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CONTENTS

METRICS FOR ENERGY EFFICIENCY IN LOGISTICS OF FREIGHT DISTRIBUTION

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Keywords: energy consumption, energy efficiency; energy management; economic indicators

Abstract*: The paper is a study on the energy efficiency indicators that can be used for the activities in logistics of freight distribution, at the company level, as well as at macroeconomic level. There are highlighted also some solutions for increasing energy efficiency in distribution channels, starting from technical and logistics management actions, at the company level. There are revealed also the impacts of energy efficiency measures.*

1. INTRODUCTION

There are several motivations for the determination of the energy efficiency indicators. First is the economic aspect, any energy savings resulting in reduced costs and thus increase profits. A second aspect is the scarcity of energy resources, reducing consumption is a measure of energy security. And thirdly, but not necessarily the least, reducing energy consumption is one of the solutions that contribute substantially to reducing pollution and global warming.

Companies handle a large amount of data, but without their systematization there are useless and sometimes difficult to manage. For this reason, it needs to use some metrics, key performance indicators, useful in determine and analyse the performance of company. Identifying and determining the energy efficiency indicators is a first step in order to analyse energy efficiency, to make comparisons in time and space between activities, processes, equipment and facilities, as well as to enhance the energy efficiency.

The methodology of this study combines together different methods, mainly literature review, data analysis and problem identification.

2. ENERGY EFFICIENCY INDICATORS IN LOGISTICS OF DISTRIBUTION

Throughout time, in order to assess energy efficiency, there have been used a number of indicators. First, they were used to determine the energy efficiency of different activities of companies. For their determination, the initial collected data are those related to absolute the energy consumption and the energy costs at the level of economic entities. These energy consumptions can be decomposed and detailed on activities, on places of work, on equipments or taken into consideration other criteria. Energy consumptions are placed in relation to the results of the activities of the entities.

In general, the most commonly used are the indicators determined as a ratio between the results, respectively goods or services, and energy consumption for them. There are also calculated the so-called specific consumptions or relative consumptions, obtained as a ratio between energy consumption and values of the respective activities, expressed in physical units. For example, in the case of energy conversion processes, their analysis is most often based on energy return.

An analysis of total energy consumptions in distribution channels is quite complicated because logistics activities are diversified, the quantification of the results of these activities is done differently and supply chain could be quite extensive.

The most representative logistics activity, freight transport, is quantified in term of performance in various units: number of kilometres, number of vehicles required for the transportation existing quantities, carried quantity. But the specific units of performance quantification that best properly reflect the transportation performance are tonne-kilometre, vehicle-kilometre or any other standard loading unit-kilometre.

Starting from these there can be determined a series of energy efficiency indicators (table 1), such as specific consumptions, energy intensity, energy specific expenditures. For example, in what it concerns the distribution channels, for measuring energy efficiency it could be considered the following categories of such of indicators:

- Fuel consumption per tonne-kilometre;
- Fuel consumption per 100 kilometres;
- Fuel consumption per pallet-kilometre;
- Fuel consumption per package;
- Fuel consumption per tonne;
- Fuel consumption per client served.

Table 1. Energy efficiency indicators for transport

Energy metrics	**Transportation metrics**	**Energy efficiency indicators**
Energy consumption (oil, electricity, gas, others): - Rail - Road - Air - Water - Pipelines	Kilometres	Energy specific consumption = Energy consumption/ 100 kilometres
	Tonnes	Energy specific consumption = Energy consumption/ tonnes
	Tonne-kilometre	Energy specific consumption = Energy consumption/ tonne-kilometre
	Palette-kilometre	Energy specific consumption = Energy consumption/ palette-kilometre
	Vehicle-kilometre	Energy specific consumption = Energy consumption/ vehicle-kilometre
	Vehicles	Energy specific consumption = Energy consumption/ vehicle
	Value added	Energy efficiency = Value added / energy consumption
		Energy intensity = Energy consumption/ value added
Energy costs	Kilometres	Specific energy expenses = Energy cost/ 100 kilometres
	Tonnes	Specific energy expenses = Energy cost/tonne
	Tonne-kilometre	Specific energy expenses = Energy cost/ tonne-kilometre
	Vehicle-kilometre	Specific energy expenses = Energy cost/ vehicle-kilometre
	Palette-kilometre	Specific energy expenses = Energy cost/ palette-kilometre
	Vehicles	Specific energy expenses = Energy cost/vehicles
	Value added	Energy efficiency = Value added / Energy cost

Besides the physical energy efficiency indicators, it presents also relevance the value indicators. There can be used metrics such as:

- absolute energy expenses;
- specific energy expenses, measured as a ratio between energy expenses and the results of activity expressed in physical units;
- the weight of energy expenses in total expenses.

