, is not treated enough.

We approached the operation of a PV module as an electrical generator from several perspectives. Possible models, the analytical ones, use the single and double diode models, based on the properties of semiconductors. These models are widely studied in the literature, they have a very good accuracy, but they require numerical solution methods, since they are presented in the form of implicit equations. This fact makes it difficult to use them, at the moment, in systems with microcontrollers. However, in order to realize the maximum power transfer between the PV generator and the load user, it is necessary to know the position of the maximum power point. From this perspective derives the possibility of modeling the operation of PV modules using artificial intelligence techniques.

Currently, MPPT systems are installed at the terminals of PV fields. The maximum power point tracking system based on the artificial neural model can be implemented on each module of a PV field, thus reducing energy losses, implicitly improving the overall efficiency of the installation and giving autonomy to each individual module.

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AN EXAMPLE OF IMPLEMENTING ADAS SYSTEMS ON A SMALL-SCALE MOBILE PLATFORM

ALEXANDRU AVRAM[1], VLĂDUŢ ADRIAN PETRUŢA[2]

Abstract: In this paper an example of Advance Driving Assistance Systems (ADAS) from automotive are implemented on a small-scale vehicle. The ADAS technologies reefer to integration of multiple electronic systems of sensors and microcontrollers for detecting nearby obstacles or driver errors and respond accordingly. Several functions of ADAS uses cameras to record external environmental images for traffic signs recognition and lane assist. For implementing the above functionalities, modern software techniques are considered for processing the data acquired by the Raspberry camera on the mobile platform. Deep learning and image processing algorithms have been interconnected in a Raspberry Pi controller on the vehicle. Software development and implementation of the above algorithms have been carried out with Phyton programing language. The proposed algorithm is used to calculate the angle of turn required to stay in the current lane while reading the traffic signs for adapting the speed. Results and conclusions are presented at the end of this article.

Keywords: ADAS, autonomous mobility, smart vehicle, image processing, pattern recognition, microcontroller.

1. INTRODUCTION

The Advanced Driver Assistance Systems (ADAS) [1] are interconnected electronic systems that aid drivers in driving safely, parking the car, guiding the vehicle in the lane, and much more. The ADAS systems improves vehicle and road safety by integrating electronic devices such as controllers, radars, cameras, and other sensors, to identify nearby obstacles or driver errors and respond accordingly.

Considerable traffic accidents are caused by human mistake. According to World Health Organization, road traffic accidents would be one of the top five major causes of mortality by 2030. Many of these deaths and injuries can be avoided by driving vehicles that are appropriately equipped with state-of-the-art technology [8], such as ADAS.

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Automatic braking and self-collision avoidance, parking or alcohol sensors, and traffic sign recognition [9] are a few examples that are becoming increasingly popular on the market.

According to recent research [10] conducted by a Swedish insurance company, an autonomous braking system can minimize driver injuries by up to 64% on highways with speeds of up to 50 km/h. Automated braking mitigated the consequences of around 40% of collisions, resulting in no casualties.

The goal of this project is to create a small-scale mobile platform [2] that can maintain its path and obey traffic signs by capturing images in real time and processing them with machine learning and pattern recognition algorithms [1].

The following specific objectives are set to achieve this goal:

- Electronic system design through current consumption calculation from power supply at idle and load.
- Electronic components selection based on technical specifications, drawing electronic control signal diagrams, and projecting PCB layout.
- Developing software algorithms using OpenCV [6] and TensorFlow libraries with use of Phyton programming language.
- Implementing those algorithms in the Raspberry Pi 4 controller.

2. OVERVIEW OF THE ADAS

The Society of Automotive Engineers (SAE) defines six level of driving automation in J3016 standard where SAE Level 0 indicates no automation and required manual control while the highest SAE Level 5 indicates a fully autonomous vehicle. As in year 2020, non-commercially SAE Level 4 vehicle exists in the market yet. In order to reach a higher autonomation level, the vehicle must be able to understand its surrounding environment and make critical decision to prevent accidents. That is where ADAS comes into play in autonomous vehicle. Multiple sensors such as camera are deployed in the vehicle granting visual capability to ADAS [12].

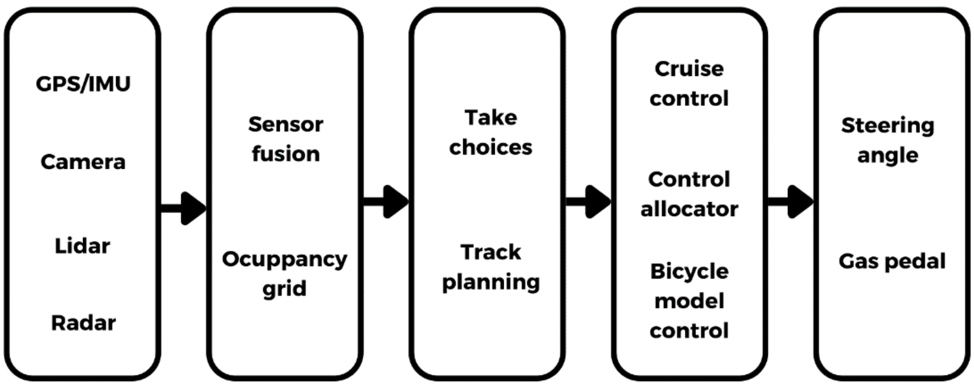


Fig.1. Mapping of one ADAS data flowchart (SAE 4)

Behind the scenes described in Figure 1 is a complex algorithm that provides all these features. This data flux is implemented into a controller through programing language, which allows for quick source code developing. Image management [5] and steering control [2] are the two parts of the programming hidden behind this flowchart. The image captured by the camera is processed using computer vison [6] algorithms, the angle of steering is calculated using a pre-trained model, common method used for sign recognition [7] too. Knowing the required steering angle for lane travel, it is communicated to the steering mechanism, and the vehicle can continue to drive at the set speed until it meets a sign that imposes the next behavior.

3. THE PLATFORM HARDWARE ARCHITECTURE

This project describes the operation of a Raspberry Pi 4 based mobile system that uses software algorithms to acquire and process images captured by a video camera. Image processing [4] is used to calculate the angle of turn required to stay in the current lane. A servo motor provides precise steering for the platform [5], pointing the two steering wheels in the desired direction. A DC motor drives the platform, distributing its rotation to a differential attached to the rear axle. The platform is equipped with a 8MP camera that provides a stable image in daylight conditions, being the main sensor of the system.

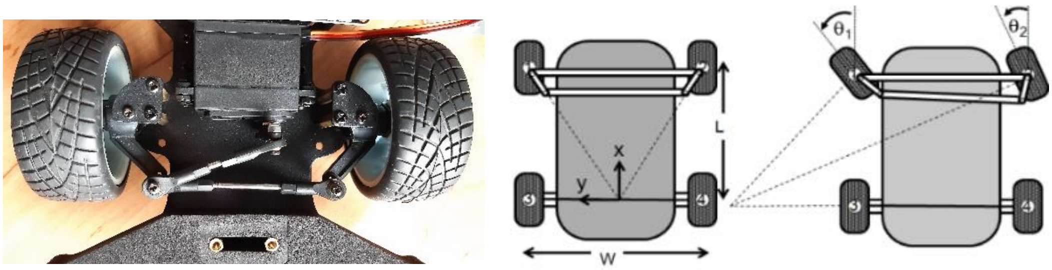


Fig.2. The mechanical steering system of the mobile platform: servo motor for steering (left) and front wheels steering principle (right)

The configuration of the mechanical components that comprise the mobile platform's chassis, steering, and distribution system, derived from a teaching kit specifically developed for such uses. The mobile platform mechanical components include a metal chassis, steering assembly (Figure 2 left), differential gearbox, and traction wheels.

The vehicle features a traditional four-wheel mobile system in terms of kinematics (Figure 2 right). The rear propulsion axle rotates along the X-axis, propelling the vehicle in the direction specified by the front steering axle. The latter conducts XoY plane motions along both axes, rotation along the X axis, and yaw in the Y axis direction.

Unlike conventional road vehicles, which have both traction and steering on the front axle, the proposed mobile platform incorporates a rear wheel propulsion mechanism that improves steering control.

4. THE ELECTRONIC SYSTEM DESIGN

This chapter describes the designing of the electronic system by calculating the current consumption and supply voltage at idle and load, selecting electronic components with technical specifications that match those of the design, drawing electronic control and control schematics, making PCB layout, and assembly of all electronic devices as shown in Figure 3.

The Fritzing freeware software, which permits the construction and viewing of electronic schematics, was used throughout the circuit design stage as presented in Figure 3, left.

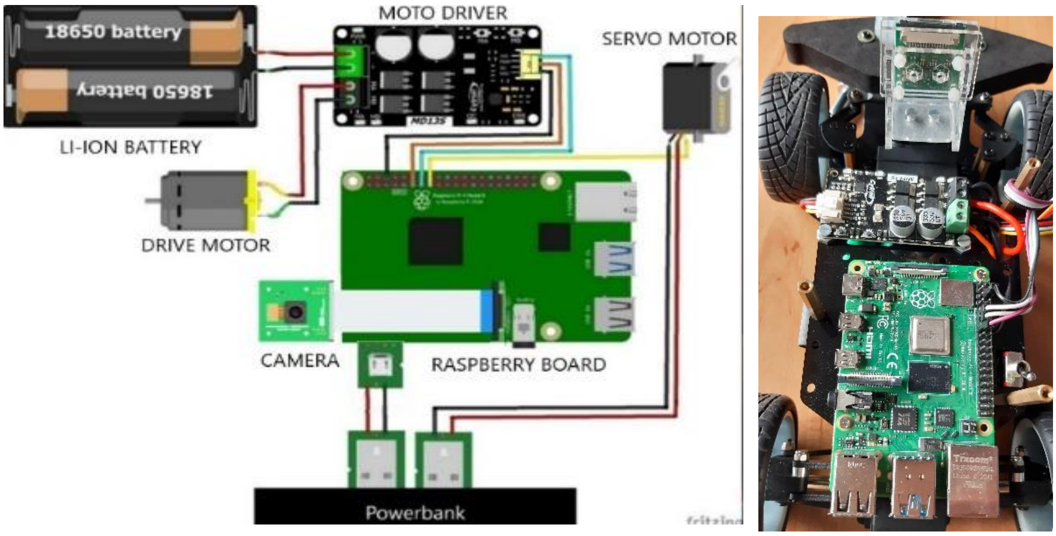


Fig.3. Electronic system architecture: schematic design in Fritzing (left) and hardware assembly on the mobile platform (right)

To achieve the project's goals, it was decided that the electronic circuit should include a DC motor driver to control the engine speeds. Thus, a DC motor is coupled to the driving differential and a servo motor for steering were connected to a microcontroller based on the Raspberry Pi 4 development platform that would process all the information from the environmental camera and make appropriate decisions.

Project advanced to the second phase after designing the electronic scheme, which was the physical execution of the wiring, with the assembly taking place on a test board as presented in Figure 3, right. The user's access to the relevant pins was considered when designing the physical circuit.

5. THE SOFTWARE ALGORITHM DESCRIPTION

The self-driving algorithm works as shown in the diagram below (Figure 4). It begins with the execution of the source code, followed by the initiation of a video capture object that stores each frame. If it captures the current frame, the program can continue;

otherwise, it shows a specified error, and the execution terminates. Following the acquisition of the current picture, preprocessing is required to accomplish the generation of the turn angle [11] and sign recognition [7]. The application uses the initial picture captured to impose the direction of travel based on the pre-trained model that computes the current turn angle.

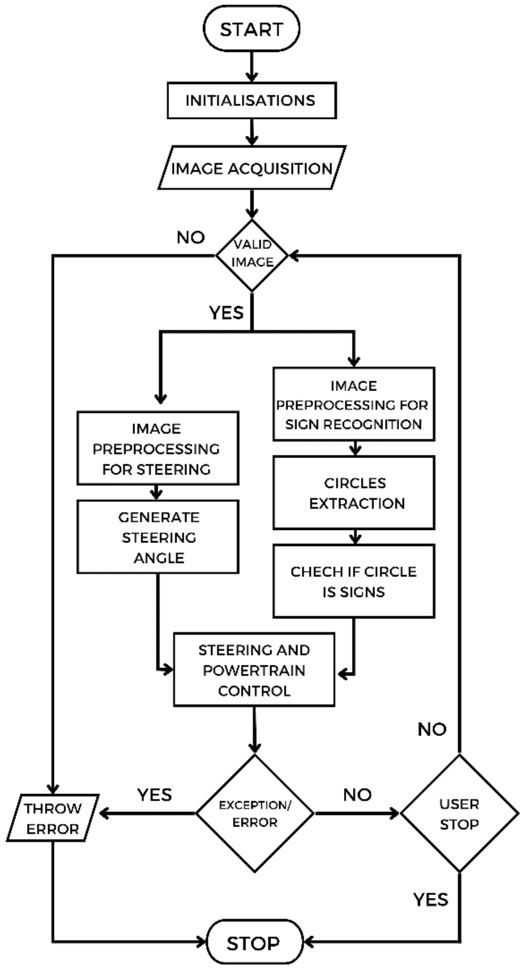


Fig.4. Software algorithm diagram

Once the needed steering angle for lane navigation is determined, the steering control function that drives the wheels to the angle specified on call is called. For sign recognition, all valid circles must be recognized and extracted from the picture, and each must be verified to determine whether it is a traffic sign. When a genuine sign is identified, the action imposed by it is carried out. Only the drive motor control remains to be conducted after establishing the direction of driving.

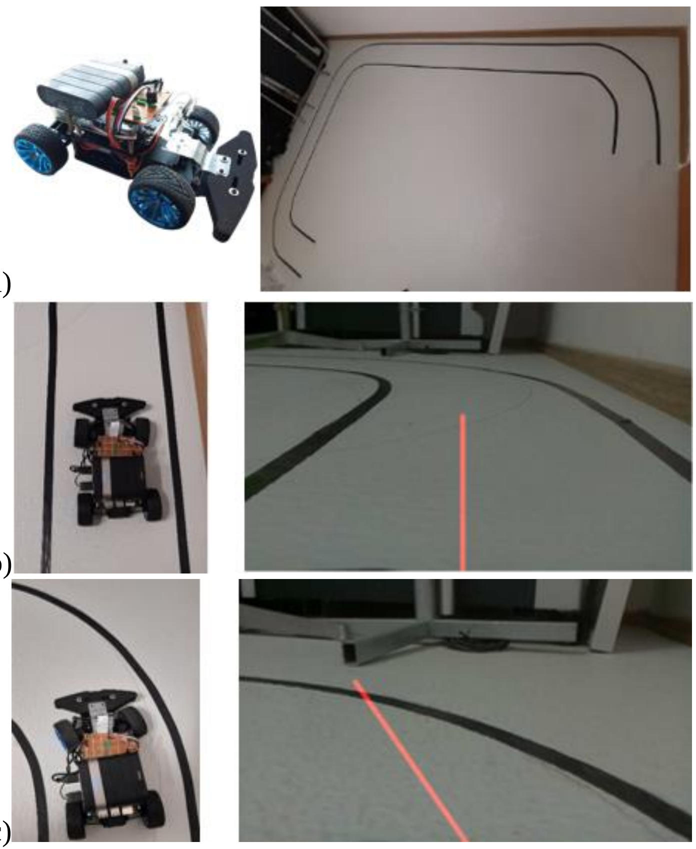
Following that, the process of capturing a fresh image and validating it is repeated in a loop. All the preceding stages are carried out as long as the camera obtains a valid image or as long as execution is not user interrupted.

For the implementation of the algorithm described above, the Python programming language was used, which was chosen for reasons of speed in the drafting of the source code and good compatibility with the development board used.

Generating the drive direction prediction model [8] and sign recognition model [7] was done with the help of Google Colab, a platform that provides free graphics power to run the algorithm generating the drive direction prediction and sign recognition model. The training algorithm used is based on the Keras library, which functions as an interface for TensorFlow, a fundamental library for deep learning [3] used in this project.

6. RESULTS AND INTERPRETATION

Finally, a mini vehicle [11] that stays in its designed lane (Figure 5, a), reads the traffic signs, and satisfies the intended objectives was obtained.



a)
b)
c)

Fig.4. Final results of the autonomous mobile platform: a) final hardware architecture and lane design; b) no steering angle for forward direction; c) left steering angle for changing direction

On the project's lane driving algorithm the following were accomplished: The steering angles (Figure 5, b) are generated at a timestep of between 12ms and 30ms for each angle generated based on the current frame, with an error rate of 5% regardless of the route configuration, either the one in which it was trained or another identical to that. The vehicle, which is usually parked in the middle of the traffic lane, has followed the tight road (Figure 5, c) correctly.

In the sign recognition algorithm, the following milestones was passed: All common round traffic signs are recognized by the system. Only a few of them are used in this project, and they all feature a motor and a directional character, such as "stay right", "turn right ahead", "forward only", "no entrance" or "speed limit x".

7. CONCLUSIONS

Implementation of lane assist and sign recognition functions from ADAS was presented in this article, that marks two of the main achievements proposed from the autonomous driving platform. This project describes the operation of a Raspberry Pi 4 based mobile system that uses software algorithms to acquire and process images captured by a video camera. Image processing is used to calculate the angle of turn required to stay in the current lane. A servo motor provides precise steering for the platform, pointing the two steering wheels in the desired direction. A DC motor drives the platform, distributing its rotation to a differential attached to the rear axle.

The driver assistance concept is well known and there are more ADAS functions that can still be implemented into the above algorithm. There is room for certain changes in the mobile platform electronic system too: like the elimination of the power bank, step down the voltage provided by the propulsion power source and rely exclusively on its energy. Another improvement of the electronics system could be energy monitoring and the redesign of a new PCB for module interconnection.

A major conclusion regarding the future developments is using a radar to monitor the surrounding objects proximity. Implementation of parking assist, collision avoidance, and adaptive cruise control are some future potential directions. Hardware and software optimisation could lead this project to a prototype of self driving vehicle that will be aware of all major parameters souroundig, state of the project that will make it worth the naming of autonomouse vehicle.

AKNODLEGEMENTS

The research presented in this article was founded through the Scientific performance scholarship program granted by the "1st of December 1918" University of Alba Iulia registered with the contract no. 493/04.07.2022.

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GENERAL CONSIDERATIONS ON RENEWABLE SOLAR ENERGY AS A SOLUTION IN SUSTAINABLE DEVELOPMENT

CRISTINA IONICI[1], TEODORA LAZAR[2]

Abstract: This paper presents a small study on the need to use renewable energy in the context sustainable development. In the first plenary session of 2018, in Strasbourg, the MEPs introduced the new amendments to the provisions of the Clean Energy Package for all Europeans. In the European context of energy policies The Paris Agreement confirmed the EU's approach until then, namely the implementation of the climate and energy policy framework for 2030. MEPs also want to protect the right of citizens to produce, store and consume their own electricity from renewable sources, without paying taxes or fees. renewable energy in the EU registers a turnover of 30 billion euros and provides 350,000 jobs. As technologies have developed, some forms of energy, especially solar energy, have seen more intensive use. But development has not been equal in the EU, and renewable energies represent only a small share of the total EU energy mix compared to the dominance of gas, oil and coal.

Keywords: electricity, efficiency, renewable energy, photovoltaic systems.

1. INTRODUCTION

By mobilizing up to 177 billion euros of public and private investments on a program with the year 2022, this package can generate growth of up to 1% of GDP in the next decade and can create 900,000 new jobs. . The package also includes actions to accelerate innovation in clean energy and to renovate buildings [1], [4]. It provides for measures to encourage public and private investment, to promote the EU's industrial competitiveness and to mitigate the impact of the clean energy transition on society. It is possible to estimate the development trend of electricity from renewable sources, forecast until 2030, figure 1 [12].

The objectives of the European energy policy in the form of 20-20-20 refer to:

- Decresead of 20% reduction in energy consumption from fossil fuels by adopting measures to improve efficiency and save energy consumption, such as thermal insulation of buildings or the use of economical light bulbs.

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- Production of at least 20% of the energy requirement by using renewable resources.
- Achieving the first two objectives by 2020 and increasing energy efficiency by 20%. On a broader level, the report on the provisions of this package made by the Committee for.

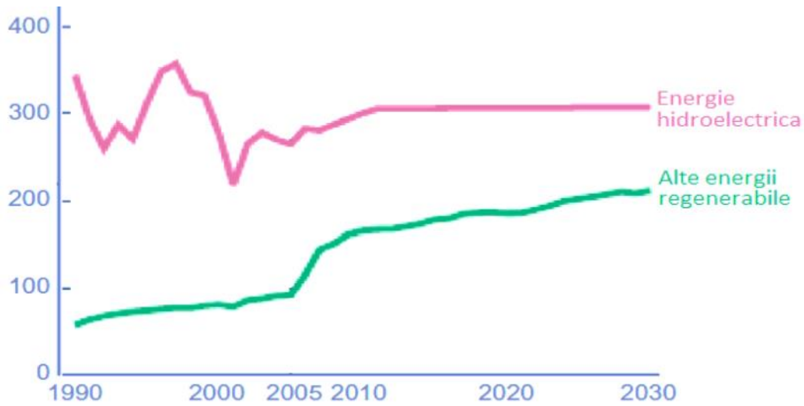

Fig.1. Development trend of electricity from renewable sources until 2030 (in billion kWh s)

The European Parliament's Industry, Research and Energy (ITRE) contains numerous amendments in the 3 areas of interest: renewable energy, energetic efficiency and control mechanisms.

2. RENEWABLE ENERGY

The European Parliament's Industry, Research and Energy Committee (ITRE) has called for a binding EU target of increasing the percentage of renewable energy to 35%. Thus, if in 2020, the EU countries agreed that the percentage of renewable energy should increase to 27% by 2030, the MEPs stated that it should be at least 35%. For the transport sector, they argued that at least 12% of the energy consumed in each EU member state should be produced from renewable sources such as solar or wind energy. MEPs also want to protect the right of citizens to produce, store and consume their own electricity from renewable sources, without paying taxes or fees. renewable energy in the EU registers a turnover of 30 billion euros and provides 350,000 jobs the work. As technologies have developed, some forms of energy, especially solar energy, have seen more intensive use. But development has not been equal in the EU, and renewable energies represent only a small share of the total EU energy mix compared to the dominance of gas, oil and coal considers the security of energy supply from internal sources a primary objective for ensuring national energy security [3], [5].

- Energetic efficiency

ITRE members have proposed a new energy efficiency target of reducing energy consumption by 40% by 2030 (ie 34% reduction in primary energy consumption compared to 2005 levels). Improving energy efficiency can reduce CO2 emissions, but also an annual bill of 350 billion euros for energy imports [2], [8].

An important area for improvement is the heating and cooling of buildings, which account for 40% of all energy consumed in the EU. About 75% of these are energy inefficient.

In December 2020, negotiators from the Parliament, Council and Commission agreed that EU countries should prepare long-term national strategies to support the renovation of residential and non-residential buildings. The aim is that by 2050 buildings in the EU will no longer emit greenhouse gases and reduce CO2 [9].

Finally, by 2022, 90% of fuel/petrol stations along the Trans-European Network roads are expected to be equipped with recharging points for electric vehicles.

- Control mechanisms.

At the same time, MEPs proposed the establishment of a cooperation and control mechanism to monitor progress towards achieving the EU's energy and climate change objectives by 2030, especially in terms of energy efficiency and renewable energy.

Even though the Clean Energy Package 2020-2030, also known as the Winter Package, has so far raised doubts as it was considered not to be ambitious enough,this is the EU's first serious attempt to create a single renewable energy market [7].

3. SOLAR ENERGY - A SOLUTION IN SUSTAINABLE DEVELOPMENT

The national energy strategy provides a vision and proposals for the development of the energy sector until 2030 and is centered around a set of fundamental strategic principles and objectives [12].

The energy sector contributes essentially to the development of Romania, through its profound influence on the competitiveness of the economy, the quality of life and the environment. In order to support consumers' expectations in the long term, the Romanian energy sector must become economically more robust, more technologically advanced and less polluting, and the national potential to produce green energy is presented in figure 2 [10].

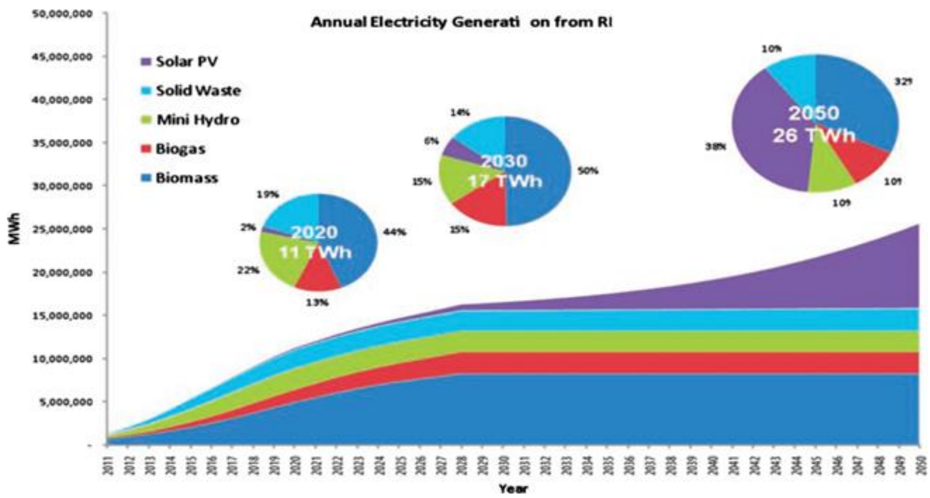

Fig.2. Renewable energy production potential

The complex energy profile of our country makes all EU measures important. In this sense, Romania considered it necessary to get involved and promote projects such as the Nabucco gas pipeline, the AGRI interconnector, the PEOP pipeline. Also, it is desired to emphasize the role of the Black Sea on the energy map of the EU, through the prism of the multiple assets of this basin (potential hydrocarbon reserves, positioning on the Caspian hydrocarbon transport route, cooperation platform in the field of renewable energies between the riparian countries) [6].

Romania must develop an active and competent presence in the intra-community energy market, in coordination with Eastern European countries, with similar energy system structures. As long as the Western Balkans and Ukraine do not participate in the ETS system, electricity produced there based on fossil fuels has the competitive advantage of not reflecting the cost of GHG emissions in the production cost [5].

The EU promotes its energy policies in South-East Europe through the Energy Community, which brings together the countries of the EU as well as those of South-East Europe and the Black Sea Basin, aiming to extend its market rules in this space.

Romania's fundamental strategic objectives are: energy security, to ensure the competitiveness of the economy, respectively the transition of the energy sector towards a sustainable development model, supported on the foundation of good governance of the energy sector and ultimately aiming to ensure energy for all consumers and its affordability by reducing energy poverty and protecting vulnerable consumers.

The evolution of dependence on energy imports influences the type of primary energy, Romania fulfilled its European commitment for 2020 to increase the SRE share to 24% of gross final energy consumption (SRE share), reaching a level of 26.3 for this indicator % in 2020 [11]. Figure 2.1 shows the structure of energy production for the next 20 years, according to Romania's Energy Strategy.

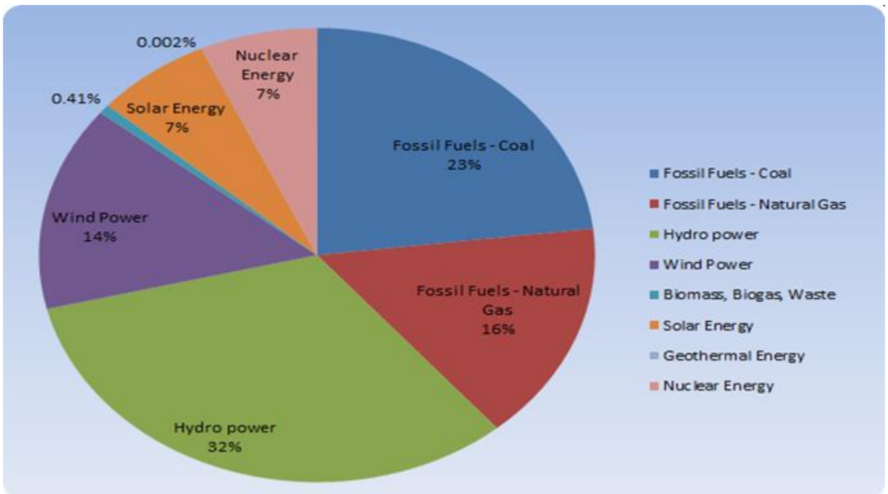

Fig.3. Structure of energy production in the 20 year in Romania

The transfer of electricity, through the transmission and distribution networks, from producers to final consumers implies the possibility of access to the network for all participants involved in this process. Access to the network represents the right of a producer, distributor, supplier or consumer to connect to the electric transmission and distribution networks, under the conditions required by the technical norms. ..Solar energy refers to a renewable source of energy that is directly produced through light and solar radiation, figure 4.

Fig.4. Photovoltaic systems

At the distribution level, free access ensures the distribution of energy from a supplier to the final consumer through the distribution network. This can be used: to generate electricity through solar (photovoltaic) cells; to generate electricity through thermal power plants; to generate electricity through solar towers; to heat blocks directly, through heat pumps or solar ovens.

The advantages of solar energy start from the fact that it is available in huge quantities, is inexhaustible (at least for a few billion years) and is ecological. The means of capturing solar energy are not polluting and have no harmful effects on the atmosphere.

4. CONCLUSIONS

Photovoltaic systems can be a reliable power source for telecommunication systems, especially in isolated areas, at long distances from the network. Examples of this are telecommunication towers, passenger information transmitters, mobile telephone transmitters, radio stations, emergency call units and military communication installations. These systems can range in size from a few watts for emergency alert systems to several kilowatts for radio stations. Of course, these systems are independent units, in which the batteries provide an alternating voltage that meets current demands. Practice has shown that such PV systems can operate for a long period of time without complex maintenance work.

Photovoltaic solar energy is appreciated as one of the most promising sources of energy in the future. Not only the sun's rays are a source of renewable energy, they are completely free and available. Solar energy is clean, unlimited and produces no emissions. It does not pollute water or air and is completely silent. It is capable of providing consistent power for residential or commercial use and the technology used to produce modern photovoltaic systems has become better, more cost-effective and more accessible than before. In today's world where new sources of energy are always sought after, the future of solar photovoltaic energy has never been brighter.

In the conditions where the degradation of the Earth reaches an increasingly high level, this problem is starting to be taken into account by more and more people, and this can be seen. And as technology develops, solar energy will be used more and more.

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PRINCIPLES OF EFFECTIVE ENERGY MANAGEMENT AND POWER CONTROL SYSTEM

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Abstract: This paper aims to emphasize the approach on energy management with its principles and give a general overview of this field of industry. The basic functionality of power system control is found in the Supervisory Control and Data Acquisition (SCADA) function that collects and records values and statuses acquired from the power system elements via remote telemetry to enable control center operators to supervise and control the power system.

Keywords: monitor, power, process, management, energy.

1. INTRODUCTION

Maintaining a reliable supply of electrical power to consumers is a highly complex process as most of this power cannot be stored and the individual elements of this process, forming what is called a power system, can be spread over a wide geographical area [7], [12].

The aim of power system management, also referred to as Energy Management, is to monitor, control and optimize this process in real-time. The basic functionality of power system control is found in the Supervisory Control and Data Acquisition (SCADA) concept that stores values and statuses acquired from the power system wirelessly to enable control center operators to control the system [9].

Other decision support functions complement this function to provide power system management for a secure and optimal process.

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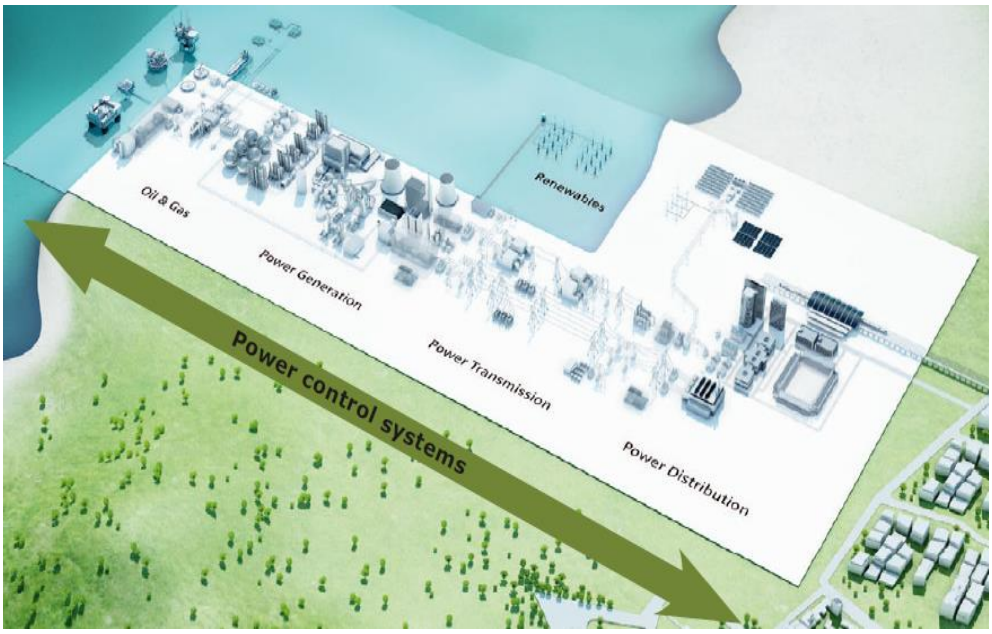

Fig.1. Power control system – serving the complete energy chain from generation to load

With the help of network control systems, the operators can obtain information from the network in real time, and they can then use that info the basis for optimizing the control of the power supply [6], [11].

The info transmitted by the station automation systems wirelessly must be stored and processed at a hub. This function, is well realisez by network control systems that are installed at central areas, which are also known as system control rooms.

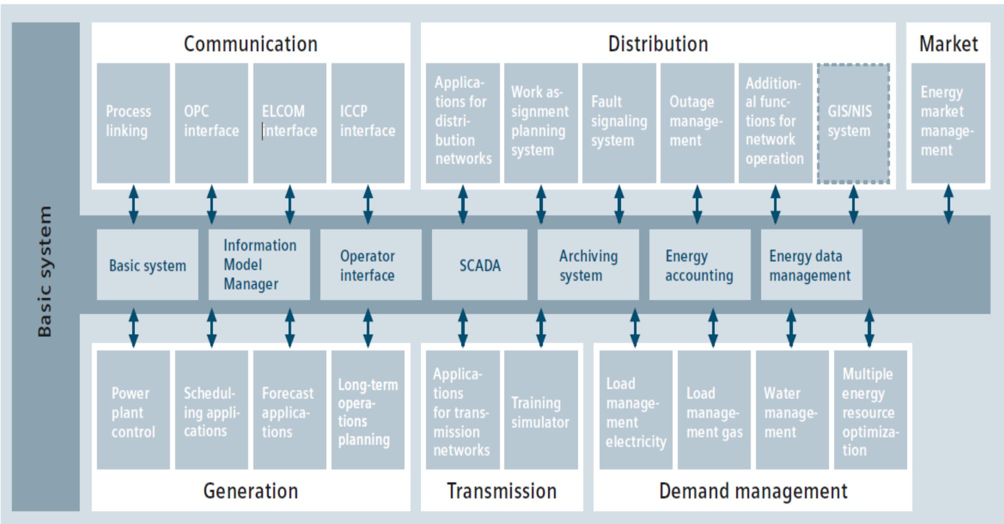

Fig.2. Power control system, element overview

The result of these many years of experience is the development of control systems for electric power systems as well as for gas, water and district heating networks (fig.2).

On the basis of a minimum configuration for operation, it is possible to add subsystems to meet the other requirements in terms of additional functions, structure and size of the system [3], [8].

With its modular structure, the system can be expanded with little effort, even subsequently.

Block modules can be swapped or new modules can be added to meet the required modifications. On the basis of the standard system, open programming interfaces permit individual adaptations and subsequent expansions for new or existing customer-specific elements. In one basic configuration a control system comprises the following elements, which are described here:

- Basic services

To be sure that the fundamental functions are provided like real time database services, data exchange and coordination of PCs involved in the control center

- UI (User interface)

For providing friendly, powerful and pleasant graphics oriented to the operator

- Information model management

For data entry and data maintenance, single line diagrams and data exchange with other computer systems

- Communication front end

For better interface of the field remote terminal units, with the process

- SCADA applications.

Fig.3. Control room

For implementing the functions required for system operation, i.e., system monitoring and controlling. In addition to these elements, the following subsystems, which are described in greater detail in the remainder of this section, are available for expanding the functionality [4], [13]. They are used and configured to match the tasks and size of the control systems:

- Historical information system
  For the archiving and subsequent reconstruction of the process data.
- Forecasting applications
  For the long-, medium- and short-term forecasting of system loads
- Power control applications
  For the monitoring and control, i.e., real-time dispatching, of the power generating units participating to frequency regulation
- Transmission network applications
  For fast and comprehensive analysis and optimization of the transmission network operation
- Training simulator

For training the operator to all range of network behaviors with the tools and user interface as used in operation.

Real-time processing

SCADA software are basic functions of the network control system and gives means of controlling the power supply system. For this aim, all info transmitted from the network is stored, processed and displayed in order to keep the operator constantly informed about the current operating state of the power supply system.

The human operator can also store additional data in the system or enter corrections for incorrectly reported [1].

2. APPLICATIONS FOR BETTER MANAGEMENT IN DISTRIBUTION NETWORK

A distribution network is characterized by a mostly radial and lightly meshed structure, which is operated mostly radial. The distribution network, typically includes a medium voltage (MV) part, a low voltage (LV) part, and is interconnected to the transmission network at HV/MV substations [2].

Under the Smart Grid pressure automation of the MV/LV substations is now accelerating in Europe whilst automation of the MV feeders is now accelerating as well in the US. For these reasons telemetry, that of power flows, is relatively limited but rapidly increasing.

Maybe the most important application in distribution network, is the outage management that is responsible for the management of all planned and unplanned outages, the latter part being also referred to as Fault Management. Outage Management integrates information from SCADA (events), metering (events), and customers (trouble calls) to infer one or more concurrent network outages. With the additional help of crews and support from analysis tools, operators are then able to promptly locate faults, isolate faults and restore service. Outage Management will also provide calculation of efficiency indices that are typically required by the regulator to assess the efficiency of the utility towards its customers. Outage Management with the support from analysis tools provides also for the coordination of planned outages with the normal operation of the network to ensure safety of the crews and continuity of service to the customers.

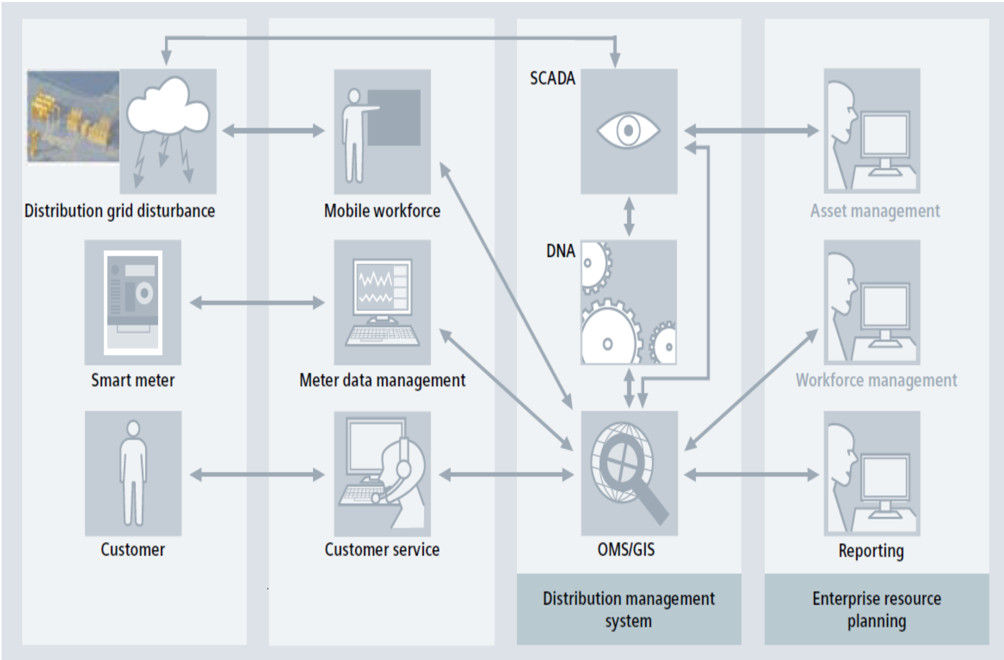

Fig.4. Schematic workflow in a distribution management system

3. TRAINING SOFTWARE SIMULATOR

The increasing complexity of existing power systems places increasing demands on operation personnel. Efficient training simulators are therefore required for carrying out the necessary comprehensive hands-on training. The following areas can be covered with training simulators:

- Familiarization of operation personnel with the control system and the existing network
- Training of experienced personnel to changes in network, operating procedures, tools, etc.
- Training of personnel to daily work as well as to emergency conditions (like blackouts)
- Simulation and analysis of operational incidents (post-mortem or anticipated) towards improving on existing operating procedures
- Testing of possible network expansions and analysis of alternatives, testing of new tools and analysis of results, etc. For the training of personnel, training simulators must reflect accurately the power system behavior and provide to the operator the very same tools, including visualization, as those used in the control center for an effective training. The training simulator includes 4 essential elements:
- A training management element
- A power system simulation element
- A telemetry simulation element

- A copy of the management system (EMS, TMS, DMS or GMS).

The power system simulation element is responsible for the accurate simulation of the dynamic behavior of the managed system, i.e., that of all its field equipment (generating units, network and loads). The telemetry simulation element feeds into the management system copy the simulated field data as they would normally come from field equipment into the control center [5].

This training simulator also provides to the trainee an environment identical to that used in operation and to the instructor an environment that allows him to create training scenarios, influence (with or without knowledge of trainee) the training session, etc.

4. OPERATOR TRAINING SIMULATOR (OTS)

OTS is based on 4 key elements:

- A training management element
- A power system simulation element
- A telemetry simulation element
- A copy of the control system

The training management element provides tools for creating training sessions, executing training sessions and reviewing trainee efficiency. It provides tools to:

• Initialize the training session, like, from real-time or a saved case

• Define the system load profile

• Create event sequences, like, a breaker opening, a telemetry failure, etc., that can be either time triggered, event triggered or command triggered

• Create training scenarios, i.e., a number of event sequences, to be activated during the training. It also provides start/stop and pause/resume functions for the execution of the training session. During the training session it is possible for the trainer to create new events and/or modify the running scenario [10].

The power system simulation element provides a realistic simulation of the power system behavior to support training from normal operation to emergency operation including islanding conditions and blackout restoration. The simulation is based on a long-term dynamic modelling of the power system including:

- Load modelling with voltage & frequency dependency
- Generation modelling with governor, turbine/boiler and generator models
- Frequency modelling
- Voltage regulator modelling
- Protection relay modelling
- External company LFC modelling.

The telemetry simulation element provides the simulation of the data communication between the power system and the control system. It transfers as simulated field telemetry the results of the power system simulation to the control system copy. And it processes all commands issued by SCADA, LFC, etc. and transfers them to the power system simulation.

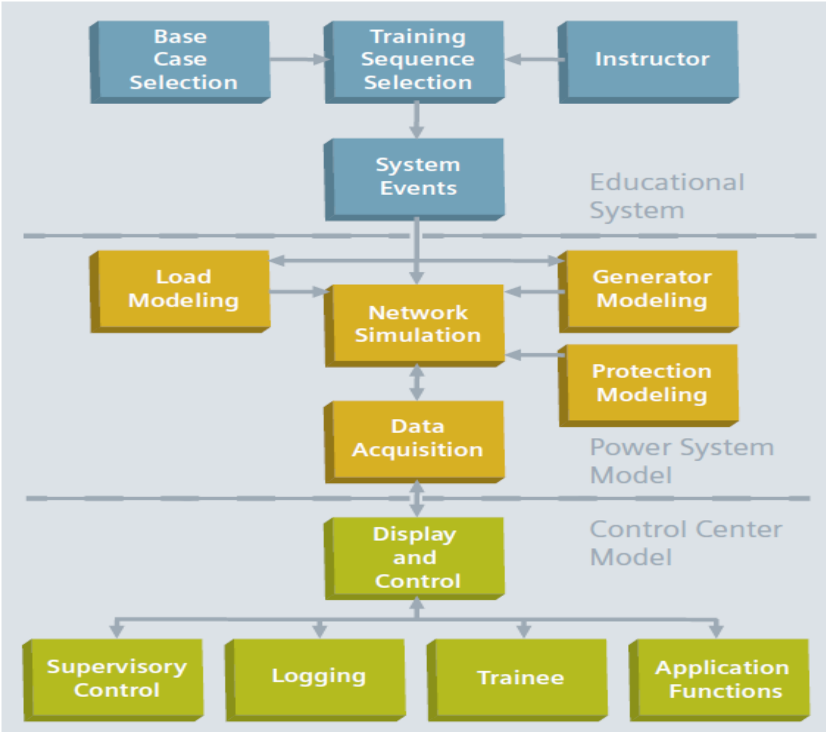

Fig.5. Block diagram of a training simulator Multi-utility

This simulated telemetry, can be modified via the scenario builder by the trainer to reflect measurement errors, telemetry or RTU failures, etc. This operator training simulator provides a dedicated environment for the trainee (operator) and one for the instructor that allows the instructor to influence the process in order to force responses from the trainees. The trainee interface is identical with that of the control system so that, for the trainee, there is no difference in functionality and usability between training and real operation.

5. CONCLUSIONS

Having the opportunity to simulate the management of a power system is highly useful for the operators, thus the efficiency of their decisions in the real management structure will be better correlated with the requirement and situations.