In what it concerns the warehousing, another logistics activity consuming important energy resources, energy efficiency indicators can be calculated by reporting to various activity data, such as of surface units, number of employees or added value of services rendered (figure 1).

There is also the possibility to report to the loading units, but this can be done rather in the case of warehouses with a very limited range of products and with physical measurement units of the same type to ensure comparability.

For warehouses with a large assortment of products, with load units of different sizes, with different physical characteristics is recommended to replace these units with value units allowing comparability and calculation of calculation of synthetic indicators at the warehouse level or storage building.

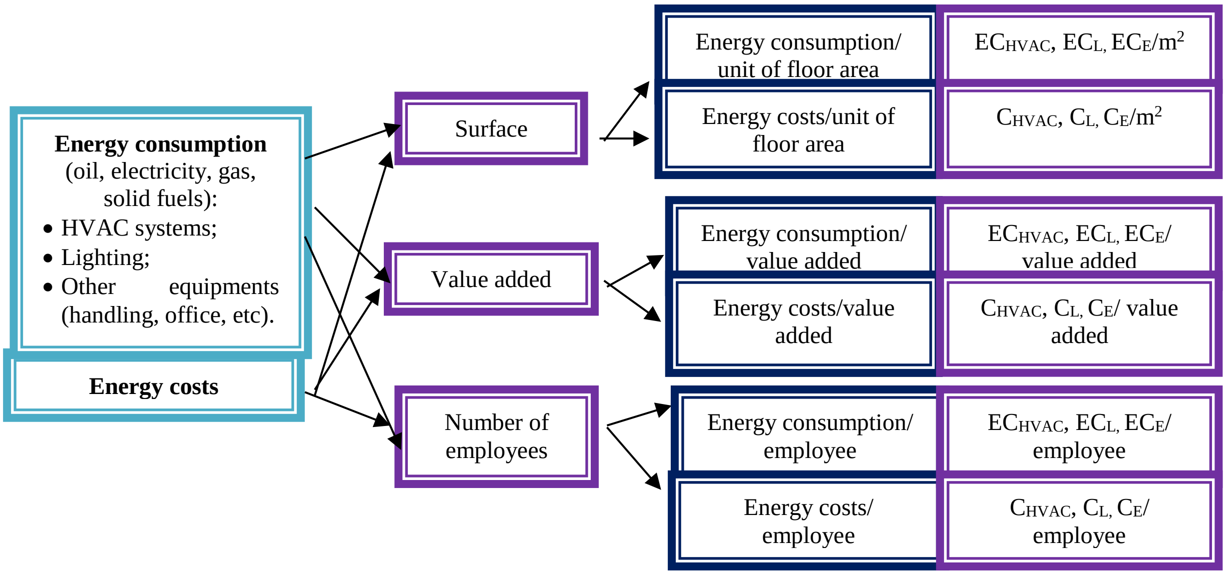

Fig.1. Energy efficiency indicators in warehousing

In order to do the analysis of energy efficiency in a warehouse, there can be made even more punctual determinations. For example, to determine the energy efficiency of lighting systems used in buildings serving logistics activities, it is reported their performance in lumens to energy consumption to obtain it. Moreover, determinations can be performed for each category of service, for each source of energy, for each heating, air conditioning or handling equipment and other technology.

In what it concerns the comparisons at international level of the energy efficiency, statistical data are most often global referring to the consumptions of energy in different sectors or to the energy intensity related to GDP or GVA (gross value added). Energy efficiency indicators can be converted into CO2 intensity indicators through unit 'gram CO2 emitted per tone-kilometer' (kg CO2 / t-km) [1].

In a classification of energy efficiency indicators realized by ICEMENERG [2], there have been identified three major categories of indicators:

1. Monitoring indicators of the trends in energy efficiency:
   a. Energy intensity;
   b. Specific energy consumption;
   c. Indicators of the evolution of energy efficiency calculated at the level of the economy as a whole or of the economic sectors;

2. Comparison indicators to compare the energy performance of different countries:
    a. Indicators adjusted according to the structures of national economies, price level, climatic conditions;
    b. Target indicators;
3. Diffusion indicators:
    a. Market penetration of the energy efficient;
    b. Diffusion of the most effective practices in terms of energy efficiency.

A study conducted by OECD [3] reveals that there are a number of issues related to data availability.

Given that the most important logistics activities are freight transport and warehousing, existing statistics are not relevant enough. Statistics relating to the transport sector allow identification of energy consumptions for freight transportation at the level of states, but in the case of activities related to storage of goods, existing statistics do not distinctly delimit this category of energy consumptions. Existent statistical data are global, related to service sector, such as energy consumptions of energy expenditures, without giving information on the specific consumptions of warehousing activities.

Aggregate indicators have the advantage of their availability, but their utility is limited and can lead to misinterpretations when they are incorrect handle [4].

3. POSSIBILITIES TO IMPROVE ENERGY EFFICIENCY IN DISTRIBUTION CHANNELS

In order to optimize logistic activities one of the objectives is reduction of energy consumption for a given level of service.

Among the logistics activities, transport stands out as the most important activity in the ensemble of these activities. For this reason, increasing energy efficiency is considered as an important goal of freight transports, especially in the case of road transports, large consumers of energy resources.

But, unfortunately transport is considered one of the most difficult sectors for improving energy efficiency [5]. Even though OECD countries are recording a reduction in energy intensity by improving the energy efficiency of new generations of vehicles, there are many problems at global level due to an increase of the use of road transport for goods in many of the countries in the world.

There can be taken into considerations some solutions for optimization energy consumption in transportation of goods, along the distribution chains, most of them based on new information and communication technologies. But it can take into account also fiscal measures to stimulate the reduction of energy consumption.

Implementing an automated fleet management solution enables improving energy efficiency [6]. In addition, it had an impact on driver safety, warning the driver about the vehicle over speed. There can be used, also, intelligent traffic management programs that optimize traffic flows in real time leading to increase energy efficiency. Route optimization using satellite navigation systems reduces fuel consumption per unit of freight transported [1].

Also for spaces used for logistics activities there have to consider a number of measures to improve energy efficiency. In order to increase energy efficiency in warehouses, it needs to take into considerations the key aspects of energy performance of the buildings, as well as handling, sorting, picking and transportation equipments.

In a study realized by Knowles [7], the author used the surface area to volume ratio as metric in order to determine the heat loss and gain direct influencing the energy performance, small values of this metric revealing minimum transfer of heat. As a result, these heat losses and gains depends on the form design, the best form identified being a cube. For day lighting and ventilation optimization the building form has to be one with building area closer to the perimeter area [8].

In order to get other energy savings for the buildings alongside the logistics channels there can be considered also:

- Orientations in relation to sun:
  - Rectangular buildings oriented on east – west direction maximize solar heat gain in winter and minimize it in summer [8];
- Orientations in relation to wind direction determine improvement in building ventilation and energy performance [9];
- Building insulation – determines reductions in heating needs, having as effect a better energy performance of the building [10].

Companies operating in logistics may use a range of optimization solutions which can cause significant reductions and energy costs. For the older buildings their isolation could be a first solution, while for new investments in storage facilities and categories of spaces for logistics, the measure would consist in construction of energy efficient buildings. In addition, their facilities such as handling, sorting, packing, labelling, picking equipments, as well as HVAC systems should be energy efficient.

By entering a building automation system (BAS) the company can control HVAC, electrical, and lighting systems [11]. The use of solutions of integration lighting and HVAC systems through daylight control and the advent of LEDs can also lead to increased energy efficiency [12]. Software-based solutions in the pump control in HVAC applications in distribution increase energy efficiency and eliminate external sensors and related procurement installation and maintenance cost.