Some distribution utilities will manage the distribution of multiple commodities, like electricity, district heating, gas and/or water. Whilst the distribution process, for example with load management, is commodity specific, inter-dependencies will be created either by the procurement process or the production model.

It is not unusual to find in distribution cogeneration power plants, also referred to as combined heat and power (CHP) power plants, providing electrical power and district heating.

Management of these 2 highly integrated commodities will require adapted tools accounting for the high inter-dependencies existing between the production and the demand of these 2 commodities.

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Annals of the University of Petrosani, Electrical Engineering, 24 (2022)

MATHEMATICAL MODELING AND SIMULATION OF INDUCTION MOTOR WITH EDDY CURRENT LEAKAGE INDUCTANCE IN THE CORE LOSS BRANCH

OLIMPIU STOICUTA[1]

Abstract: The article presents the parallel mathematical model of the induction motor in which the stator iron core losses are modeled taking into account the core loss resistance and the eddy currents leakage inductance, in series connected in the base loss branch of the equivalent circuit of the motor. The induction motor simulation program is made in Matlab-Simulink and is based on the use of an S-Function block.

Keywords: iron core losses, induction machines, eddy currents, simulation.

1. INTRODUCTION

Currently, the vast majority of field-oriented control (FOC) algorithms of induction machines are based on the mathematical model of the machine in which iron losses are neglected [2], [4], [11], [18], [19].

E. Levi, as well as other researchers have shown that these iron losses cannot be neglected when voltage source type inverters (VSI) are used in the vector control systems of induction machines [5] - [9], [12] - [15], [17]. Neglecting the iron losses in the mathematical model of the induction motor leads to reduced dynamic performances of the vector control system [6],[7].

Considering the mentioned, this article presents the parallel mathematical model of the induction motor, in which the losses from the stator iron, as well as the losses due to the eddy currents, are modeled by means of a series RL circuit, placed in parallel with the mutual inductance, in within the equivalent circuit of the induction motor [7]. This type of mathematical model of the induction machine was suggested for the first time by Boldea and Nasar in 1987, and then it was investigated by several researchers [3].

In this context, this article presents in detail how to use the S-Function block, specific to the Matlab-Simulink program [10], [16], in order to modeling and numerical simulation the induction motor in which iron losses are not neglected.

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2. THE PARALLEL MODEL OF THE INDUCTION MOTOR

The equivalent circuit of the induction motor in which iron losses are not neglected, is presented in Fig.1 [7].

In order to model the iron losses in the stator, an RL series connection is used, consisting of the resistance of the stator iron (R_f) and the eddy currents leakage inductance (L_f). In the equivalent circuit of the induction motor, the series RL connection is placed in parallel with the mutual inductance. By means of the leakage inductance (L_f) the rate of change of the eddy currents iron loss is modeled.

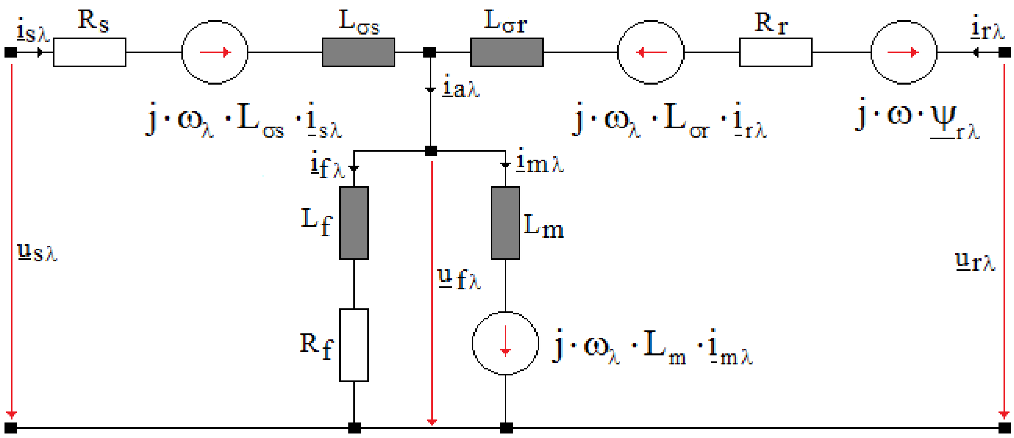

Fig. 1. The equivalent circuit of the induction motor

Based on the equivalent circuit in Fig.1, the equations that define the parallel mathematical model of the induction motor can be determined very easily. The mathematical relationships that can be written based on the circuit in Fig.1, are [7]:

- the stator voltages equation

$$\underline{u}_{s\lambda} = R_s \cdot \underline{i}_{s\lambda} + \frac{d}{dt}\underline{\psi}_{s\lambda} + j \cdot \omega_\lambda \cdot \underline{\psi}_{s\lambda} \tag{1}$$

- the rotor voltages equation

$$0 = R_r \cdot \underline{i}_{r\lambda} + \frac{d}{dt}\underline{\psi}_{r\lambda} + j \cdot (\omega_\lambda - \omega) \cdot \underline{\psi}_{r\lambda} \tag{2}$$

- the stator flux equation

$$\underline{\psi}_{s\lambda} = \underline{\psi}_{m\lambda} + L_{\sigma s} \cdot \underline{i}_{s\lambda} \tag{3}$$

- the rotor flux equation

$$\underline{\psi}_{r\lambda} = \underline{\psi}_{m\lambda} + L_{\sigma r} \cdot \underline{i}_{r\lambda} \tag{4}$$

- the air-gap flux equation

$$\underline{\psi}_{m\lambda} = L_m \cdot \underline{i}_{m\lambda} \tag{5}$$

- the currents equation

$$\underline{i}_{s\lambda} + \underline{i}_{r\lambda} = \underline{i}_{m\lambda} + \underline{i}_{f\lambda} \tag{6}$$

- magnetic branch voltage equation

$$\underline{u}_{f\lambda} = R_f \cdot \underline{i}_{f\lambda} + L_f \cdot \frac{d}{dt}\underline{i}_{f\lambda} = \frac{d}{dt}\underline{\psi}_{m\lambda} + j \cdot \omega_\lambda \cdot \underline{\psi}_{m\lambda} \tag{7}$$

- motion equation of the induction motor

$$J \cdot \frac{d}{dt}\omega_r = T_e - F \cdot \omega_r - T_L \tag{8}$$

where T_e is the electromagnetic torque and T_L is the load torque

$$T_e = \frac{3}{2} \cdot \frac{z_p}{L_{\sigma r}} \cdot \mathrm{Im}\left(\underline{\psi}^*_{r\lambda} \cdot \underline{\psi}_{m\lambda}\right) \tag{9}$$

The following notations were used in the above relationships:

$\underline{u}_{s\lambda} = u_{ds\lambda} + j \cdot u_{qs\lambda}$; $\underline{u}_{f\lambda} = u_{df\lambda} + j \cdot u_{qf\lambda}$; $\underline{i}_{s\lambda} = i_{ds\lambda} + j \cdot i_{qs\lambda}$; $\underline{i}_{r\lambda} = i_{dr\lambda} + j \cdot i_{qr\lambda}$;
$\underline{i}_{m\lambda} = i_{dm\lambda} + j \cdot i_{qm\lambda}$; $\underline{i}_{f\lambda} = i_{df\lambda} + j \cdot i_{qf\lambda}$; $\underline{\psi}_{s\lambda} = \psi_{ds\lambda} + j \cdot \psi_{qs\lambda}$; $\underline{\psi}_{r\lambda} = \psi_{dr\lambda} + j \cdot \psi_{qr\lambda}$;
$\underline{\psi}^*_{r\lambda} = \psi_{dr\lambda} - j \cdot \psi_{qr\lambda}$; $\underline{\psi}_{m\lambda} = \psi_{dm\lambda} + j \cdot \psi_{qm\lambda}$; $j = \sqrt{-1}$; $\omega = z_p \cdot \omega_r$.

The previously presented relations are written in an orthogonal reference system $d\lambda - q\lambda$ which rotates with the angular speed $\omega_\lambda = d\lambda/dt$.

The previous relations can be put in matrix form. In the following we will present the *stator currents-rotor fluxes-air-gap fluxes* mathematical model.

$$\frac{d}{dt}\begin{bmatrix} \underline{i}_{s\lambda} \\ \underline{\psi}_{r\lambda} \\ \underline{\psi}_{m\lambda} \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ 0 & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \cdot \begin{bmatrix} \underline{i}_{s\lambda} \\ \underline{\psi}_{r\lambda} \\ \underline{\psi}_{m\lambda} \end{bmatrix} + \begin{bmatrix} b_{11} \\ 0 \\ b_{31} \end{bmatrix} \cdot \underline{u}_{s\lambda} \tag{10}$$

$$\frac{d}{dt}\omega_r = H_{m1}\cdot \mathrm{Im}\left(\underline{\psi}^{*}_{r\lambda}\cdot\underline{\psi}_{m\lambda}\right) - H_{m2}\cdot\omega_r - H_{m3}\cdot T_L \tag{11}$$

where $\sigma_a = \frac{L_{\sigma s}\cdot k_1}{L_{\sigma s}\cdot k_1 - 1}$; $k_1 = k_{1a} + k_{1b}$; $k_{1a} = \frac{1}{L_f} + \frac{1}{L_{\sigma s}}$; $k_{1b} = \frac{1}{L_{\sigma r}} + \frac{1}{L_m}$; $\gamma = \frac{1}{\sigma_a}$;

$a_{11} = a_{11\_re} + a_{11\_im}\cdot j\cdot\omega_\lambda$; $a_{11\_re} = -\gamma\cdot\left(\frac{1}{T_{\sigma s}} + \frac{1-\gamma}{\gamma\cdot T_f}\right)$; $a_{11\_im} = -\gamma$; $T_{\sigma s} = \frac{L_{\sigma s}}{R_s}$; $T_f = \frac{L_f}{R_f}$;

$a_{12} = a_{12\_re} + a_{12\_im}\cdot j\cdot(\omega_\lambda - \omega)$; $a_{12\_re} = \frac{\gamma-1}{L_{\sigma r}}\cdot\left(\frac{1}{T_f} - \frac{1}{T_{\sigma r}}\right)$; $a_{12\_im} = \frac{1-\gamma}{L_{\sigma r}}$; $T_{\sigma r} = \frac{L_{\sigma r}}{R_r}$;

$a_{13} = a_{13\_re} + a_{13\_im}\cdot j\cdot\omega_\lambda$; $a_{13\_re} = (\gamma-1)\cdot\left(\frac{1}{T_{\sigma r}\cdot L_{\sigma r}} - \frac{k_{1b}}{T_f}\right)$; $a_{13\_im} = (\gamma-1)\cdot k_{1b}$;

$a_{22} = a_{22\_re} - j\cdot(\omega_\lambda - \omega)$; $a_{23} = -a_{22\_re}$; $a_{22\_re} = -\frac{1}{T_{\sigma r}}$; $b_{11} = \frac{\gamma}{L_{\sigma s}}$; $\omega = z_p\cdot\omega_r$;

$a_{31} = a_{31\_re} + a_{31\_im}\cdot j\cdot\omega_\lambda$; $a_{31\_re} = L_{\sigma s}\cdot(1-\gamma)\cdot\left(\frac{1}{T_f} - \frac{1}{T_{\sigma s}}\right)$; $a_{31\_im} = L_{\sigma s}\cdot(\gamma-1)$;

$a_{32} = a_{32\_re} + a_{32\_im}\cdot j\cdot(\omega_\lambda - \omega)$; $a_{32\_re} = -L_{\sigma s}\cdot a_{12\_re}$; $a_{32\_im} = -L_{\sigma s}\cdot a_{12\_im}$;

$a_{33} = a_{33\_re} + a_{33\_im}\cdot j\cdot\omega_\lambda$; $a_{33\_re} = -L_{\sigma s}\cdot a_{13\_re}$; $a_{33\_im} = L_{\sigma s}\cdot(\gamma-1)\cdot k_{1a}$; $b_{31} = 1-\gamma$;

$H_{m1} = \frac{3}{2}\cdot\frac{z_p}{J}\cdot\frac{1}{L_{\sigma r}}$; $H_{m2} = \frac{F}{J}$; $H_{m3} = \frac{1}{J}$; $L_r = L_{\sigma r} + L_m$; $L_s = L_{\sigma s} + L_m$; $j = \sqrt{-1}$.

When $\omega_\lambda = 0$ in (10), we obtain the mathematical model in stator reference of the induction motor. On the other hand, the mathematical model of the induction motor in rotor reference, is obtained when in relation (10) we have $\omega_\lambda = \omega$.

3. NUMERICAL SIMULATION OF THE INDUCTION MOTOR

The mathematical model of the induction motor, which is simulated in Matlab-Simulink based on an S-Function type block, is given by relations (10) and (11), for $\omega_\lambda = 0$. In the simulation, starting the induction motor is of the direct on-line (DOL) type, in load (the load torque is equal to the rated torque).

In order to numerical simulate, a 1.5 [kW] induction motor is used, which has the electrical and mechanical parameters given in table 1.

Table 1. ***The electrical and mechanical parameters of the induction motor [1]***

	Name	Value		Name	Value
R_s	*Stator resistance*	4.85 [Ω]	J	*Motor inertia*	0.031[kg·m^2]
R_r	*Rotor resistance*	3.805 [Ω]	F	*Friction coefficient*	0.008[N·m·s/rad]

R_f	*Core loss resistance*	500 [Ω]	n_N	*Rated speed*	1420 [rpm]
L_s	*Stator inductance*	0.274 [H]	z_p	*Number of pole pairs*	2
L_r	*Rotor inductance*	0.274 [H]	f_N	*Rated frequency*	50 [Hz]
L_m	*Mutual inductance*	0.258 [H]	U_N	*Rated voltage*	220 Δ/380 Y [V]
L_f	*Eddy currents leakage inductance*	0.1 [H]	M_N	*Rated torque*	10 [N·m]

The induction motor simulation program is presented in Fig. 2.

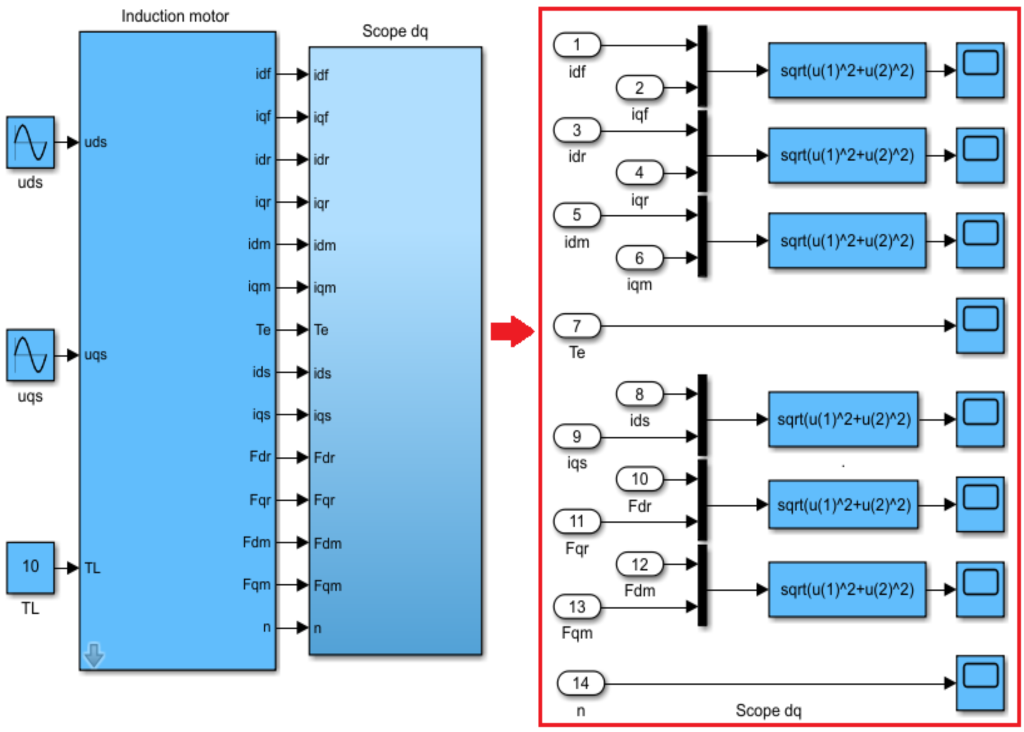

Fig. 2. The induction motor simulation program

The internal structure of the “Induction motor” block (from Fig.2), is presented in Fig.3.

Within the simulation program, the d-q components of the stator voltages are given by the following relations

$$\begin{cases} u_{ds} = U_N \cdot \sqrt{\dfrac{2}{3}} \cdot \sin(\omega \cdot t) \\ u_{qs} = U_N \cdot \sqrt{\dfrac{2}{3}} \cdot \sin\left(\omega \cdot t - \dfrac{\pi}{2}\right) \end{cases} \quad (12)$$

where: $U_N = 380[V]$; $\omega = 2 \cdot \pi \cdot f$; $f = 50[Hz]$.

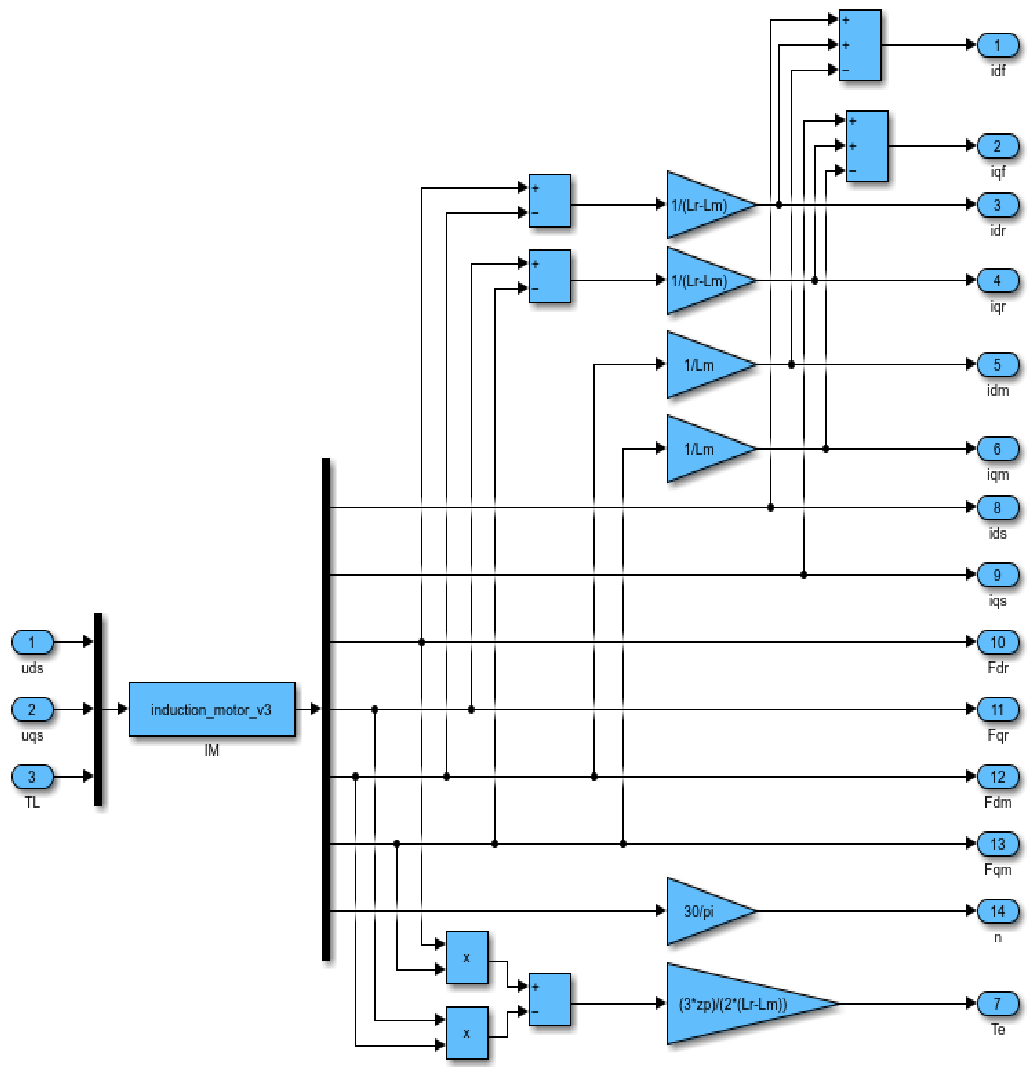

Fig. 3. The internal structure of the "Induction motor" block

In Fig.3, the "IM" block is of the S-Function type. The Matlab program attached to this block is shown in Fig.4.

The parameters of the S-Function block (from Fig.3) are: Rs, Rr, Rf, Lf, Ls, Lr, Lm, J, F, zp (see Table 1). The "Induction motor" block (see Fig. 2) is obtained based on the program shown in Fig. 3, using the operation of creating a subsystem (shortcut key: Ctrl+G), specific to the Simulink program. On the other hand, the "Induction motor" block (from Fig.2) has a created mask (shortcut key: Ctrl+M), in which electrical and mechanical parameters of the induction motor are entered (see Table 1).

```
function [sys,x0]=induction_motor_v3(t,x,u,flag,Rs,Rr,Rf,Lf,Ls,Lr,Lm,J,F,zp)
Lgs=Ls-Lm;
Lgr=Lr-Lm;
Tgs=Lgs/Rs;
Tgr=Lgr/Rr;
Tf=Lf/Rf;
k1a=(1/Lf) +(1/Lgs);
k1b=(1/Lgr) +(1/Lm);
k1=k1a+k1b;
ga=(Lgs*k1)/(Lgs*k1-1);
gam=1/ga;
a11_re=-gam*((1/Tgs) +(1-gam)/(gam*Tf));
a12_re=((gam-1)/Lgr) *((1/Tf) -(1/Tgr));
a12_im=(1-gam)/Lgr;
a13_re=(gam-1) *((1/(Tgr*Lgr))-k1b/Tf);
a22_re=-1/Tgr;
a31_re=Lgs*(1-gam) *((1/Tf) -(1/Tgs));
a32_re=-Lgs*a12_re;
a32_im=-Lgs*a12_im;
a33_re=-Lgs*a13_re;
b11=gam/Lgs;
b31=1-gam;
Hm1=(3*zp)/(2*J*Lgr);
Hm2=F/J;
Hm3=1/J;
if abs(flag)==1
     sys=[a11_re*x(1)+a12_re*x(3)+a12_im*zp*x(7)*x(4)+a13_re*x(5)+b11*u(1);
          a11_re*x(2)+a12_re*x(4)-a12_im*zp*x(7)*x(3)+a13_re*x(6)+b11*u(2);
          a22_re*x(3)-zp*x(7)*x(4)-a22_re*x(5);
          a22_re*x(4)+zp*x(7)*x(3)-a22_re*x(6);
          a31_re*x(1)+a32_re*x(3)+a32_im*zp*x(7)*x(4)+a33_re*x(5)+b31*u(1);
          a31_re*x(2)+a32_re*x(4)-a32_im*zp*x(7)*x(3)+a33_re*x(6)+b31*u(2);
          Hm1*x(3)*x(6)-Hm1*x(4)*x(5)-Hm2*x(7)-Hm3*u(3)];
elseif flag==3
   sys=x;
elseif flag==0
   sys=[7 0 7 3 0 0];
    x0=[0;0;0;0;0;0;0];
else
   sys=[];
end
```

Fig. 4. The Matlab program of the "IM" block

The simulation of the induction motor is done using the Dormand-Prince numerical method (ode45), which has a relative and absolute error of $\varepsilon = 10^{-7}$.