Improvement of HVAC and control infrastructure, the introduction of centralized energy management control systems and replacing inefficient lighting systems cause significant energy savings [13]. In a study conducted in 2014 [14], it had been revealed that in the selection of lighting products for office buildings, besides product quality, energy efficiency (97%) is decisive.

At the level of the member countries of the European Union introducing energy labeling and energy performance standards referring to technologies, equipment and buildings were some of the measures applied on a large scale. In Romania, at governmental level, there are, also, concerns regarding energy efficiency. In 2014 the requirements of the Directive on energy efficiency were transposed into national law.

Mandatory energy auditing of the companies and energy certification of buildings are among the measures taken by governments to make businesses to choose energy efficient solutions. In addition, the use of fiscal measures by the states can stimulate energy efficient investments.

A large part of these measures are also applicable to the companies operating in the logistics sector, in the distribution channels, such as those regarding the electric motors, electric traction, electric drive, air conditioning systems, equipment office, lighting products, which can contribute substantially to increasing the energy efficiency of logistics channels.

In order to inform all users there can be created information and energy consulting centres, but there can be used also a number of other means, such as guides, newsletters, dissemination best practice of energy efficiency solutions. Besides consumers' information measures, an important impact might have the programs for energy technology development and incentive programs for equipment manufacturers, as well as for producers of freight transport vehicles.

4. CONCLUSIONS

For monitoring energy efficiency and in order to be able to make comparisons in time and space, it is necessary to use energy efficiency indicators universally recognized and creation of databases adequate to these determinations. Different metrics regarding energy performance allow comparison of different kinds of systems and their relative efficiencies.

At the macroeconomic level it can be considered the relation between energy consumption and GDP, GVA, population and other macroeconomic variables.

To quantify the energy intensity of specific activities in distribution of goods it can be considered energy consumption reported to physical or monetary units resulting from these activities.

Increasing energy efficiency contributes not only to increase profitability of companies in logistic channel, but also to achieve social goals and sustainable development.

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ON-LINE MONITORING SYSTEM FOR POWER TRANSFORMERS

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Keywords: monitoring system, power transformers, power system protection*;*

Abstract: *Power transformers are the most important and expensive equipment from the electricity transmission system,* so *it is very important to know the real state of health of such equipment in every moment. De-energizing the power transformer accidentally due to internal defects can generate high costs. Annual maintenance proved to be ineffective in many cases to determine the internal condition of the equipment degradation due to faults rapidly evolving. An On-line Monitoring System for Power Transformers help real-time condition assessment and to detect errors early enough to take action to eliminate or minimize them. After abnormality detected, it is still important to perform full diagnostic tests to determine the exact condition of the equipment. On-line monitoring systems can help increase the level of availability and reliability of power transformers and lower costs of accidental interruption. This paper presents* ***cases studies*** *on several power transformers equipped with on-line monitoring systems from Transelectrica substation.*

1. INTRODUCTION

A sudden increase in key gases and the rate of gas production is more important in evaluating a transformer than the accumulated amount of gas. One very important consideration is acetylene (C_2H_2). Generation of any amount of this gas above a few ppm indicates high-energy arcing. Trace amounts (a few ppm) can be generated by a very hot thermal fault (500 degrees Celsius or higher). A one- time arc, caused by a nearby lightning strike or a high voltage surge, can also generate a small amount of C_2H_2. If C_2H_2 is found in the transformer ,oil samples should be taken weekly or even daily to determine if additional C_2H_2 is being generated.

If no additional acetylene is found and the level is below the minimum value established by the standards, the transformer may continue it’s service. However, if acetylene continues to increase, the transformer has an active high-energy internal arc and should be taken out of service immediately. Further operation is extremely hazardous and may result in explosive catastrophic failure of the tank, spreading flaming oil over a large area.

2. TRANSFORMER OIL TESTS THAT SHOULD BE PERFORMED ANNUALLY WITH DISSOLVED GAS ANALYSIS

Dielectric Strength. This test measures the voltage at which the oil electrically breaks down. The test gives an indication of the amount of contaminants (water and oxidation particles) in the oil, [1].

The dielectric strength test is not extremely conclusive; moisture in combination with oxygen and heat will destroy cellulose insulation long before the dielectric strength of the oil has indicated anything is going wrong but the tests explained below are much more important in that regard.