The results obtained after the simulation are presented in the following figures

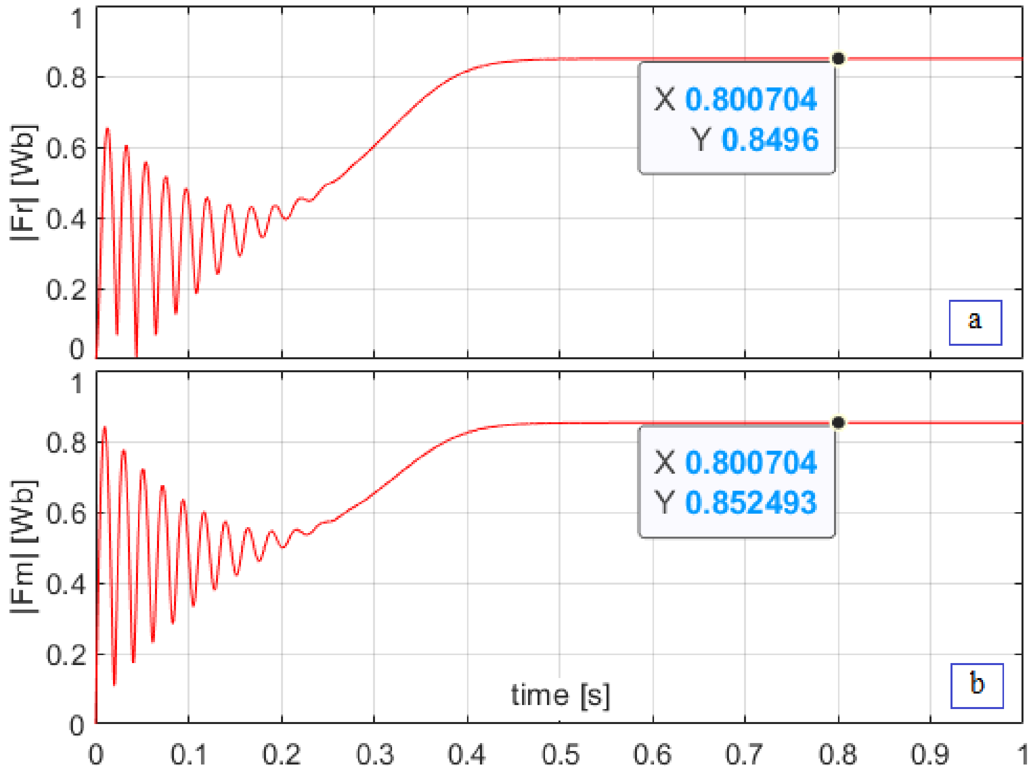

Fig. 5. The rotor flux (a) and the air-gap flux (b) space vectors - absolute values

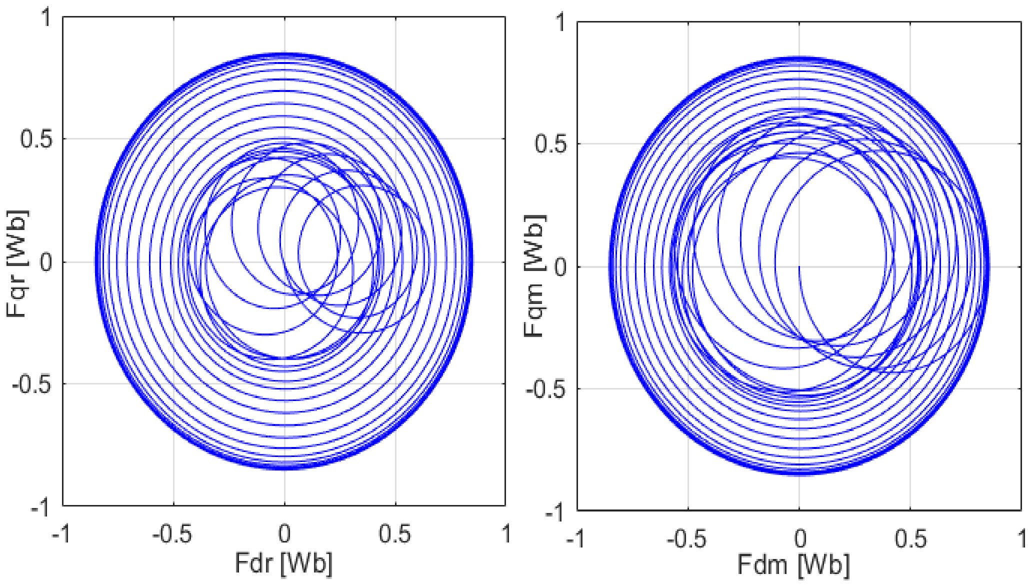

Fig. 6. The trajectory of the rotor flux (a) and of the air-gap flux (b) - space vectors

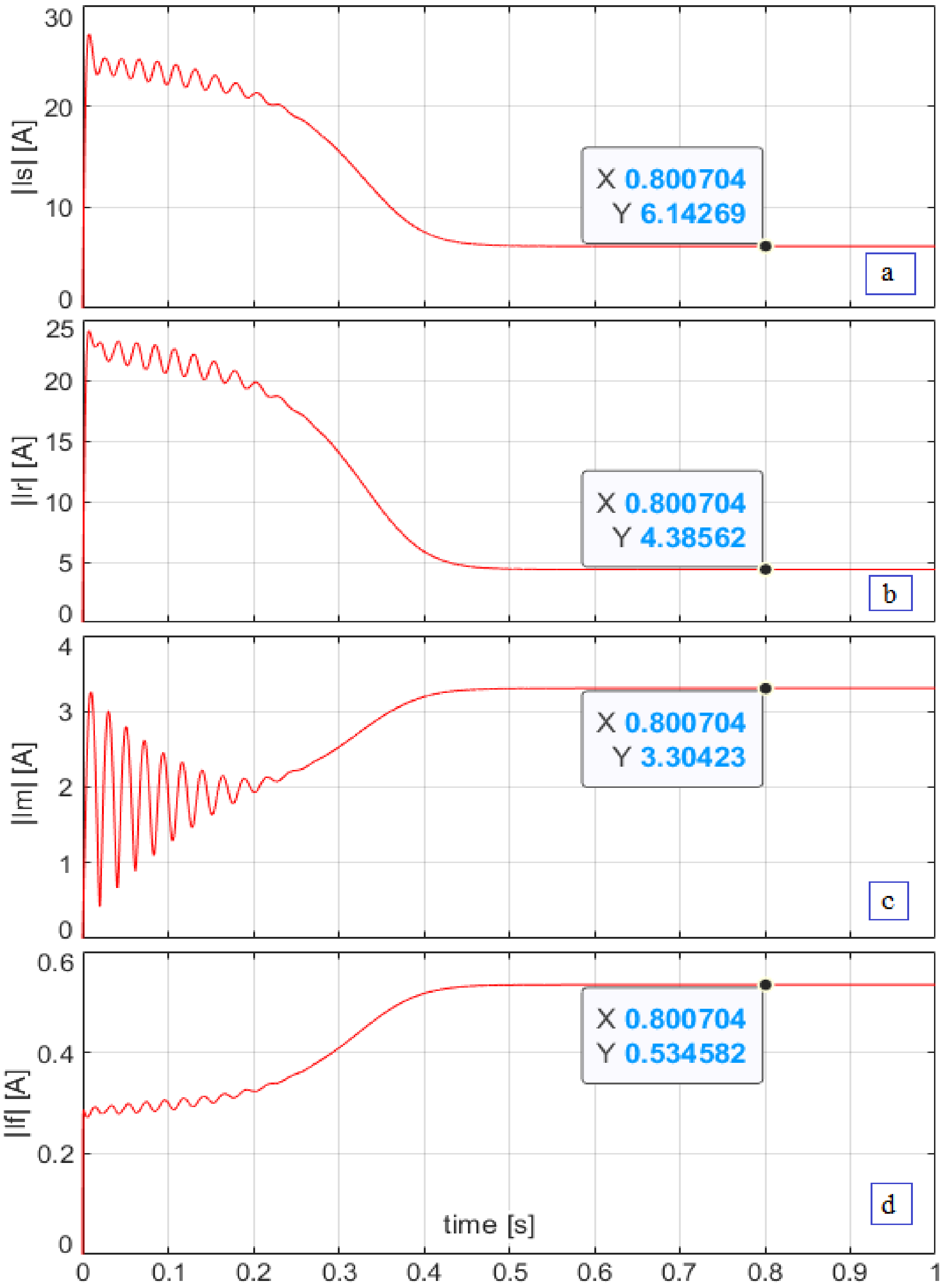

Fig. 7. The currents space vectors - absolute values
(a) the stator current; (b) the rotor current; (c) the magnetizing current; (d) the current through the core loss branch

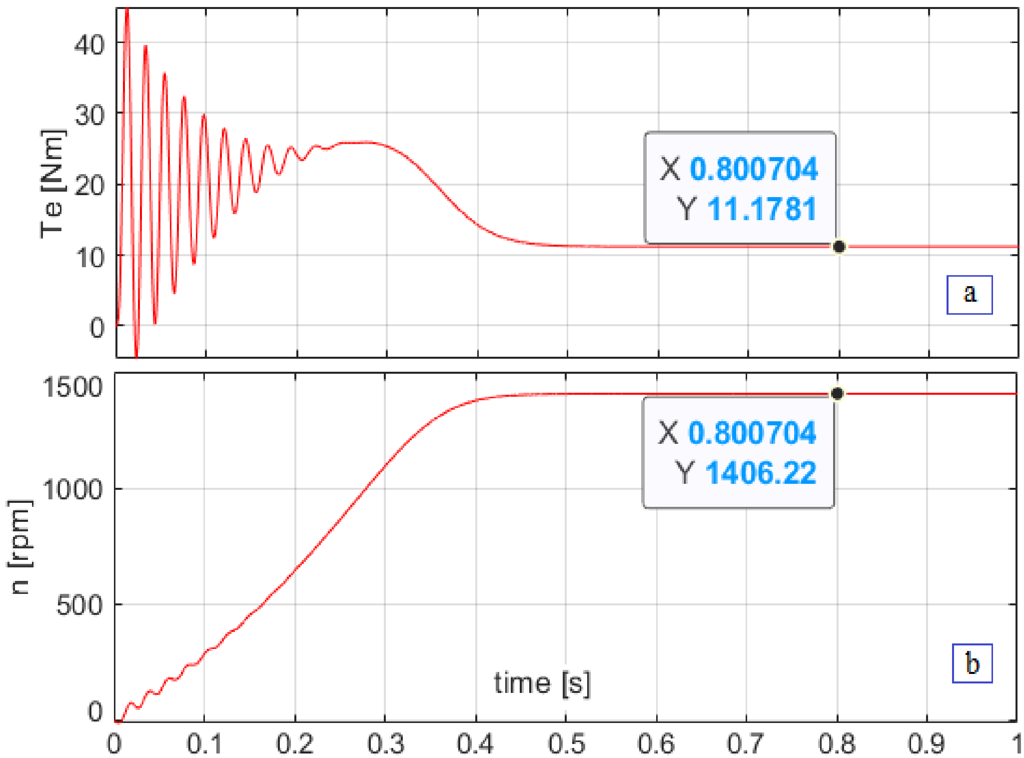

Fig. 8. The electromagnetic torque (a) - The speed of the induction motor (b)

From Fig.8 it can be seen that the induction motor, upon direct application of the supply voltages, starts the load without problems, reaching a speed of 1406 [rpm], after a time of 0.5 [s]. At the same time, the electromagnetic torque developed by the induction motor reaches the approximate value of 11 [Nm].

On the other hand, from Fig.7, it can be seen that both in transient mode and in stationary mode, we can write the following inequalities between the values of the induction motor currents space vectors: $|\underline{i}_s| > |\underline{i}_r| > |\underline{i}_m| > |\underline{i}_f|$.

At the moment of starting in load of the induction motor, the module of the stator current space vector reaches the value of 27.13 [A], while the module of the rotor current space vector reaches the value of 24. 08 [A]. The time at which these maximum values are reached is approximately 7.5 [ms].

The trajectories of the space vectors of the rotor flux and of the air-gap flux are perfectly circular in stationary regime (see Fig. 6). Due to the direct start in the load, the trajectories of the two space vectors, in transitory regime, show oscillations that amortize in time (see Fig. 6). These oscillations stabilize after a time of approximately 0.5 [s] (see Fig.5).

On the other hand, from Fig. 5, it can be seen that: $|\underline{\psi}_m| > |\underline{\psi}_r|$ (this inequality is valid both in transitory regime and in stationary regime).

4. CONCLUSIONS

The inclusion of the eddy current leakage inductance in the core loss branch complicates the parallel mathematical model of the induction motor. The number of mathematical operations increases, and the 3x1 vector that multiplies the stator voltage space vector, has an additional element, compared to the mathematical model in which the eddy current leakage inductance is not taken into account. On the other hand, the inclusion of the eddy current leakage inductance in the core loss branch does not significantly increase the accuracy of the mathematical model of the induction motor. However, the use of the mathematical model presented in this article in the vector control systems of the speed of induction motors can lead to better dynamic performances, in terms of the dynamics of flux and/or speed observers.

The detailed presentation of both the mathematical model and the induction motor simulation program offers specialists a very useful support. The induction motor simulation program is based on the use of an S-Function type block, specific to the Simulink program.

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THE INVOLVEMENT OF THE STATE IN FINANCING ELECTRIC TRANSPORT SYSTEM

CLAUDIA ISAC[1]

Abstract: This paper presents a financial perspective of green businesses, in particular how they can be financed. Thus, we presented the main external sources of financing, highlighting the role that European funds play in this context. In the second part of the paper, I presented the methods through which the state can stimulate these businesses, and in particular the financial incentives granted through different categories of programmes. I ended the paper by highlighting the main conclusions that I reached after studying this topic.

Keywords*:* financial perspective, green business, European funds, electric transport system, electric vehicles.

1.INTRODUCTION

Generally speaking, business financing means obtaining and making available sums of money, rights and productive goods that allow the company's activity to be carried out under normal conditions. In order to finance its development, an enterprise can resort to internal and external sources [2].

Financing from internal sources is achieved through self-financing and increasing the social capital by incorporating incentive pays and reserves. Financing from external sources knows two main ways of achieving, namely increasing the social capital through the issuance of new shares and increasing the degree of indebtedness through: contracting bank loans, issuing bonds, financing through leasing, financing through factoring, lump sum, etc. Apart from these "classic" funding sources, in recent years, access *to European funds has become an important source for business development.*

In the context of Romania's integration into the European Union, the most important source of financing is the non-refundable financing intended to support activities in areas for which there are not enough financial resources currently accessible or in areas where there is a need for financial resources greater than availabilities. The system of external public non-reimbursable financing is one of the components of the broader mechanisms of collaboration between states, it has the connotation of support

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given to solve special situations for which the beneficiary state does not have the necessary financial resources.

Much like the pre-accession funds (Sapard, Phare, Ispa), the structural funds are a form of non-reimbursable financing that became operational in Romania starting with 2007, with Romania's integration into the EU. The structural funds are financial instruments through which the European Union pursues eliminating or reducing economic and social disparities, in order to achieve economic and social cohesion between regions and are allocated to various projects through development programs that contain certain development directions and eligible measures to receive such funding.

2. GREEN BUSINESS FINANCING

Ecological or green businesses have an innovative character, which also determines technological and managerial risks, a fact for which their development is constrained from a financial point of view.

Since accessing funds with a non-reimbursable component is beneficial for the financing of green businesses, the factors that can prevent access to financing have been identified, such as: the uncertainty and complexity of technologies, the ambiguity of the evaluation criteria by creditors due to the lack of evaluation specialists, the instability market demand and the regulatory environment.

Knowing them allows institutions with attributions in developing strategies and with a role in financing green businesses to create the necessary framework through which green entrepreneurship is stimulated [3].

Green businesses have a high potential to provide much better sustainability compared to conventional businesses. The involvement of interested stakeholders is a key element for the development of these businesses [1].

Thus, it is important to implement a set of government measures aimed at protecting the environment through which the necessary conditions for the emergence of green entrepreneurship on a wider scale can be stimulated and new trends can be identified in enhancing the role of institutions for the performance and survival of green entrepreneurship. From this perspective, European funding can complement the funding sources related to the development of this type of business.

For the period 2014-2020, the most important European funding program with important effects on infrastructure and resources is the Large Infrastructure Operational Program whose objectives were: the development of transport infrastructure, environment, energy and risk prevention to European standards, strengthening the capacity to management of the COVID-19 health crisis in order to create the premises for sustainable economic growth, in safe conditions and efficient use of natural resources [4].

In the field of the environment, the investments considered the implementation of the community acquis in the field of water and wastewater, by continuing the process of regionalization of management in this sector, as well as that of waste management, the financing of protected natural areas and Natura 2000 sites, as well as the decontamination of historically polluted industrial sites and from the perspective of climate change, the investments were oriented towards non-structural and structural measures with the role of prevention of the main risks faced by Romania, namely floods, drought and coastal erosion, also granting attention to strengthening the response capacity of structures with a role in the management of emergency situations.

Clean energy and energy efficiency, as well as ensuring the flexibility of electricity and natural gas transport, are a priority dedicated mainly to the private sector, both for producers and distributors of energy from renewable resources whose potential has been less exploited, and for commercial companies active in the industrial sector, who want to make their energy consumption more efficient through cogeneration.

In the next period, the European Resilience and Recovery Mechanism will be implemented, which is the central element of the Next Generation EU Instrument, with loans and grants worth 672.5 billion euros, available to support the reforms and investments undertaken by the countries of the European Union.

The implementation of this project aims to mitigate the economic and social impact of the pandemic and to make European economies and societies more sustainable, resilient and better prepared for the challenges and opportunities offered by the transition to a green economy and the digital transition.

From the perspective of environmental protection, the first pillar of the Green Transition, which is structured in 6 priority areas, is important [7]:

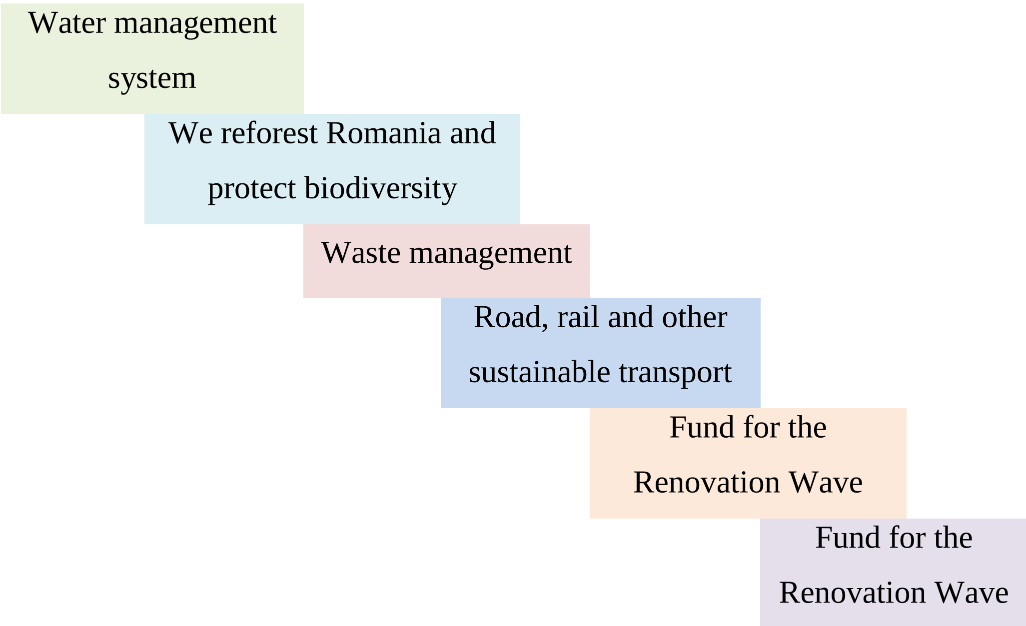

Fig.1. Priority area in Green Transition

Another source of funding is the Investment Plan for a Sustainable Europe, which mobilizes public investments and contributes to unlocking private funds through EU financial instruments worth at least 1000 billion euros. This funding source will mobilize EU funds and create an enabling framework to facilitate and stimulate the public and private investments needed for the transition to a climate-neutral, green, competitive and inclusive economy.

The plan is based on three components [8]:

- *The financing component* through which more than 1,000 billion euros representing sustainable investments will be mobilized in the coming years. The largest share will be redirected to climate and environmental actions and will make it possible to attract private funds with the help of the European Investment Bank;
- *The facilities component*, which provides incentives for unlocking and redirecting public and private investments, will facilitate the realization of sustainable investments by public authorities and will encourage the largest share of the budget to be directed towards ecological public procurement;
- *The advisory component* through which support will be provided to public authorities and those interested in sustainability projects.

Nowadays more and more institutions and organizations are interested in supporting the concept of green entrepreneurship, an example being Startarium created by Impact Hub and ING Bank and which developed Black Sea ClimAccelerator, an opportunity for green start-ups in Romania [9] which has the role of supporting innovative Romanian solutions in the field of climate change by financing green start-ups that are in the idea stage or green startups with a prototype validated with customers and scalable solutions.

Examples of ideas that startups can apply for consulting and funding follow [10]:

- eco-innovation solutions through clean urban mobility;
- Green and sustainable solutions for cities and buildings;
- waste management projects;
- climate-smart agriculture;
- nature education projects;
- projects for the development of a circular economy;
- intelligent transport solutions [6];
- ecological transport solutions;
- projects for the development of sustainable materials;
- ways and solutions that encourage responsible consumption.

3. THE FINANCIAL INVOLVEMENT OF THE STATE FOR THE DEVELOPMENT OF ELECTRIC TRANSPORT

An area with a negative impact on the environment is the area of transport, especially land transport, with motor vehicles that use fuels. For these reasons, research in the field comes up with various ways to replace them that will have a much more protective impact on the environment and will constitute effective solutions for the transport of people and goods.

The trends in this field are moving towards the use of electricity as fuel, so the production of electric cars and the provision of the necessary logistics represent niches for business development and more and more entrepreneurs have identified this potential.