Interfacial Tension. This *Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method*, is used by laboratories to determine the interfacial tension between the oil sample and distilled water. The oil sample is placed in a beaker of distilled water at a temperature of 25 degree celsius. The oil will float. because it's specific gravity is less than that of water. There should be a distinct line between the two liquids. The interfacial tension number is the amount of force (dynes) required to pull a small wire ring upward a distance of 1 centimeter through the water/oil interface. A dyne is a small unit of force equal to 0.000002248 pound. Good clean oil will make a very distinct line on top of the water and give an IFT(interfacial tension) number of 40 to 50 dynes per centimeter of travel of the wire ring, [2].

As oil ages, it is contaminated by tiny particles (oxidation products) of the oil and paper insulation. Particles on top of the water extend across the water/oil interface line which weakens the surface tension between the two liquids. Particles in oil weaken interfacial tension and lower the IFT number.

IFT and acid number together are excellent indictors of when oil needs to be reclaimed. It is recommended the oil be reclaimed when the IFT number falls to 25 dynes per centimeter. At this level, the oil is very contaminated and must be reclaimed to prevent sludging, which begins at around 21 dynes per centimete. If oil is not reclaimed sludge will settle on windings, insulation, cooling surfaces, etc., and cause loading and cooling problems. This will greatly shorten transformer life.

There is a definite relation between acid number, the IFT, and years-in-service. The accompanying curve, *figure 1* shows the relationship and is found in many publications. Notice that the curve shows the normal service limits both for the IFT and the acid number, [3].

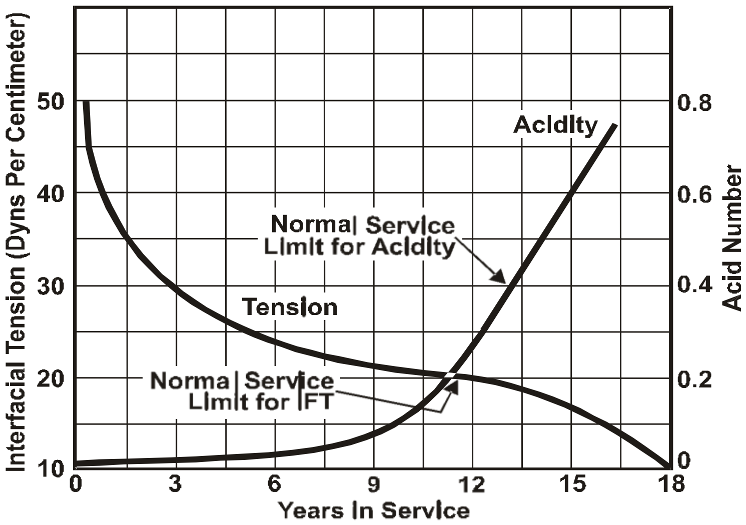

Fig.1. Service Limits for Transformer Oil.

Acid Number. Acid number is the amount of potassium hydroxide (KOH) in milligrams (mg) that it takes to neutralize the acid in 1 gram of transformer oil. The higher the acid number, the more acid is in the oil. New transformer oils contain practically no acid. Oxidation of insulation and oils form acids as the transformer ages. Oxidation products form sludge particles in suspension in the oil which dripping inside the transformer. The acids attack the metals inside the tank and form soaps. Acid also attacks cellulose and accelerates insulation degradation. Sludging has been found to begin when the acid number reaches 0.40. The oil with this acid number should be reclaimed long before it reaches 0.40. It is recommended that the oil be reclaimed when the acid number reaches 0.20 mg KOH/g, [3].

Furans. Furans are a family of organic compounds which are formed by degradation of paper insulation. Overheating, oxidation, acids, and decay caused by high moisture with oxygen accelerate the destruction of insulation and form furanic compounds.

When furans become greater than 250 parts per billion (ppb), [4], the oil should be reclaimed; paper insulation is being deteriorated and transformer life is reduced at a high rate. Furanic content in the oil is especially helpful in estimating remaining life in the paper insulation, particularly if several prior tests can be compared and trends established.

Oxygen. Oxygen (O_2) must be watched closely during the tests. Many experts and organizations, believe that above 2,000 ppm, [3], oxygen in the oil greatly accelerates paper deterioration. This becomes even more critical with moisture above safe levels.