In Romania, to promote electric vehicles, the Ministry of the Environment has implemented the program to stimulate the purchase of electric and hybrid cars [11]. *This program is modified by the 2020-2024 National Car Park Renewal Stimulation Program, approved by Order of the Minister of Environment, Water and Forests no. 324/2020, with the subsequent amendments and additions to modify the Rabla (Olod Cars) Program and provides*: a bonus of 10,000 euros and zero tax for the electric car; obtaining a voucher of 45,000 lei for the purchase of a new purely electric vehicle and 20,000 lei for the purchase of a new hybrid electric vehicle with an external power source through the Rabla program.

And other states have implemented "national policies on the promotion of electric cars and the pollution-free market" [12], the most interesting being the following: In Belgium from 2016, the battery of electric vehicles is included "in the same tax scheme of oil and diesel cars. The resulting increase in the number of registrations will be gradual, to 20% of the total taxes in 2016, 40% in 2017, 65% in 2018, 90% in 2019, 100% in 2020; In France there is an option to offer a registration tax exemption for alternative fuel vehicles (eg electric, hybrid, CNG, LPG and E85). \

A premium is also guaranteed for the purchase of a new electric vehicle, for a vehicle that emits 20g CO_2 / km or less, the bonus amounts to 63,000 euros. Electric vehicles are exempt from the car tax, hybrid cars that emit less than 110g CO_2 / km are exempt in the first 2 years after registration; In Denmark, battery electric vehicles are exempt from paying annual taxes; in Germany, non-polluting cars with zero CO_2 emissions are exempt from car taxes; In Greece, electric and hybrid cars are exempt from all taxes; in Ireland until December 2021, electric vehicles benefit from a 5,000 euros discount on the vehicle registration fee; in Italy, buyers of electric cars benefit from a 75% tax reduction; exemptions from purchase tax and annual road tax have been adopted in Norway for electric cars.

In conclusion, the state has a very important role in stimulating business in the field of transport, by reducing taxes in the purchase of an electric car, exemptions from annual road taxes, bonuses granted for the purchase of an electric car, etc.

Although electric cars were introduced to the market more than three decades ago by major car manufacturers, it is only in recent years that they have become popular among consumers, with both hybrid and electric cars having a significant impact on the car market. "Electric cars are classified into five categories" [13]:

- *BEV – Battery Electric Vehicle* – a car that is set in motion by one or more electric motors, powered by a battery that needs to be recharged at a special station or at home at a regular outlet. Charging times vary by cable and method, ranging from 30 minutes to 12 hours. The most popular electric cars of this kind in Romania are Renault Zoe, Nissan Leaf or Volkswagen e-Golf.
- *PHEV – Plug-In Hybrid Electric Vehicle* – where the power is provided by an internal combustion engine, simultaneously with an electric motor. The battery of the electric motor can be charged separately or via the heat engine. Popular examples in Romania would be the Mitsubishi Outlander PHEV, Peugeot 508 or Toyota RAV 4 PHEV.
- *MHEV – Mild Hybrid Electric Vehicle* – the car is based on the internal combustion engine but also on an electric drive with the role of conserving

resources during braking, constant driving or stops. Even if this electric propulsion is not enough to move the vehicle by itself, it allows the thermal engine to be stopped in the right circumstances and restarted promptly, thus saving fuel and reducing polluting emissions.

- *EREV – Extended Range Electric Vehicle* – a variant of "PHEV" in which the batteries are charged when needed and by a small current generator that has the function of a very small gasoline engine (around 500-600cc) and that can be fed at any gas station. An example for this category is the BMW i3.
- *HEV – Hybrid Electric Vehicle* – the electric engine works simultaneously with the thermal engine, thus achieving excellent consumption performance. Popular models that use this technology are the Toyota CH-R and the Toyota Prius.

According to the data presented in the Deloitte report „Electric Vehicles. Setting a course for 2030 [14]", electric car sales will grow by almost 30% annually over the next ten years, so that one in three new cars sold globally will be electric and the total number of electric cars sold annually worldwide will increase from 5 million in 2021, to 11.2 million in 2025 and to 31.1 million in 2030.

The authors of this report also identified a key factor in stimulating the increase in demand for electric cars, namely the change in consumer attitudes by dissipating the barriers that have, until now, limited access to such cars, respectively: limited model supply for electric and hybrid cars, relatively high prices, user education, poor logistics for charging electric cars etc.

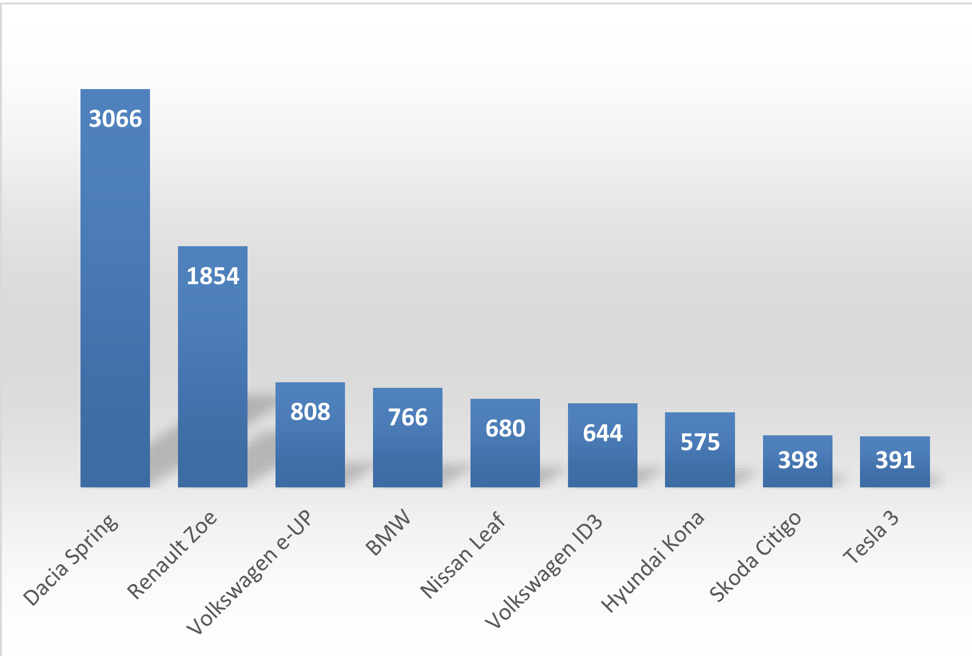

Fig.2. Electric vehicles registered in Romania, 2021

In Romania, in 2020 there were 3210 electric vehicles, ZOE, i3 and Leaf, which were the most popular, totalling together over 53% of the BEV market, where you can also add the E-Golf reaching almost 64%.

Due to the COVID pandemic, the number of electric cars purchased in 2020 recorded a decrease of approximately 46%, the most popular cars being the most affected, namely the Renault Zoe which had a decrease of 80%, the Hyundai I3 by 40% and the Leaf by 25%.

The electric vehicles registered in Romania in 2021 had an increase compared to the previous period and the best-selling cars were: Dacia Spring with a number of 3066 units, followed by Renault Zoe with 1854 units and the other brands, respectively Volkswagen, BMW, Nissan, Hyundai, Skoda, Tesla with a much smaller number.

Businesses and entrepreneurs with innovative ideas can reimagine and create services, products and supply chains that do not negatively impact the planet.

4. CONCLUSIONS

In conclusion, green business financing is necessary and possible and businesses and entrepreneurs with innovative ideas can reimagine and create services, products and supply chains that do not have a negative impact on the planet.

Thus, by operationalizing these ideas a society shapes its economic, social and environmental system so that global natural resources and life support systems are maintained and used efficiently.

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THE NECESSITY AND OPPORTUNITY OF ESTABLISHMENT THE STRATEGIC STUDIES OF ENERGY SECURITY RESEARCH CENTER FROM THE UNIVERSITY OF PETROSANI

NICOLAE DANIEL FÎȚĂ[1], MIHAI SORIN RADU[2], ILIE UȚU[3], MARIUS DANIEL MARCU[4], DRAGOȘ PĂSCULESCU[5], SORINA DANIELA STĂNILĂ[6]

Abstract: The "Strategic Studies of Energy Security " Research Center was established following Decision no. 136 of October 4, 2021 of the Senate of the University of Petrosani, based on the provisions of the National Education Law no. 1/2011, the Charter of the University of Petrosani and the Regulation on the organization and functioning of the Senate of the University of Petrosani. The academic community within the "Strategic Studies of Energy Security " Research Center is a national and international elite group composed of professionals with extensive academic experience in the field of energy, industrial, economic and national security, accumulated during years of study and experience professional and who are always ready to fulfill their obligations at the highest level of quality and professionalism, patriotic, honest, proactive and who are always ready to be in the service of the country.

Keywords: research center, strategic studies, energy security.

1. WHO WE ARE

The “Strategic Studies of Energy Security” Research Center was established following the Decision no. 136 of October 04, 2021 of the Senate of the University of Petrosani, based on the provisions of the National Education Law no. 1/2011 (with subsequent amendments and completions), The Charter of the University of Petrosani and the Rules of Organization and operation of the Senate of the University of Petrosani [7], [9], [11].

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Purpose is to become the most important pillar of national civil scientific knowledge and expertise, by developing strategic energy security studies for the Romanian Presidency, Prime Minister, Ministry of Energy and other public structures with attributions to ensure energy, industrial and national security [5], [8], [10].

The "Strategic Studies of Energy Security" Research Center is a national and European elite group (thing Tank) composed of civil and military teachers, researchers, experts, evaluators, specialists, officers, etc., with extensive professional and academic experience in the following areas:

- *Security*: national, energy, industrial, critical infrastructure, etc.;
- *Engineering*: industrial, electrical and energy, systems, oil and natural gas, mining, nuclear, transport, etc. [6], [13], [15].

Context of establishment:

- the increasing occurrence of cases of *energy terrorism* – black/brown-out (total/partial exit of some energy subsystems or of the entire integrated National Energy System);
- using energy (in all its aspects and dimensions) as a possible *energy weapon* or *pressure instrument* around the world;
- certain critical energy infrastructure may be the *target of terrorist* or *cyber attacks* [1] [2] [14].

2. MISSION AND VALUES

The mission of the "Strategic Studies of Energy Security" Research Center is to stimulate scientific research activities, through research carried out in order to strengthen managerial capacity, covering various thematic sectors and providing the organizational and informational framework necessary for the elaboration, development and implementation of the project – development projects initiated by the members of the academic community of the Center.

The "Strategic Studies of Energy Security" Research Center will promote, in the field of scientific research, the following set of values:

- professionalism and proactive attitude in the field of engineering and security (national security, economic security, industrial security, energy security, cyber security, security, etc.) electrosecurity, security of critical systems and infrastructures, etc.);
- ethics;
- feasibility;
- performance in research;
- protection of intellectual property rights;
- extensive dissemination of scientific research results;
- professional development and improvement of human resources [3], [12], [17].

3. PURPOSE AND OBJECT OF ACTIVITY

The "Strategic Studies of Energy Security" Research Center aims to develop multidisciplinary and interdisciplinary scientific research, to train students, teachers and specialists in key strategic areas of the national energy industry, with reference to energy security:

- national security;
- economic security;
- industrial security;
- security of resources, reserves and strategic energy storage;
- security of extraction, transport and distribution of energy resources;
- security of electricity generation;
- security of electricity transmission and distribution;
- occupational health and safety;
- cyber security;
- security of critical energy systems and infrastructures;
- electrical safety.

They take place through a process of supporting the balance between continuity and innovation in the field of fundamental and applied research in the existing industrial context following integration in the European Union and NATO, aiming to improve communication between universities, institutions and economic agents, as well as non-governmental organizations in the research area [4], [16], [18].

The " Strategic Studies of Energy Security" Research Center has as object of activity:

- carrying out scientific research activities;
- developing strategic studies and providing scientific documentation on specific energy security issues for decision makers within the national economy and industry and other structures with attributions in the field of energy, industrial and national security;
- elaboration of scientific papers for the purpose of developing the theory and practice of energy security;
- to respond to the strategic challenges of the contemporary energy security environment in the context of dynamism and energy process, by developing, implementing and disseminating the results of scientific research;
- providing consultancy, expertise and services specific to state and private institutions and entities with attributions in the field of energy, industrial and national security;
- substantiating the theoretical basis of the place and functions of the energy component in the main strategic documents for national security planning;
- the introduction of energy security in the national security component;
- investigating changes in the evolution of the strategic energy environment with influence on national interests;
- exploring the energy role in the future operational environment of national security;
- study of phenomena within the energy environment with impact on national security;
- developing cooperation with civil and military research institutes, governmental and non-governmental structures, other universities in the country and abroad;
- promoting the strategic, energy, industrial and national security culture in the romanian society;

- involvement in the educational process by supporting professional training at strategic level within the University of Petrosani, at doctoral, master, bachelor and postgraduate level;
- initiation and development of research works in the field of energy industrial risk assessment;
- participation in research and development programs and grant programs of the Ministry of Education and Research, the Academy of Romanian Scientists, the Academy of Technical Sciences of Romania, or of international institutions;
- participation in the organization of various scientific events enrolled in the program of the University of Petrosani, as well as those initiated by the "Strategic Studies of Energy Security" Research Center;
- capitalizing on the results of research works by publishing and disseminating information bulletins and documentaries, good practice guides and other scientific publications.

The " Strategic Studies of Energy Security" Research Center organizational chart is as shown in fig. 1.

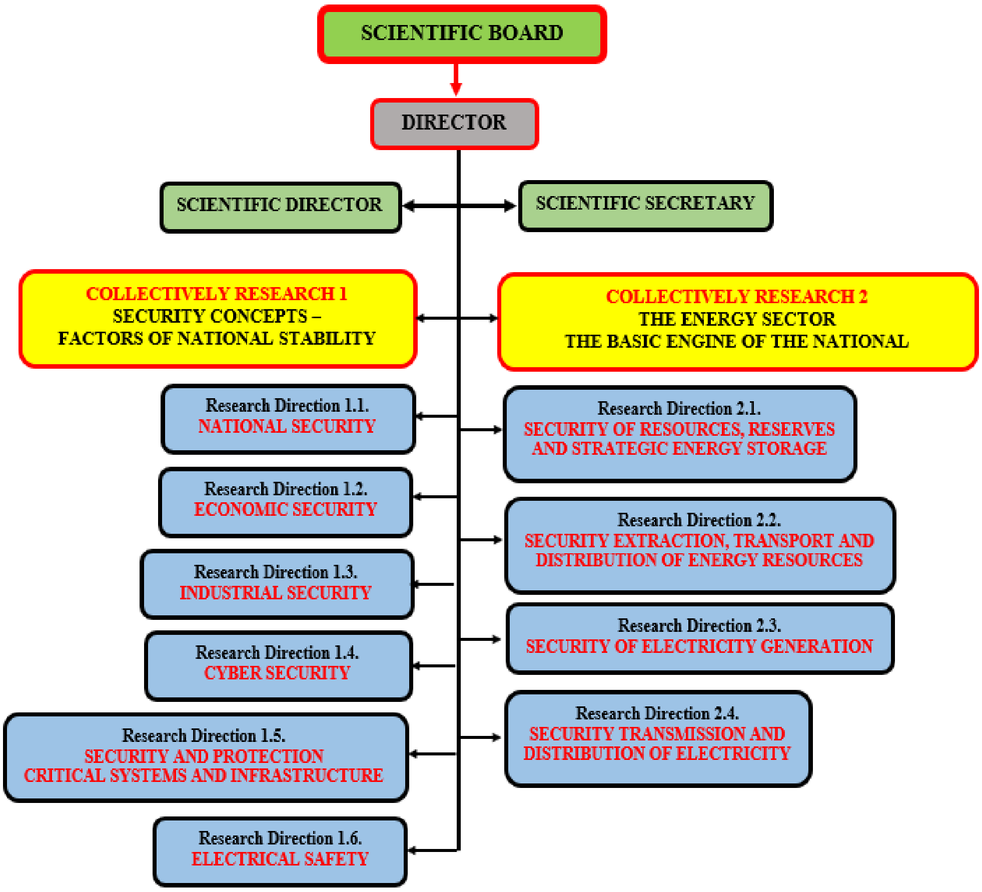

Fig. 1. Strategic Studies of Energy Security Research Center organizational chart

4. CONCLUSIONS

The importance and necessity of the "Strategic Studies of Energy Security" Research Center arises from the following considerations:

- the increasing occurrence of cases of energy terrorism – black/brown-out (total/partial exit of some energy subsystems or of the entire integrated National Energy System);
- using energy (in all its aspects and dimensions) as a possible energy weapon or pressure instrument around the world;
- certain critical on-shore or off-shore energy infrastructures on the territory of Romania or from the Romanian Black Sea platform, or certain appliances and equipment within these critical energy infrastructures (oil pumping stations, natural gas compression stations, power stations and power plants, offshore drilling platforms, extraction wells, refineries, marine terminals, strategic storage facilities, land or marine pipelines, land or sea pipelines, air power lines and certain nuclear facilities or equipment), may be remotely remote from a distance through cyber-attacks or may be the target of terrorist attacks;
- vulnerability of critical infrastructures leads to consumers' lack of energy and to a national crisis, by the fact that all sectors of the national economy depend on energy;
- the crisis triggered leads to a state of social imbalance and at the same time brings extreme damage to the safety of the citizen and national security;
- in this context, the integrated National Energy System, through the other related subsystems (resources, reserves and energy storage, oil, natural gas, mining, nuclear, electricity), becomes a strategic objective of national importance by being a generator of national and european critical infrastructures.

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REALISATION A REAL 24-HOUR ELECTRICITY BALANCE AT LIGNITE COAL MINE

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Abstract: In recent years, reducing energy use and complying with environmental regulations and legislation have become an integral part of the strategy of industrial enterprises. In a lignite quarry, due to the specific nature of the activity carried out, the main objectives (set at European Community level) that the technologies applied must meet are: reduced raw material requirements, reduced energy requirements and the production of reduced pollutant emissions and waste.

Thus, the interest in improving applied technologies is both energy, environmental and economic. For these reasons, I have proposed to present a general model of energy analysis of a quarry outline; in order to establish and prioritize plans of measures to reduce the energy used and the environmental impact.

Keywords: energy balance, energy losses, useful energy, mining excavator.

1. INTRODUCTION

The elaboration and analysis of energy balances is a scientific method for assessing the energy-economic efficiency of all electrical installations of users in a lignite quarry, with the aim of improving energy yields, raising the technical-economic level of their operation and improving electricity supply schemes.

Electroenergy balances are used to:

- determination of electricity losses throughout the installations and their component parts;
- highlighting unused secondary resources from an electroenergy point of view and establishing possibilities for their exploitation;

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- the rationale for the technical and organisational measures envisaged to increase the efficiency of electricity use in all electrical equipment in the installations;
- the development of scientifically substantiated standards for specific electricity;
- determining quality indicators in order to compare actual indicators with those designed or with indicators from other similar companies.

The work in a lignite quarry must be carried out along the following lines:

- improving the environmental performance of industrial activities;
- use of clean technologies as a pollution prevention measure; application of efficient processes in the use of natural resources in power generation; taking measures to correct environmental impacts;
- the use of waste as secondary raw materials and fuels.

For energy-intensive industries (day-to-day exploitation of lignite), energy is an important part of the total production cost within the energy complex.

Lately, lignite quarries have had to implement energy efficiency measures on a large scale, facing tough international competition. Product prices are set on the global market and characterised by high CO_2 per unit of sales.

In the following, we have developed the general concept of an analysis model aimed at energy, environmental and economic assessment of technological processes in a typical industrial contour belonging to an energy complex.

Taking into account what was presented and statistical data of the analyzed Energy Complex, some diagrams and tables we determined electricity losses in some electric networks, electric motors, transformers, i.e. we made real electric balance on some machines.

At the quarry analysed, the contour for which the energy balance is being drawn up is defined as the approved quarry perimeter with 20 kV overhead power lines as inputs, starting from the 110/20 kV transformer station [6].

The main machines supplied with electricity that are components of the technological flow at the quarry are: excavator type ERC - 2000, excavator E01 type ERc 1400 30/7, excavator E02 type ERc 1400 30/7, excavator E03 type ERc 1400 30/7, excavator E04 type ERc 470 15/3,5, excavator E05 type ERc 1400 30/7, excavator E06 type ERc 1400 30/7, bucket A01 type MH 6500/90, bucket A02 type MH 6500/90, bucket A03 type MH 4400/170, belt trolley - MAN 1 type CBS 1200, belt trolley - MAN 2 type CBS 1200, belt trolley - MAN type CDS 1400, stacker type MST-1-T 2053, stacker type MST-2-T 2053, warehouse removal machine type T 2846, belt conveyors of various types and sizes [1].

2. ENERGY BALANCE OF EXCAVATOR TYPE ERC - 1400X30/7

The excavator type ERc 1400 30/7 is designed for excavating tailings and coal and depositing the excavated material on the face conveyor.

Table 1 shows the main technical characteristics of the excavator type Erc 140030/7 required for the energy analysis.

Table 1. ***Technical characteristics of the excavator type ERc - 1400x30/7***

Working arrangements	**long-lasting**	
Nominal cup capacity	1	1400
Diameter of bucket wheel on cutting centre	m	11,5
Number of cups:		
- cutting	buc	9
- filling	buc	9
Theoretical excavation capacity	m^3/h	3280/3860
Cutting speed	m/s	2,6/3,08
Electric motor power to drive the bucket wheel	kW	630
Cutting height above support plane	m	about 30
Cutting depth below support plane	m	about 7
Horizontal swivel range of the bucket wheel arm	degrees	210°
Rubber mat width		
- for conveyor bands	mm	1800
- for dirt bands	mm	2000
Transport speed:		
- for conveyor bands	m/s	3,6
- for dirt bands	m/s	1
Travel speed	m/min	about 6
Average pressure on the ground	daN/cm^2	1,07
Minimum turning radius	m	about 60
Maximum admissible slope		
- during work		1:25
- when changing workplace		1:20
Service table of the installation	t	about 1980
Mass in service	t	about 2050
Power supply voltage and frequency	V, Hz	6000, 50
Installed power	kW	2950

In the technological excavation process, the following equipment is permanently in operation: bucket wheel mechanism, bucket wheel drive (630 kW motor; 6 kV; 104.7 rad/s (1000 rpm)) and the strip plant comprising: strip no. 1 driven by 2 motors of 200 kW at a voltage of 0.4 kV with 104.7 rad/s (1000 rpm), strip no. 2 driven by 2 x 160 kW motors at 0.4 kV at 104.7 rad/s (1000 rpm), strip No. 3 driven by 1 x 250 kW motor at 0.4 kV at 104.7 rad/s (1000 rpm), strip No. 4 driven by 1 x 200 kW motor at 0.4 kV at 104.7 rad/s (1000 rpm) [3].

The energy balance of the ERc-1400 30/7 consists of the following balances:

a) - energy balance of the cupped wheel mechanism,

b) - energy balance of conveyor belts,

c) - energy balance of electric transformers,

d) - energy balance auxiliary electrical installations and own energy services [2], [5], [7].

2.1. Energy balance of excavator type erc - 1400x30/7

The balance is only for active energy, the energy input (E_i) is the energy absorbed from the grid.

In electric drives, the useful energy (E_u) is the mechanical energy developed at the end of the kinematic chain, which is declared as the difference between E_i and the sum ΔE of losses.

The main losses are electrical in the power line ΔE_L, electrical in the motor coils ΔE_{inf}, electrical in the magnetic circuit of the motor ΔE_{Fe}, mechanical in the rotor $\Delta E_{mec.mot.}$, mechanical in the driven mechanism $\Delta E_{mec.mecanism}$.

The (hourly) balance equation is written as:

$$\Delta Ei = E_u + \Delta E = E_u + \Delta E_L + \Delta E_{inf} + \Delta E_{Fe} + \Delta E_{mec.mot.} + \Delta E_{mec.mecanism} \quad (1)$$

The following elements were measured for the balance sheet:

- Active energy used in four consecutive half-hours
  E_{i1} = 302 [kWh]; E_{i2} = 304 [kWh]; E_{i3} = 315 [kWh]; E_{i4} = 308 [kWh]
- Average active energy used per hour E_i = 614 [kWh]
- Average reactive energy absorbed per hour E_{ri} = 60,5 [kVArh]
- Length of power cable L = 76 m (from the 6 kV cell, to the hub wheel motor)
- Specific cable resistance R_{sp} = 0,1462 [Ω/km]
- Stator resistance r_1 = 0,5 [Ω]
- Rotor resistance r_2 = 0,019 [Ω]
- Power supply voltage U_i = 6 [kV]
- Voltage between the rotor winding phases with the rotor open U_2= 0,968 [kV]
- Electrical power and current absorbed by the motor with the rotor circuit open:
  $P_{rd} = 14{,}1$ [kW]
  I_{rd} =21 [A]
- the electrical power and current absorbed by the motor when idling (decoupled from the gearbox and the cupped wheel)
  $P_{0\ mot}$ = 22,2 [kW]
  $I_{0\ mot}$ = 26 [A]
- power and electric current absorbed by the motor when idling the bucket wheel (without excavating material)
  P_0 = 541 [kW]
  I_0 =51,14 [A]

It is calculated:

- the average absorbed electric current:

$$I_{med} = \frac{\sqrt{\left(\sum E_{ik}\right)^2 + E_{ri}^2}}{\sqrt{3} \cdot U \cdot \tau} = \frac{\sqrt{614^2 + 60{,}5^2}}{1{,}73 \cdot 6 \cdot 1} = 59{,}43 \cong 59 \text{ [A]} \quad (2)$$

Bucket wheel mechanism

- the form factor of the electric current:

$$K_f = \frac{I_{mp}}{I_m} \cong \sqrt{n}\,\frac{\sqrt{\sum E_{ik}^2}}{\sqrt{E_{ik}}} \quad (3)$$

$$K_f = \sqrt{4}\,\frac{\sqrt{302^2+304^2+315^2+308^2}}{302+304+315+308} = 2\cdot\frac{\sqrt{377709}}{1229} = 1,0001 \quad (4)$$

- motor power supply line resistance [6kV]

L = 76 [m]; S = 3x120 [mm²]; $R_L = R_{sp}\cdot L$ = 0,1462·0,076 = $1,011\cdot 10^{-3}\,\Omega$

Calculating losses (τ_f = 1 h)

$$\Delta E_L = 3\cdot K_f^2\cdot I_{med}^2\cdot R_L\cdot \tau_f\cdot 10^{-3} \text{ [kWh]} \quad (5)$$

$$\Delta E_{\inf} = 3\cdot K_f^2\cdot I_{med}^2\cdot R_e\cdot \tau_f\cdot 10^{-3} \text{ [kWh]} \quad (6)$$

K_f = 1,01 in the case of asynchronous ring motors,

I_{med} – the arithmetic mean value of the electric current absorbed by the motor in the range τ_f [A],

τ_f – running time [h],

R_e – equivalent motor resistance [Ω],

r_1 – stator resistance [Ω],

r_2' – reduced rotor stator resistance [Ω],

$$r_2' = 0,98\left(\frac{U_1}{U_{2i}}\right)^2 r_2 \quad (7)$$

r_2 – rotor resistance [Ω],

U_i – voltage between stator phases [V],

U_{2i} – phase-to-phase voltage at the rotor rings (measured with the rotor locked and the circuit open) [V],

$$\Delta E_{\inf} = 3\cdot 1,001^2\cdot 59^2\cdot\left[0,5+0,019\cdot 0,98\left(\frac{6}{0,968}\right)^2\right]\cdot 1\cdot 10^{-3} = 12,69 \text{ [kWh]} \quad (8)$$

$$\Delta E_{Fe} = \left(P_{rd} - 3\cdot i_{1d}^2\cdot r_1\cdot 10^{-3}\right)\tau_f \text{ [kWh]} \quad (9)$$

P_{rd} – is the power absorbed by the motor when the rotor circuit is open [kW],

i_{1d} – stator electric current when the rotor circuit is open [A],

r_1 – stator resistance $[\Omega]$,

$$\Delta E_{Fe} = \left(14{,}1 - 3 \cdot 21^2 \cdot 0{,}5 \cdot 10^{-3}\right) \cdot 1 = 13{,}44 \quad \text{[kWh]} \qquad (10)$$

$$\Delta E_{mec.mot} = P_{0\,mot} \cdot \tau_f - \Delta E_{Fe} - 3K_f^2 \cdot R_e \cdot I_{0mot}^2 \cdot \tau_f \cdot 10^{-3} \quad \text{[kWh]} \qquad (11)$$

$$\Delta E_{mec.mot} = 22{,}2 \cdot 1 - 13{,}44 - 3 \cdot 1{,}0001^2 \cdot \left[0{,}5 + 0{,}019\left(\frac{6}{0{,}968}\right)^2\right] \cdot 26^2 \cdot 1 \cdot 1 = 6{,}27 \quad \text{[kWh]} \qquad (12)$$

$$\Delta E_{mec.mecanism} = P_0 \cdot \tau_f - \Delta E_{\inf} - \Delta E_{Fe} - 3K_f^2 \cdot R_e \cdot I_0^2 \cdot \tau_f \cdot 10^{-3} \quad \text{[kWh]} \qquad (13)$$

$$\Delta E_{mec.mecanism} = 541 \cdot 1 - 12{,}69 - 13{,}44 - 3 \cdot 1{,}01^2 \cdot \left[0{,}5 + 0{,}019 \cdot 0{,}98 \cdot \left(\frac{6}{0{,}968}\right)\right] \cdot 26^2 \cdot 1 \cdot 10^{-3} = 512{,}33 \quad \text{[kWh]} \qquad (14)$$

Useful energy: E_u

$$E_u = E_i - \left(\Delta E_L + \Delta E_{\inf} + \Delta E_{Fe} - \Delta E_{mec.mot} + \Delta E_{mec.mecanism}\right) = 75{,}53 \quad \text{[kWh]} \qquad (15)$$

2.2. Energy balance sheet of the transportation band

Conveyor belt: drive - 2x motor type MIP 3
The balance equation is:

$$E_i = E_U + \sum \Delta E = = \Delta E_L + \Delta E_{\inf} + \Delta E_{Fe} - \Delta E_{mec.mot} + \Delta E_{mec.mecanism} \quad \text{[kWh]} \qquad (16)$$

Loss calculation:

$$\Delta E_L = 3 \cdot 1{,}1^2 \cdot 146^2 \cdot 0{,}0148 \cdot 1 \cdot 10^{-3} = 1{,}145 \quad \text{[kWh]} \qquad (17)$$

$$I_{med} = \frac{\sqrt{E_i^2 + E_{ri}^2}}{\sqrt{3}U\tau} = \frac{\sqrt{18{,}1^2 + 18{,}2^2}}{1{,}73 \cdot 0{,}4 \cdot 1} = 146 \quad \text{[A]} \qquad (18)$$

K_f = 1,1 – form factor of electric current

$$K_f = \frac{I_{mp}}{I_m} \approx \sqrt{n}\frac{\sqrt{\sum E_{ik}^2}}{\sum E_{ik}} \quad (19)$$

The motor is powered by a 3x50mm² section copper cable, 50 m long.

$$r_{Cu}\left(3\times 50mm^2\right) = 0,37 \text{ [}\Omega\text{/km]} \quad (20)$$

$$R = r_{Cu}\cdot L = 0,37\cdot 0,04 = 0,0148 \text{ [}\Omega\text{]} \quad (21)$$

$$\Delta E_{Cu} = 3\cdot 1{,}1^2\cdot 146^2\left[0{,}196 + 0{,}01617\cdot\left(\frac{6}{0{,}968}\right)^2\right]\cdot \cdot 1\cdot 10^{-3} = 15{,}62 \text{ [kWh]} \quad (22)$$

$$\Delta E_{Fe} = \left(10,6 - 3\cdot 7,52^2\cdot 0{,}196\cdot 10^{-3}\right)\cdot 1 = 10,56 \text{ [kWh]} \quad (23)$$

$$\Delta E_{mec.mot} = 18{,}6\cdot 1 - 10{,}56 - 3\cdot 1{,}1^2\cdot 0{,}20\cdot 13{,}2^2\cdot 1\cdot 10^{-3} = = 18{,}6 - 10{,}56 - 0{,}126 = 7{,}91 \text{ [kWh]} \quad (24)$$

$$\Delta E_{mec.mecanism} = 157\cdot 1 - 15{,}62 - 10{,}56 - - 3\cdot 1{,}1^2\cdot 0{,}2\cdot 220^2\cdot 1\cdot 10^{-3} = 98{,}92 \text{ [kWh]} \quad (25)$$

$$E_U = 181 - \left(1{,}145 + 15,62 + 10,56 + 98,92\right) = 54,75 \text{ [kWh]} \quad (26)$$

Since the conveyor belt has two 200 kV motors, all losses (as input energy and useful energy) are multiplied by two [8].

2.3. Energy balance of electrical transformers

The excavator type ERc 1400 30/7 supplies users at 0.4 kV from three transformers (Table 2).

Table 2. ***Characteristics of the transformers on the excavator***

S_n kVA	Primary tension kV	Secondary tension kV	ΔP_0 kW	ΔP_{sc} kW	I_0 (% from I_n)	u_{sc} (from U_n)
200	6	0,4	0,45	3,25	3,0	4,0
800	6	0,4	1,85	12,0	2,0	6,0
1250	6	0,4	2,6	18,0	2,0	6,0

Equation of the active electricity balance of a transformer substation:

$$E_i = E_U + \Delta E_T + \Delta E_L \text{ [kWh]} \quad (27)$$

where: E_i and E_u is the sum of the active energy entering the post contour and the useful active energy leaving the contour.

ΔE_T and ΔE_L the sum of the losses of electricity in the substation transformer, i.e. in the lines, busbars and connecting conductors around the substation.

The active power losses in a transformer can be determined using the relationship:

$$\Delta P_T = \Delta P_0 + \beta^2 \Delta P_{SC} \quad (28)$$

ΔP_0 and ΔP_{SC} are the active power losses in the transformer during no-load operation and the active power loss in the transformer during short-circuit operation; β – the average load factor of the transformer.

$$\Delta E_{T200} = 0,45 \cdot 1 + \left(\frac{1,1 \cdot 2,8}{5,78} \right)^2 \cdot 3,25 \cdot 1 = 0,45 + 0,92 = 1,37 \text{ [kWh]} \quad (29)$$

$$\Delta E_{T800} = 1,85 \cdot 1 + \left(\frac{1,1 \cdot 11,4}{23,12} \right)^2 \cdot 12 \cdot 1 = 1,85 + 3,53 = 5,38 \text{ [kWh]} \quad (30)$$

$$\Delta E_{T1250} = 2,6 \cdot 1 + \left(\frac{1,1 \cdot 17,5}{36,1} \right)^2 \cdot 18 \cdot 1 = 2,6 + 5,12 = 7,72 \text{ [kWh]} \quad (31)$$

The other mechanisms, which operate intermittently, can be considered as average hourly energies of up to 30% of the power installed in the transformers mounted on the excavator [2], [4], [6].

$$E_{iserv.aux} = 0,3P_n = 0,3 \cdot S_{mot} \cdot \cos\varphi = 0,3 \cdot 2250 \cdot 0,85 = 573,75 \text{ [kWh]} \quad (32)$$

$$\Delta E_{serv.aux} = 0,4E_{iserv.aux} = 0,4 \cdot 573,75 = 229,5 \text{ [kWh]} \quad (33)$$

$$E_{Userv.aux} = 0,6 \cdot E_{iserv.aux} = 0,6 \cdot 573,75 = 344,25 \text{ [kWh]} \quad (34)$$

The calculation of total energy losses is summarised in Table 3.

Table 3. ***Calculation of total energy losses***

Component name	**[kWh]**	**[%]**
Energy input	1688,0	100,000
Energy output		

1.Useful energy (transport of mining mass)	592,93	35,126
2. Losses		
- in the supply line	11,57	0,685
- in engine windings	98,21	5,818
- in the engine iron	61,86	3,66
- mechanical in engine	54,5	3,228
- mechanical in gearboxes and moving parts of conveyors	625,66	37,07
- auxiliary and internal services	229,5	13,617
- in transformers	14,47	0,857
Total losses	1095,07	64,94
Total	1688,0	100,000

On the basis of these calculations it is possible to construct the Sankey diagram for the large excavator ERc - 1400 (Figure 1).

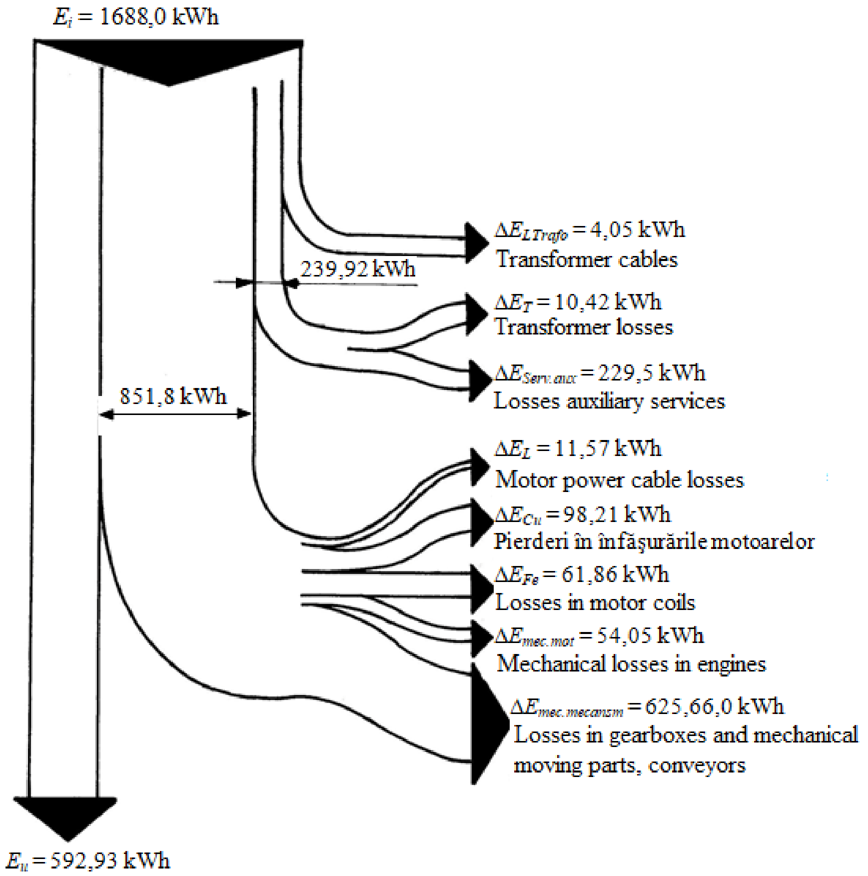

Fig. 1. Sankey diagram for excavator ERc 1400

3. CONCLUSIONS

The elaboration and analysis of energy balances is a scientific method for assessing the energy-economic efficiency of all electrical installations of users in a lignite quarry, with the aim of improving energy yields, raising the technical-economic level of their operation and improving electricity supply schemes.

For quarry mining operations, energy is an important part of the total production cost within the energy complex.

In recent times, quarries have been applying energy efficiency measures on a large scale, facing tough international competition. Product prices are set on the global market and characterised by high CO_2 per unit of sales.

We have developed the general concept of an analysis model aimed at energy, environmental and economic assessment of technological processes in a typical industrial contour belonging to an energy complex.

Taking into account the theoretical aspects and on the basis of real statistical data we determined the electricity losses in some electric networks, electric motors, transformers, i.e. we made the real electric balance on significant machines in the quarry.

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FUNCTION OF THE ENERGY SECTOR BY ESTABLISHMENT THE NATIONAL AUTHORITY OF ENERGY SECURITY IN THE CONTEXT OF ENSURING NATIONAL AND EUROPEAN SECURITY

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Abstract: A strong and secure energy industry gives Romania a solid and secure economy, and in this way we can become a strategic partner with the other NATO and EU states. Thus, energy security becomes one of the most important pillars of national and European security. For this reason, the authors consider it necessary to establish the National Authority of Energy Security, which must concentrate, monitor, manage and control the entire national energy chain, creating factors of stability, safety, security and resilience to the most important and strategic sector in Romania and to be able to be prepared at any time for special crisis or war situation.

Keywords: national authority of energy security, European security.

1. INTRODUCTION

The establishment of the National Authority of Energy Security – N.A.E.S., directly subordinated to the President of Romania and the Supreme Defence Council of the country, must concentrate, monitor, manage and control the entire national energy chain, creating stability, safety, security, security and security factors. Security and resilience of the most important and strategic industrial sector in Romania and to be able to cope at any time with special crisis or war situations [7], [9].

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N.A.E.S., has the mission to create stability, security, energy security and implicitly national and European security factors, by bringing under the same umbrella all state or private entities in the energy industry, being able to successfully coordinate the entire national energy chain, for energy to be used for well-intended purposes, automatically bringing the well-being of citizens and Romania and not to be used as an energy weapon or pressure tool [8].

The increasingly frequent occurrence of cases of energy terrorism – black/brown-out (total/partial exit of some energy subsystems or the entire integrated National Energy System) and the use of energy as a possible energy weapon or pressure instrument around the world, It makes the approached proposal of great importance and actuality, knowing that certain critical on-shore or off-shore energy infrastructures on the territory of Romania or on the Romanian Black Sea platform, or certain appliances and equipment within these critical energy infrastructures: oil pumping stations, natural gas compression stations, power stations and power plants, offshore drilling rigs, extraction wells, refineries, marine terminals, strategic storage facilities, land or marine pipelines, land or marine pipelines, overhead power lines and certain nuclear installations or equipment, they can be remotely controlled by cyberattacks or they can be the target of terrorist attacks [10].

Failure to supply energy to consumers automatically triggers a national crisis, as all sectors of the national economy depend on energy. Once the crisis is triggered, a state of social imbalance sets in, which simultaneously brings extreme damage to the safety of the citizen and national security. In this context, the integrated National Energy System, through the other related subsystems: Energy resources, oil, natural gas, mining, nuclear, electricity becomes a strategic objective of national importance by being a generator of national and european critical infrastructures [4] [5].

2. PRINCIPLES OF OPERATION

The National Authority of Energy Security – N.A.E.S. is organized and operates as a specialized body of the central public administration, with legal personality, subordinated to the President of Romania and the Supreme Defence Council of the country [4], [12].

The management of N.A.E.S. is ensured by:

- 1 President with the rank of Secretary of State;
- 1 first Vice-President with the rank of Secretary of State;
- 5 Vice-Presidents with the rank of under-Secretary of State.

appointed for a period of 5 years and relieved from office by decision of the President of Romania.

Object of activity:

- monthly/quarterly/half-yearly/annual reporting or whenever the situation requires, to the President of Romania and/or the Supreme Council of National Defence, the national energy situation, as a component of the national security field, by the following [1], [2], [3], [11]:
    - very short / short / medium / long / very long term energy strategies (1 year - 50 years);

  - the situation and state of energy resources;
  - the situation and strategy of strategic energy reserves;
  - the state and state of the Integrated National Energy System.
- carries out guidance and control activities in the entire national energy field;
- ensures the energy security of Romania by:
  - management, monitoring and permanent control of a national strategic energy resource on-shore and off-shore;
  - management, monitoring and permanent control of the state strategic energy reserves stored;
  - management, monitoring and permanent control of the on-shore and off-shore National Petroleum System (oil / natural gas) and ensuring the closure of the full Romanian oil cycle;
  - management, monitoring and permanent control of the National Nuclear System and ensuring the closure of the full Romanian nuclear cycle;
  - management, monitoring and permanent control of the National Mining System and ensuring the closure of the full Romanian mining cycle;
  - management, monitoring and permanent control of the National Power System and ensuring the closure of the Romanian full power cycle;
  - establishment, management and monitoring of the integrated National Energy System, integrating all related energy systems: The National Petroleum System (oil / natural gas); the National Nuclear System; the National Mining System; the National Power System.
- ensures the proper functioning, monitoring and correlation of all state or private energy authorities and companies, participating in the energy chain, with / without their dislocation within the current entity;
- ensure the legislative harmonization of all energy entities involved in the energy chain;
- ensure the security of place of works through optimal working conditions;
- ensure the safety and health at work of workers within the energy entities participating in the energy chain, through mandatory national authorizations for the prevention of accidents at work and occupational diseases;
- ensure the identification of all national and european critical energy systems and infrastructures;
- ensures sector-specific risk assessment for all national and european critical energy systems and infrastructures;
- ensures through physical and safe elements the prevention and combating of terrorism;
- ensure through safe elements the prevention and fight against corruption;
- provide energy efficiency elements;
- ensures the issuance of certifications, licenses, attestations and authorizations;

Structure by sections and departments:

N.A.E.S. is structured in 13 sections and departments, as follows: [4], [6]

1) STRATEGIC RESOURCES AND RESERVES SECURITY SECTION:
   a. Department – Strategic resources;

   b. Department – Strategic reserves;
   c. Department – Strategic storage.
2) PETROLEUM SECURITY SECTION:
   a) Department – Oil;
   b) Department – Natural Gas.
3) MINING SECURITY SECTION:
   a. Department – Superior coal;
   b. Department – Lower coal.
4) NUCLEAR SECURITY SECTION:
   a. Department – Uranium ore extraction;
   b. Department – Uranium ore processing;
   c. Department – Manufacture of nuclear fuel;
   d. Department – Production of nuclear electricity;
   e. Department – Radioactive waste disposal;
   f. Department – Production and storage of heavy water.
5) POWER SECURITY SECTION:
   a. Department – National Energy System;
   b. Department – Electricity production;
   c. Department – Electricity transmission;
   d. Department – Electricity distribution;
   e. Department – Electricity supply.
6) OCCUPATIONAL HEALTH AND SAFETY SECTION:
   a. Department – Identification and evaluation of onshore risks;
   b. Department – Identification and evaluation of offshore risks;
   c. Department – Identification and risk assessment in potentially explosive environments;
   d. Department – Personal authorization from the point of view of OHS;
   e. Department – Personal authorization from an antiex point of view.
7) ECOLOGICAL SECURITY AND SUSTAINABLE DEVELOPMENT SECTION:
   a) Department – Ecological security;
   b) Department – Sustainable development.
8) CYBERSECURITY SECTION:
9) SECURITY OF CRITICAL SYSTEMS AND INFRASTRUCTURES | CLASSIFIED INFORMATION SECTION:
   a. Department – Security of critical systems and infrastructures;
   b. Department – Security of classified information.
10) PREVENTING AND COMBATING TERRORISM AND CORRUPTION SECTION:
   a. Department – Prevention and fight against terrorism;
   b. Department – Prevention and fight against corruption.
11) ENERGY EFFICIENCY SECTION

12) LICENSING | CERTIFICATIONS | AUTHORIZATIONS | ATTESTATIONS SECTION:

a. Department – Certifications;
b. Department – Licensing;
c. Department – Attestations;
d. Department – Authorizations.