High atmospheric gases (O_2 and nitrogen [N_2]) normally mean that a leak has developed in the bladder or diaphragm in the conservator. If there is no conservator and pressurized nitrogen is on top of the oil, expect to see high nitrogen but not high oxygen.

Oil Power Factor. Power factor indicates the dielectric loss (leakage current associated with watts loss) of the oil.A high power factor indicates deterioration or contamination from byproducts such as water, carbon, or other conducting particles, including metal soaps caused by acids attacking transformer metals, and products of oxidation. If the power factor is greater than 1.0% at 25 degrees celsius, [4], the oil may cause failure of the transformer; replacement or reclaiming of the oil is required immediately. Above 2%, oil should be removed from service and replaced because equipment failure is imminent, [5]. The oil cannot be reclaimed.

Moisture. Moisture, especially in the presence of oxygen, is extremely hazardous to transformer insulation.

When 2% moisture is reached, plans should be made for a dry out. Never allow the moisture to go above 2.5% in the paper or 30% oil saturation before drying out the transformer, [2]. Each time the moisture is doubled in a transformer, the life of the insulation is cut by one-half as the life of the transformer is determinated by the life of the paper, and the life of the paper is extended by keeping out moisture and oxygen.

When the transformer is new, this water is distributed equally through the transformer but when the transformer is energized, water begins to migrate to the coolest part of the transformer and the site of the greatest electrical stress. This location is normally the insulation in the lower one-third of the winding. Paper insulation has a much greater affinity for water than oil does. Insulation acts just like blotting paper or paper towels; it soaks up water superbly. The water will distribute itself unequally, with much more water being in the paper than in the oil. The paper will even partially dry the oil by absorbing water from the oil, [6]. Temperature is also a big factor in how the water distributes itself between the oil and the paper.

It is critical for life extension to keep transformers as dry and as free of oxygen as possible. Moisture and oxygen cause paper insulation to decay much faster than normal and to form acids, metal soaps, sludge, and more moisture. Sludge settles on windings and inside the structure, causing transformer cooling to be less efficient, and slowly, over time temperature rises. Acids cause an increase in the rate of decay, which in turn forms additional acid, sludge, and moisture at a faster rate. This is a vicious cycle of increasing speed with deterioration forming more acid and causing more decay. The answer is to keep the transformer as dry as possible and free of oxygen as possible.

3.TRANSFORMER DIAGNOSTICS AND REHABILITATION

Determining transformer condition is useful in itself for making short-term decisions regarding operation and maintenance. Assessing transformer condition through diagnostic techniques is also important for conducting asset management studies for transformer replacement. Transformer condition is an important input to an engineering and economic model used in determining the most cost-effective alternative for power train rehabilitation, (continued operation, refurbishment, or replacement). A methodology has been developed to use information derived from the diagnostics described in this document for rehabilitation purposes.

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ASPECTS REGARDING SF6 SWITCH DISCONNECTOR FRAMEWORK DESIGN

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Keywords: Finite element analysis; high-voltage techniques; switchgear

Abstract*: The complexity of the designing process of a switch disconnector framework comes from the almost impossible task to appreciate the discrepancy between the ideal and practical electric strength. Complicated geometries characterized by nonuniform fields are predesigned based on a set of analytical relations and corrected/optimized based on numerical methods and high voltage testing on prototypes. This paper suggest some approaches to minimize the effort and the steps required to achieve an acceptable stainless steel housing, in the insulators area, for a medium voltage SF_6 switch disconnector. The results are based on simple analytical evaluation and finite element analysis in both 2D and 3D configurations.*

1. INTRODUCTION

The commutation in SF_6, alongside that in vacuum are, nowadays, the basis of the power system technology [1], [2]. The switchgears have to be continuously improved regarding their safety, endurance, operating simplicity, capability of integration in smart grids and availability for higher and higher voltages and currents. All these demands constitute the input data for design process, which is carried out through an analytical methodology. The result, the prototype is subject of improving and validation based on a set of standardized tests in accordance with its rated parameters. Actual development of virtual reality, offers a faster and cheaper way to improve/validate an analytical pre-sized configuration, avoiding the prototyping steps until the final validation. The numerical methods for solving any type of engineering problems are affordable and a right use of them, guarantees results comparable with real tests. Finite element analysis (FEA) is one of the most powerful tools for electric field computation with good results in electrical apparatus simulation, [3-6].