13) MONITORING AND CONTROL SECTION:

a. Department – Monitoring and control of legal entities certified, licensed, certified;
b. Department – Monitoring and control of authorized natural persons;
c. Department – Monitoring and control of industrial consumer installations;
d. Department – Monitoring and control of household consumer installations;

3. ORGANIZATIONAL CHART

The National Authority of Energy Security – N.A.E.S. organizational charts is as shown in Figure 1 and Figure 2 [4].

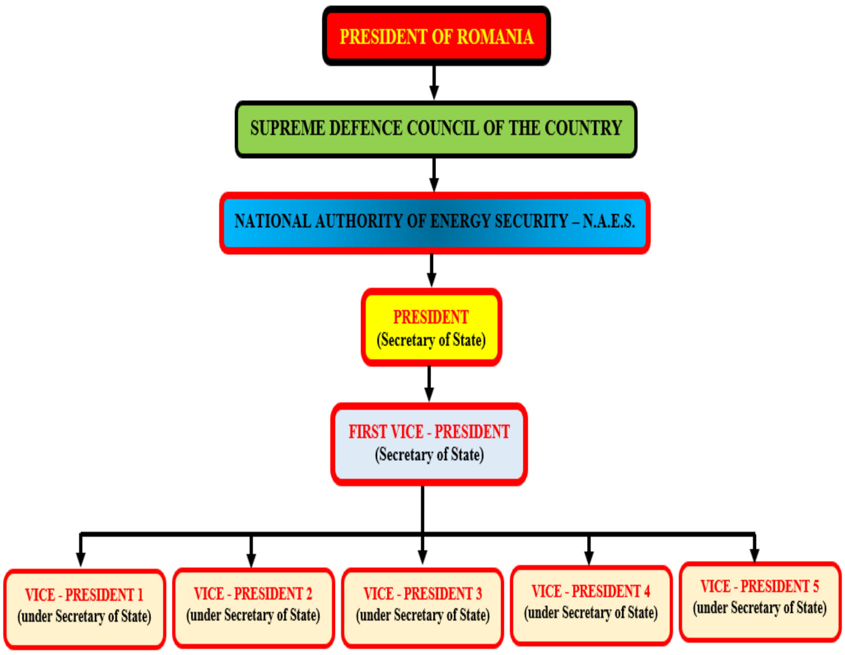

Fig. 1. The National Authority for Energy Security – N.E.S.A. organizational chart

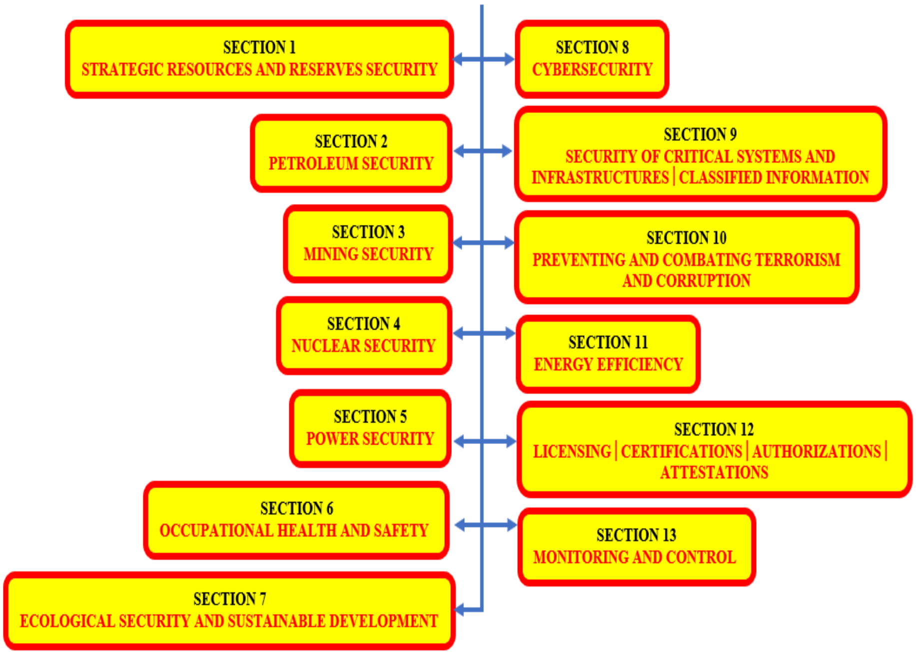

Fig. 2. The National Authority for Energy Security – N.A.E.S. – sections

4. CONCLUSIONS

The need to establisment an energy security entity results from the following considerations:

- a single national entity that includes the entire spectrum of the energy sector in the economy (simplistic approach and understanding) and simpler control of the President of Romania and the Supreme Council of Defense of the country regarding the situation at any time of the energy state of our country and implicitly of the energy security (from a single entity/person);
- according to Directive 2008/114/EC of the European Council of 8 December 2008 on the identification and designation of European critical infrastructures and the assessment of the need to improve their protection and the Government Emergency Ordinance no. 98 of 3 November 2010 on the identification, designation and protection of critical infrastructures, It is noted that within the energy sector, the 3 related sub-sectors are included under the same umbrella:
  - **electricity**: infrastructure and facilities for the production, transmission and distribution of electricity, including the energy resources used;
  - **oil**: oil production, refining, treatment, storage and distribution through pipelines;
  - **natural gas**: gas production, refining, treatment, storage and distribution via pipelines, LNG terminals.
- simple management and monitoring of all state or private companies in the entire energy chain;
- better transparency through common laws and regulations;

- a single common investment strategy on the formation of the Integrated National Energy System;
- easier access to European funds on the formation, safety and security of the Integrated National Energy System;
- easier assessment and monitoring in terms of identifying risks, vulnerabilities, hazards and threats to the entire energy sector;
- the formation of a single integrated security system (Critical Infrastructure Protection Management, Occupational Safety and Health Management, Risk Management, Process Continuity Management, etc.), coherent, transparent and convergent toward the SECURITY objective;
- harmonization of all state entities, state companies and private companies, in a common technical and legislative system, through the principle of transparency;
- joint investments to combat and eliminate the vulnerability of energy security;
- the opportunity for joint scientific research dedicated to the risk assessment of each sector involved in the energy chain and the development of assessment methods dedicated to minimizing occupational risks that can be used by all actors involved.

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THE ROLE OF STATCOM IN DYNAMIC COMPENSATION OF ELECTRICAL NETWORKS

MARIA DANIELA STOCHITOIU[1], ILIE UTU[2]

Abstract: The STATCOM device is based on the voltage source converter has been implemented in many power systems as way for the dynamic compensation of electrical networks for maintain the voltage level and to rise the transmission capacity in transitory operating steady as well as oscillations damping. The paper presents the theoretical aspects regarding the configurations of the STATCOM and the implementation role.

Keywords: power flow control, controller, transmission capacity, power system.

1. INTRODUCTION

The STATCOM device represents an efficient solution for the system operators for power systems in efficiency way to meet the economic and regulatory requirements under conditions of connection of new transmission lines and the need of stability voltage and power flow control under various operating conditions.

This device is equivalent with an ideal synchronous machine for producing three phase sinusoidal voltages at fundamental frequency. The STATCOM system shows the same operating characteristics as turning synchronic compensator without mechanical inertia. The device is allowing to control fast the module and angle phase of three phase voltages in the connection point. The based components are semiconductors GTO and IGBT used in voltage source converter (VSC), which has performances on reactive power control [1],[5].

The STATCOM device, usually has in composition a transformer, a converter/inverter voltage source and a capacitor operating at direct current voltage (figure 1). The control element of STATCOM is fully controlled valve. The thyristor GTO and a diode are connected antiparallel forming a turn-off asymmetrical device. Due to the current flows in both directions through voltage source converter, the valves have to be bidirectional. The valve resistance is null when GTO is on and the valve resistance is infinite when the GTO is off.

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The operating consists to maintain the capacitor loaded at continuous voltage V_{dc} and to provide with VSC an voltage $\underline{V}_0$ in phase with the network voltage $\underline{V}$ [2].

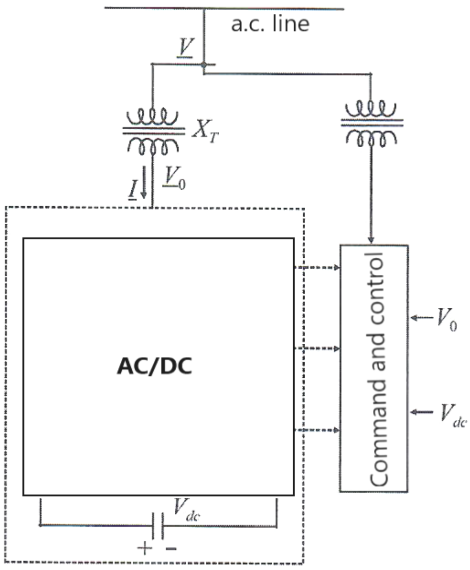


Fig.1. The STATCOM scheme

The difference between those two voltage amplitudes is applied to the inductive reactance X_T and determines the reactive current flow:

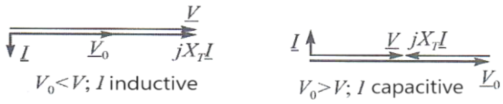
$$\underline{I} = \frac{(\underline{V} - \underline{V}_0)}{jX_T} \qquad (1)$$

The effective value of this voltage difference determines the amplitude of reactive current and the sign (positive or negative) as the dephasing sense between network voltage and current. The reactive power Q is:

$$Q = \frac{1 - \frac{V_0}{V}}{X_T} \cdot V^2 \qquad (2)$$

The electrical network perceives the STATCOM device as a variable impedance of reactive element. The reactive properties of STATCOM are depending of voltage amplitude V_0 from output inverter going from stored energy capacitor. The V_0 measurement is depending of capacitor potential V_{dc}.

The device works as an inductance when the current is phased with π/2 behind the voltage and absorbs reactive energy and the device works as a capacitor when the current is phased with π/2 beyond the voltage supplying reactive energy (figure 2). If $V_0 = V$ the current flows through the impedance is null and there is not energy exchange [3],[1].



a) b)

Fig.2. The phase voltages schemes

The possibility of exchange the energy even inductive or capacitive using only one inductance X_T is the advantage of this device. In comparation with Static Var Compensator based on current source converter, the STATCOM device has not capacitive element which can determines resonance phenomena with inductive elements form electrical network. STATCOM can produce an inductive current and supply the capacitive current which is not depending by the connected network voltage. The device can supply nominal capacitive current for any alternative voltage.

STATCOM device can be operated in electroenergetical power systems resolving some features.

2. STATCOM OPERATING FIELDS

The STATCOM behavior in static steady is described by V-I characteristic (figure 3). There are three operating fields:

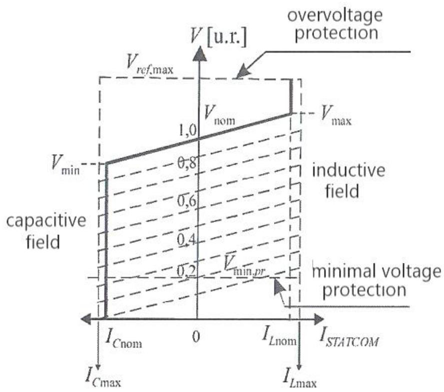


Fig.3. The V-I characteristics

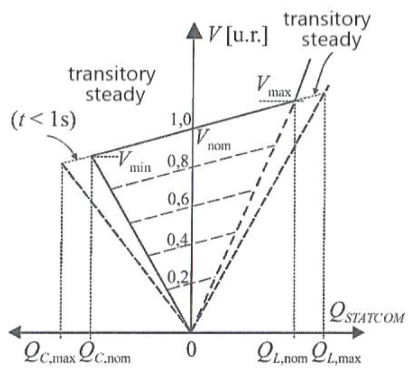


Fig.4. The V-Q characteristics

- linear control field, delimitated by nominal currents ($I_{Cnom,}$ I_{Lnom}) and maximum currents (I_{Cmax}, I_{Lmax}) for short term steady;

- capacitive field, where STATCOM delivers in the connection node a constant current equal with capacitive maximum current;

- inductive field, where STATCOM absorbs in the connection node a constant current equal with inductive maximum current.

Without the current restrictions there are some voltage operating restrictions as:

- maximum restriction of reference voltage ($V_{ref,max}$);
- protection restriction of minimum voltage ($V_{min,\ pr}$).

The maximum reactive power produced by a STATCOM device is equal with the current multiplied voltage and in the transitory stage the STATCOM can increase the current values on the limited period of time in dependence with the temperature of semiconductors junction (figure 4) [5], [6], [7]. The characteristic behavior of STATCOM can be equivalent with a voltage source behind of reactance and fast control the amplitude and phase angle.

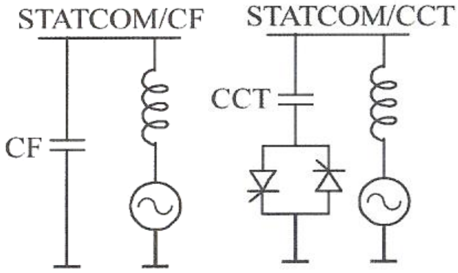


Fig.5. The mounting STATCOM schemes

Some possibilities of STATCOM mounting, in schemes with fixed capacitor or with thyristor switched capacitor are shown above.

3. CONCLUSIONS

The advantages of STATCOM in comparation with fixed capacitors mounting in the derivation node involve high response speed and ability to maintain a constant reactive current and providing dynamic reactive power support, the system voltage can be established shortly after grid fault, and the transient voltage stability will be improved. The STATCOM responds like a voltage source, which may control the injected current almost independently of the network voltage. In addition, controllable-shunt compensators, like STATCOM may contribute to resolve the flicker phenomena and to the transient stability of the system and transmission capacity increasing for electrical grid.

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ENERGY ANALYSIS AND ENERGY BALANCE CALCULATION FOR WARMAN 12-10 GAH PUMP BASED ON IN SITU MEASUREMENTS IN A MINING OPERATION

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Abstract: The paper aligns current global concerns regarding energy sustainability, focusing on issues of operational sustainability of water pumping system.

WARMAN 12-10 GAH pump used in mining groundwater pumping, identification and analysis of the major components, energy flows and performance of this system is the core of the article.

Keywords: energy balance, liquid carrier pumps, energy losses.

1. INTRODUCTION

In order to show the energy performance of the pump at actual operating conditions, energy balances were drawn up on the basis of experimental determinations and analytical calculations; the values obtained were centralised in summary tables and visualised using Sankey diagram [7].

WARMAN 12-10 GAH pump energy balances provide information - in tabels form and graphically - on useful and wasted energies, allowing energy managers at the companies concerned to plan the necessary measures to assess energy consumption and prepare annual reports to the National Energy Regulatory Authority (ANRE) [6].

2. MEASURING APPARATUS USED IN EXPERIMENTAL DETERMINATIONS

The measuring instruments used in the experimental determinations are in the laboratories of the University of Petroșani. For flow measurement, the ultrasonic flow meter FLUXUS - ADM 6725 was used, it uses ultrasonic signals, which vary in time.

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The ultrasonic signals are emitted by a transducer installed on one side of a pipe and reflected to the second transducer. These signals are emitted alternately in the direction of flow and vice versa. The transit time of the ultrasonic signals in the flow direction is shorter than against the flow direction [1], [4].

Fig. 1. FLUXUS ultrasonic flow meter - ADM 6725

The transit time difference Δt is measured and allows the determination of the average flow velocity along the propagation path of the ultrasonic signals. Correction of the flow profile is performed to obtain the average flow velocity which is proportional to the flow rate.

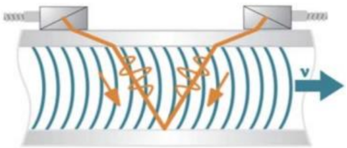

Fig. 2. Ultrasonic signal path

The calculation of the volume flow is performed using the equation:

$$Q = k_{\mathrm{Re}} \cdot A \cdot k_{\alpha} \cdot \Delta t / \left(2 \cdot t_{t}\right) \qquad (1)$$

The received ultrasonic signals will be checked for their usefulness as well as for the measurement and plausibility of the measured values which will be immediately evaluated. The complete measurement cycle is controlled by integrated microprocessors. Disturbances will be removed by statistical signal processing [2].

In the pictures below you can see the location of the ultrasonic flowmeter and see the different water flow values.

Fig. 3. Ultrasonic flowmeter recording a flow rate of 1449,90 m^3/h

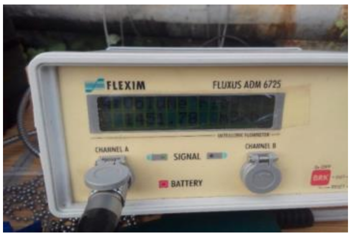

Fig. 4. Ultrasonic flowmeter recording a flow rate of 1451,78 m^3/h.

Fig. 5. Ultrasonic flowmeter recording a flow rate of 1457,33 m^3/h.

3. WATER FLOW VARIATION DIAGRAM

Following the measurements carried out on site, using the ultrasonic flow meter and recording the data in the measurement sheet, I was able to produce the water flow variation diagram where the flow rate can be observed over a period of 10 seconds, Figure 6 [4].

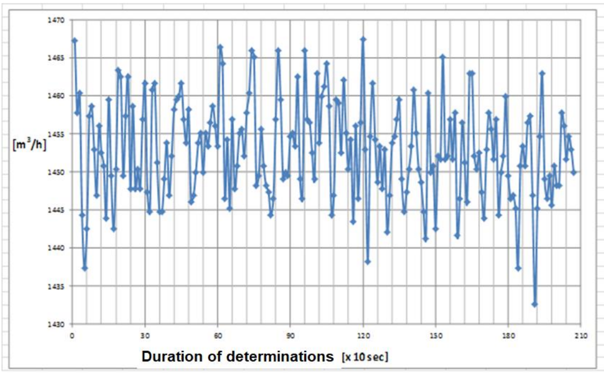

Fig. 6. Water flow variation diagram

4. ENERGY BALANCE FOR WARMAN PUMP 12-10 GAH AT DIFFERENT LOADS

The elements of the actual hourly energy balance for the WARMAN 12-10 GAH pump at nominal load and part load have been highlighted.

a) Elements of the actual hourly energy balance for the WARMAN 12-10 GAH pump at nominal load with nominal parameters according to the characteristic curves in the brochure [4]:

- Q_{max} = 1800 m^3/h; H_{max} = 78 m; P_{mot} = 382 kW;
- Pump shaft power P_p = 450 kW;
- Total pump efficiency η_p = 84,87 %;
- Mechanical efficiency η_m =96,20 %;
- Hydraulic efficiency η_h = 89,84 %;
- Efficiency volumetric η_v = 98,20 %;
- Nominal specific energy consumption $C_{nom.\ sp.en.}$ = 0.278 kWh/m^3.

Table 1. ***The actual hourly balance for WARMAN 12-10 GAH pump - nominal load***

Energy input in contour			**Energy output in contour**		
Name	**[kWh]**	**[%]**	**Name**	**[kWh]**	**[%]**
Energy at the pump shaft	450,00	100,00	Useful energy		
			Water flow energy	381,91	84.87
			Lost energy		
			Mechanical losses in the pump	18,45	4,10
			Hydraulic losses in the pump	41,13	9,14
			Volume losses in the pump	8,51	1,89
			Total losses	68,09	15,13
TOTAL	450,00	100,00	TOTAL	450,00	100,00

b) Elements of the actual hourly energy balance for the WARMAN 12-10 GAH pump at part load with measured and calculated parameters [4]:

- Q_{max} = 1453 m^3/h; H_{max} = 70 m; P_{mot} = 277 kW;
- Pump shaft power P_p = 384,72 kW;
- Total pump efficiency η_p = 72,00 %;
- Mechanical efficiency η_m =92,00 %;
- Hydraulic efficiency η_h = 83,20 %;
- Efficiency volumetric η_v = 94,10 %;
- Specific energy consumption $C_{sp.en.}$ = 0.294 kWh/m^3.

Table 2. ***The actual hourly balance for WARMAN 12-10 GAH pump - part load***

Energy input in contour			**Energy output in contour**		
Name	**[kWh]**	**[%]**	**Name**	**[kWh]**	**[%]**
Energy at the pump shaft	384,72	100,00	Useful energy		
			Water flow energy	277,00	72,00
			Lost energy		
			Mechanical losses in the pump	29,20	7,59
			Hydraulic losses in the pump	65,06	16,91
			Volume losses in the pump	13,46	3,50
			Total pierderi	107,72	28,00
TOTAL	384,72	100,00	TOTAL	384,72	100,00

The energy balance based on experimental determinations and analytical calculations is shown in Figure 7.

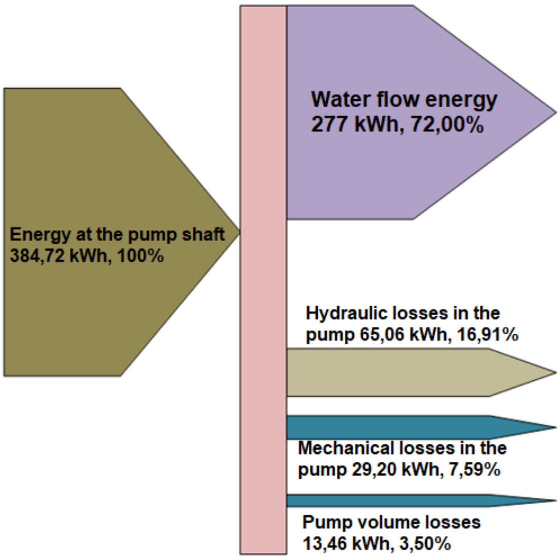

Fig. 7. Sankey diagram for energies in and out of the WARMAN 12-10 GAH pump contour

In order to determine the average energy used daily (24 hours) by a pump, on the basis of existing statistical data from the beneficiary, correlated with the literature, the values (at the level of energy used per hour from the grid of 500 kWh, related to the nominal regime) specified in Table 3 and shown in Figure 8 were calculated [3],[5].

Table 3. ***Average daily energy use***

Load regime/consumption characteristics		**Energy consumption/day**
Load factor	**Duration**	**[kWh]**
[%]	**[hours/day]**	25
10	0,5	50
20	0,5	75
30	0,5	200
40	1	250
50	1	1470
60	4,9	2100
70	6	2080
80	5,2	1800
90	4	200
100	0,4	8250
TOTAL	24	16500

The variation of the energy used by the pump during a day, as a function of the load factor and the duration of the load related to the load factor.

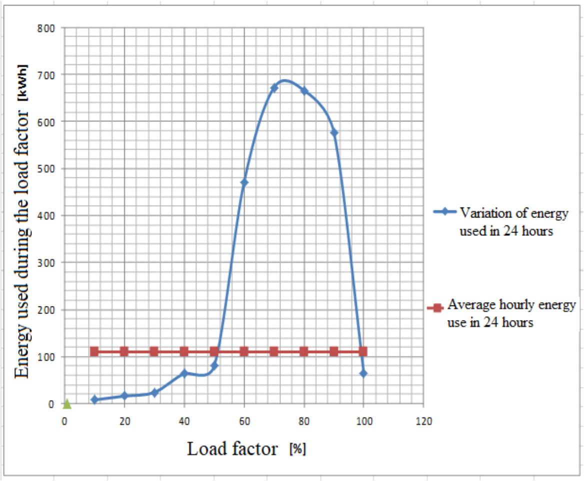

Fig. 8. Energy used during the load factor [kWh]

Dividing the total daily consumption (8250 kWh) by 24 hours results in a daily average hourly consumption of 343.75 kWh, which corresponds to a useful power of the water current of 222,5 kW.

5. CONCLUSIONS

From the curve of variation of the energy used in 24 hours, it appears that the major consumption values fall in the range of 60-90% of the nominal load. Such a load corresponds to the rational area (from the pump characteristic) of operation. In this zone the pump has major efficiencies and shows hydrodynamic stability.

One (costly, energy-efficient) measure to be taken by the technical staff, which will make a significant contribution to increasing energy efficiency and reducing energy consumption, is to introduce flow regulation through speed regulation.

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Annals of the University of Petrosani, Electrical Engineering, 24 (2022)

THE USE OF THE DC MOTOR IN THE ACTUATION ELECTRIC OF A CAR

ILIE UȚU[1], MARIA DANIELA STOCHITOIU[2]

Abstract: This paper studies aspects of using DC electric drives in vehicles. It summarizes the main characteristics of the DC motor, the constructive variants, the advantages it presents in relation to the asynchronous motor. The paper also outlines an example of equipping a car with electric drive, that would correspond as much as possible to the current requirements both regarding the environment and the economic and social one.

Key words: *DC motor, adjustable drive, electric car*.

1. INTRODUCTION

Human being was always in need to move around. Starting from the prehistoric times, man discovered bipedal walking, and over history he researched, discovered and experienced more and efficient ways of transportation. In modern times, internal combustion engines represented the main drive principle used for land transportation.

While realizing that use fossil fuels in internal combustion engines are harmful to environment and the reserves of fossil fuels needed to run cars are dwindling, a new solution expanded rapidly around the world: electric cars that use energy produced by renewable sources.

In this paper we're going to study electric-powered cars, particulary using the D.C motor.

2. CONSTRUCTION AND PRINCIPLE OF OPERATION OF THE DC MOTOR

The foundations of DC motors were laid by William Ritchie and Hippolyte Pixii in 1832. Like any rotary electric machine, the DC motor (figure 1) consists of two armatures, the stator and the rotor [4], [1].

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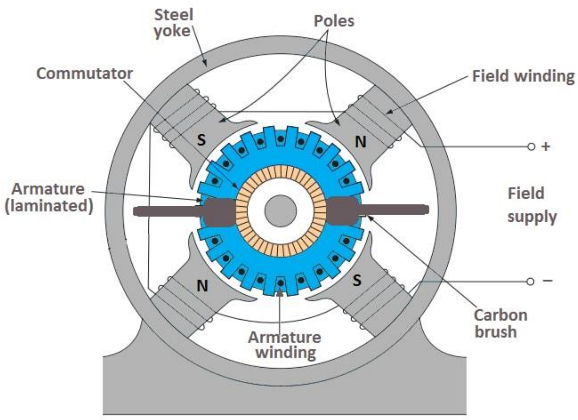

Fig.1. Cross-section through the DC machine with main pole detail

The stator is the fixed part formed by the stator yoke, the main poles, which carry the excitation winding, the auxiliary poles, the side shields, which support the bearings with bearings or slides, as well as the system of brushes and brush holders. *The rotor* is the mobile part of the machine, made up of a package of tubes with notches on the outside that support a direct current induced type winding. The tole pack is fixed on the machine shaft like the collector and rotates with it.

3. OPERATING EQUATIONS

Considering the DC motor with separate excitation connected to a constant voltage network (U), the equations are obtained [4], [10]:

$$U = E + R \cdot I + \Delta U_p \quad (1)$$

$$E = k_e \cdot n \cdot \emptyset \quad (2)$$

$$\emptyset = \emptyset(I_{ex}, I) \quad (3)$$

$$M = \frac{k_e}{2\pi} \cdot \emptyset \cdot I = k_m \cdot \emptyset \cdot I \quad (4)$$

4. DESIGN PRINCIPLES

Computer-aided design systemis used for modeling parts, assemblies and for making technical drawings [6], [7].

The design is based on the generation of solid entities that are created with the help of construction entities such as two-dimensional profiles, but also of additional elements, such as surfaces, intersection curves, projection curves, intersection points or geometric constructions [6], [7], [9].

As can be seen in figure 2, the base of the chassis has a symmetrical shape, as well as the covers related to the two engines.

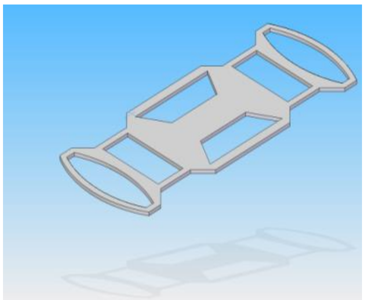

Fig.2. Chassis of the designed vehicle

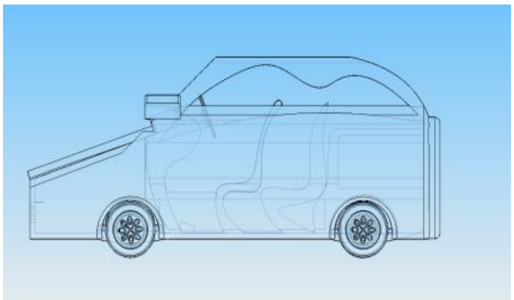

Fig.3. Longitudinal section of the whole car

Figure 3 shows a longitudinal section of the entire vehicle through which you can see both the interior and its functionality [12].

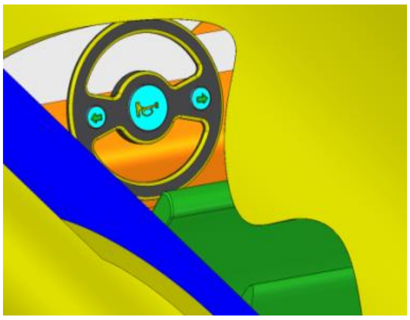

Fig.4. Steering wheel

The seats have an ergonomic shape, are made of very light materials, have in their composition a material that takes the form of the passenger who sits in it and returns to its original shape with its release.

Wheels are a core component of any car. They are made of an aluminum alloys, low in weight, with good resistance to mechanical shocks. Tubeless tires ensures necessary grip inoperation.

The steering wheel (figure 4) accomodates basic functions, including signaling of change of travel direction, as well as the command of audible warning feature in case of danger (i.e. control of the horn).

5. ELECTRICAL PART AND SIMULATION

AutoCAD Electrical software can be used to design the electrical diagram on the basis of which the electric car operates (figure 5) [11].

5.1. The principle of operation of the prototype

In the figure 5 is shown the detailed call that includes the measuring instruments [5], [8] for the parameters of each main component: V_1 , A_1 - voltmeter, ammeter for battery batteries; V_2 , A_2 – voltmeter, ammeter for the DC motor that sets the car in motion; V_3 , A_3 - voltmeter, ammeter for "secondary generator"; K - regulates the supply voltage to the dc motor; AUX - the other consumers such as the lighting system, the audio system, the navigation system, the cooling system of the passenger compartment.

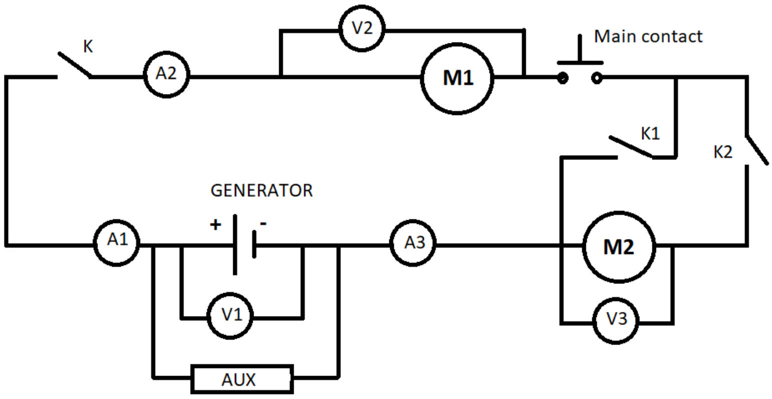

Fig.5. Detailed diagram of the designed electric vehicle

5.2. Simulation of the start-up mode of the DC motor used in the drive of the motor

A direct current motor whose initial technical data is as follows will be considered: power - 22 kW, nominal voltage - 240 V, electromagnetic field voltage - 300 V, rotational speed - 1750 rpm.

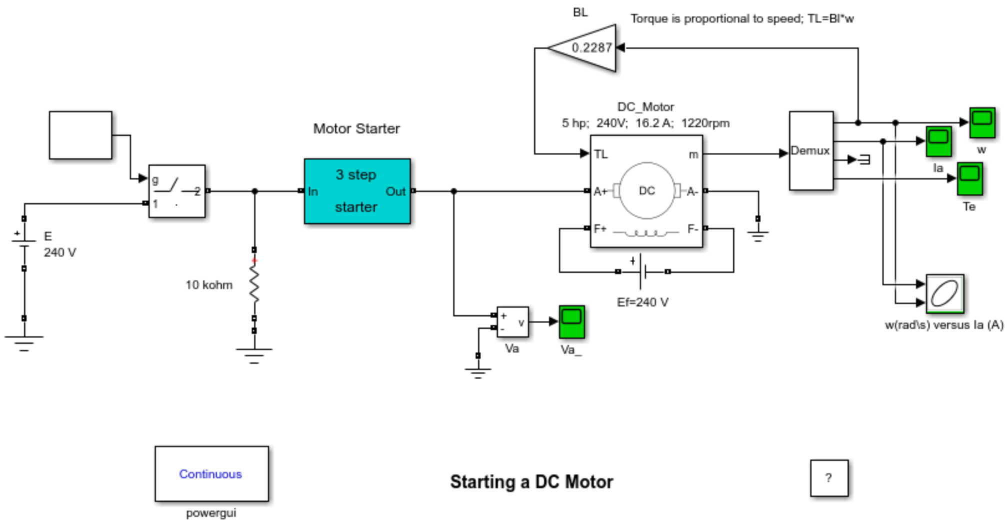

Fig.6. Starting DC Motor scheme

Using the simulation scheme presented in figure 6, the information resulting from the process will be displayed on the devices called "sinks", respectively w, Ia, Va and Te, with the specific indications of the quantities: rotation speed, current, voltage, electromechanical torque of the DC motor [2],[3].

Following the simulation, the following values were obtained:

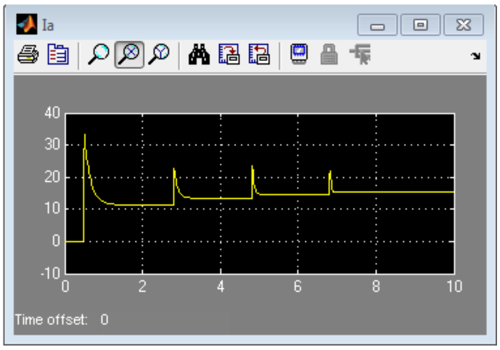

Fig.7. Current diagram

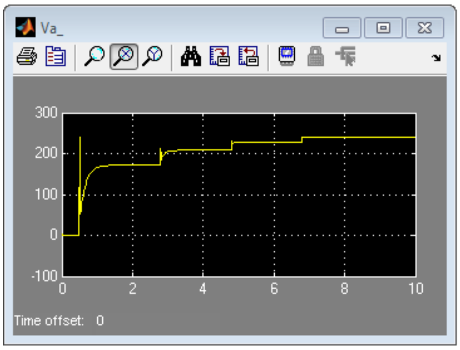

Fig.8. Voltage diagram

The reference speed change rate closely follows the acceleration and deceleration values to avoid sudden reference changes that could cause overcurrent in the armature and destabilize the entire system. The current regulatory controls the current in the armature by calculating the appropriate control angle of the thyristors. This generates the output voltage required by the rectifier to obtain the desired current through the armature.

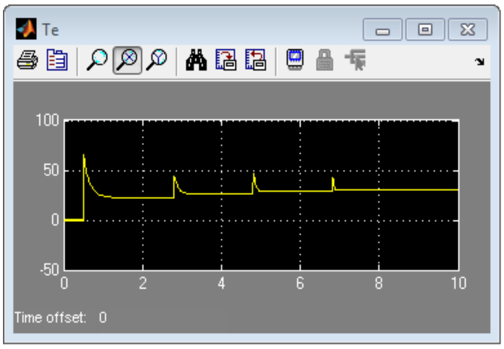

Fig.9. Electromechanical torque

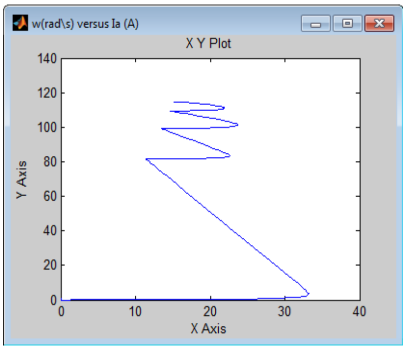

Fig.10. Variation of the speed

6. CONCLUSIONS

Following the analysis of the construction, as well as of the specific phenomena of operation underload provided by available sources of information, we came to the conclusion that although the DC motors have a relatively simple construction, a control circuit that does not require many components, yet they are outperformed by little by the AC motors.

Of all the models of electric motors that operate in direct current, the one that is best suited to propelling a car is the one with series excitation, because:

- it has a soft mechanical characteristic, at which the speed varies within wide limits depending on the torque.

- the power taken by themotor from the power supply is approximately equal to the electromagnetic power,
- at low values of the load torque, the speed can increase, and the danger of its mechanical damage may appear. For this reason, it should not be allowed to run idle, instead it must be rigidly coupled with the load mechanism.

In the near future, the manufacturing technologies of the motor will have to be improved, for a higher efficiency, better cooling and more affordable cost. Regarding the batteries, without which the electric car cannot function, it is necessary to consider the highest possible capacity for storing electricity, to occupy as little volume as possible and, implicitly, to have a reduced mass. All these aspects apply also to the chassis, body parts, interior compartment, as they directly influence the travel autonomy, as well as the safety of the users of the electric car.

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Annals of the University of Petroşani, Electrical Engineering, 24 (2022)

CHALLENGES OF THE EUROPEAN ENERGY TRANSITION

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Abstract: The European electricity market is facing many challenges today, adding new dimensions to the crises that need to overcome. The digital technology is stepping into high rhythm, involving changes in laws and regulations in every domain. The electric networks have to digitize and the software applications are playing an important role due to their self-acting implementation during current operation.

Key words: digital, sustainable development, efficiency.

1. INTRODUCTION

Romania is on the last positions from the EU countries viewing wind and solar energy per capita, although the EU leaders insist for rapid passing to clean energy and to reduce the dependence of Rusia and the dependence of fossil. The growth of wind and solar production capacity is all the more important in the rise of energy price caused by the dependence of fossil fuel from Rusia. The prices from summer months were about fourth time bigger than last year.

The energy transition includes all the technologies that ensure the transition from conventional to non-conventional fuels and accelerating the electrification of production technologies and services.

Sometimes, the life has demonstrated that it overtook, the world sanitary crises and pandemic have changed behaviors, the regulations and legislations are changing in a lot of fields [1], [6].

Nowadays, European states are severely affected by the war in Ukraine which led to historical natural gas and oil barrel prices. Russia provides a third of the block`s gas demand and a quarter of the oil demand, dependents on that provider has become the biggest vulnerability in the European energy sector.

The energy efficiency requirements have also been reinforced, reflecting technological progress and market evolution in the past decade. The global energy transition is advancing so the risks to the transition are rapidly evolving [2].

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The energetically entities or private operators of photovoltaic systems and different types of monitoring electrical energy are representing new aspects in electrical networks and also new requirements for network operation. The operating behavior of electrical networks which were primary designed must be switched due to higher number of actors appearance of electrical network. The control systems of new actors as well be considered in the entire system due to their software components which can influence the stability and security of electrical network. For obtaining the desired control, the behavior of control systems has to take into account when new functionalities are implemented [4], [5].

2. ENERGY INDUSTRY IS ALSO MANAGING THE IMPACTS OF COVID-19 PANDEMIC

The COVID-19 pandemic has been catalyst for accelerating the digitization of Europe and the world. A strong and effective competition policy and enforcement in this regard is required to contribute to a resilient recovery and a smooth transition. The COVID-19 pandemic has represented a catalyzer to accelerate the digitization on Europe and the world. A strong and effective policy in the competition domain is necessary to contribute at a resilient recovery and a double transition for ensuring rules of compliance.

The European electricity market is facing many challenges today, adding new dimensions to the crises that need to overcome. Every day marks new rethinking of the strategies on which energy companies are based, increasing volatility and uncertainty increase the inclinations of market players to act with more caution on momentan impulses. The entire energy sector has begun to give signs of concern in the longer time [3], [6].

The energy transition is as valid as at the beginning of the COVID-19 pandemic. The COVID-19 pandemic is still ongoing and here are some things to know [8]:

- energy and economic growth remain strongly coupled;
- not all economies recovery will support energy transition in the same mode;
- need assuring that people who are most vulnerable are protected;
- the challenges in international collaboration remain;
- inconsistent communication and administrative mistakes can lead to a loss of trust and lead to misinformation.

If there is a decreasing in the cost of competition between producer entities and supplier entities, which is more determined by production costs, also appears increase in market complexity costs given by transaction costs.

The effect of price on customers' behavior determines the concept on vulnerability measured by weight more than 10% of energy costs in family income residential consumer.

The effects of extended and updating processes on the large scale could not be tested into a real electrical network.

3. INCREASING THE DEGREE OF AUTOMATION IN ELECTRICAL NETWORKS AND DIGITALIZATION OF PROCESSES

The digitization will determine a huge assignment both of network operators and for new participants on electrical networks. To maintain a safe operating, it is necessary to have the possibility of updating the software used in digitized operation. [6]

For an incremental structure, the software infrastructure will be permanently improved. Examples of similar software are applications that analyze the network behavior and can predict the potential problematic situations as overload or to adjust the voltage level.

The integration of new participants as charging station operation or private energy suppliers determines a global software management for which there are missing content regulation or technical interfaces [7], [5].

Nowadays, software management systems are integrated with the control of physical system that make possible to ordinary manage of various software system. The system state which is monitored also can be influenced in order to optimally implement the software.

An implementation program may include actions for loading behavior of the storage systems in the energy network, changing consumers or for bandwidth reservation in the IT communications network.

The effects of the extending and updating processes cannot be tested in a real power grid, so the negative effects from the beginning by temporally stopping the control functions are minimized.

The digitization technologies have a significant potential in contribution and facilitation of energy transition due to innovative solutions or systems which are contributing to a more functional, intelligent, integrated and clean energetically system. Standardization, requirements, budgeting and exchange of good practices to UE can accelerate the digitization of energetically system [8], [10]:

- Creating a series of studies and involving stakeholders to identify the ways through the digitization can support the energetically system
- Promoting the digitization solutions for allowing implementation of energy systems enabling utility operators and networks to better coordinate, plan developing and operating at the local level of energetically system.
- Standardization at EU level for digital solutions in energy domain inclusively for automation, control system, data protection and cybernetic security.
- Digitization as a distinct dimension in the energy labelling regulations/ ecological design, especially for heat system, representing ways to support the intelligent operation of equipment in buildings.
- Strengthening the framework of Readiness Indicators for Intelligent solutions to intensify measures regarding demand response, self-generation and self-consume.

According with the decarbonization EU politics the renewable energy sources are about 64-97% from total produced energy. Through the costs decreasing, the renewable sources have not need support politics. Due to the energy from renewable sources becomes available economical, processes digitization, innovation and the support offered renewable sources determine that these sources to have bigger and bigger weight in energy mix with the approach of the 2050.[5][7]

It can observe now that the electrical energy price overtakes record levels without chance to decrease in the short period of time in the same time that the doubt increases the action of energy market actors based on the momentary impulses. Entire energy sector has begun to sign concerns on the long period of time. The gas demand is increasing worldwide.

The development of energy systems should require the intelligent solutions use for assuring the system security and energy needs.

Romania has an energy mix in correspondence with nowadays requirements. Romania produces half as much CO_2 per capita as the EU. At the same time, the energy mix is changing as technology advances, consumer preferences shift and policy measures evolve. The energy mix is accomplished from national energy resources [6]. Gas offers a much cleaner alternative to coal for power generation and can lower emissions at scale. In the transition period the coal power plant has to pass on natural gases for total decreasing the greenhouse effect till 2040. Romania can reach whole natural gases necessity even through on shore exploitation and off shore deposits from Black Sea [3], [9]. The nuclear energy which is considered clean energy from greenhouse effect point of view, will play an important role in this transition period. The renewable energy should be continuously developed for reaching about 30-35% from Romanian energy mix. For adding new technology in using or production energy, the digitization of entire energy system components is most important.

4. CONCLUSIONS

Energy transition is the main strategy for reducing greenhouse gas emissions and significant contribute to mitigate changes climate. The energy system development supposes using intelligent solutions in ensuring the system security an energy necessary covering. The energy sector begins to profit of digitize advantages through helping consumers gain more control over their energy consumption and bills through new digital tools and services; controlling energy consumption in the TIC sector, including through an eco-labelling system for data centers, of measures to increase transparency regarding the energy consumption of telecommunications services; consolidating the cyber security of energy networks through new legislation, including for cyber security aspects of cross-border electricity flows.

The growth of wind and solar production capacity is all the more important in the rise of energy price caused by the dependence of fossil fuel from Rusia. The electrical energy market in Europe has to face a lot of challenges taking into account the new dimensions of crises. The prices evolution is influenced both of business fundaments and subjectivism that marks new rethinking of energy strategy. Artificial intelligence, faster data processing and other digital technologies have great potential for increasing efficiency and driving down emissions. However, the country's performance in terms of the integration of digital technologies and digital energy services is poor compared to other EU member states.

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