In this paper the dielectric design of the stainless steel housing is studied in the insulators area, for an indoor, 24 kV rated voltage, 630 A rated current, switchgear, filled with 0.15 MPa pressure SF_6.

The dielectric design is conducted on breakdown in uniform and weakly nonuniform fields. The "practical electric strength" of the SF_6 for given structure is, [7]:

$$E_b = \left(\frac{E_b}{p}\right)_t \cdot (10 \cdot p)^z \quad [kV/cm] \tag{1}$$

$(E_b/p)_t$ in KV/(cm·MPa) is the "technical relative strength", p in MPa is the pressure of the insulated gas and z is a factor introducing different types of applied voltages. For a positive lightning impulse (1.2/50 μs), $(E_b/p)_t$ = 80 KV/(cm·MPa) and z = 0.8, [7]. The result becomes 110.65 KV/cm.

Imposing the standardized voltage for impulse testing, [8], V_{imp} = 125 KV, the minimum insulation distance could be determined as:

$$d = \frac{V_{imp}}{E_b \cdot e_r \cdot e_{max} \cdot \eta} \quad [cm] \tag{2}$$

Variable e_r is the roughness factor, here considered as 0.75, covering technical mean roughness, [7], [9], [10]; e_{max} is the curvature factor, equal to 1.1 for an inner radius of the electrode equal to 9 mm, [7]; η is the Schwaiger factor or the degree of uniformity close to 0.23 for the desired configuration [7]. The computation goes to a value of 6 cm for minimum insulation distance.

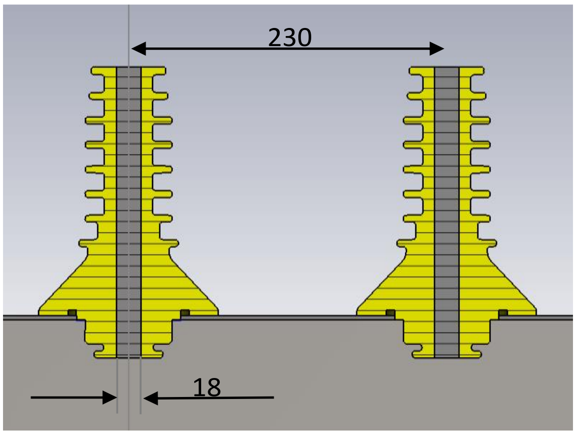
In above conditions the corrected practical electric strength is:

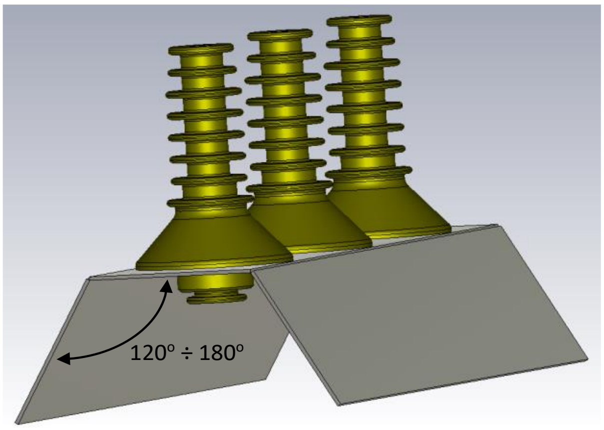
$$E_b = E_b \cdot e_r \cdot e_{max} \quad [kV/cm] \tag{3}$$

with a value of 91.2 KV/cm which must be satisfied in all regions inside of the switchgear tank.

2. INVESTIGATED CONFIGURATIONS

The insulators are 230 mm spaced and the inner cooper rod is 18 mm diameter, Figure 1 (a). The geometries of the upper side of the housing are started with a flat configuration, which will be bent between up to a flip angle of 120° to create a compact structure, Figure 1 (b). Also, based on actual solution for stiffen the insulators against rotation (two linear carvings cut out into insulators and also in the housing), the bushing diameter is another parameter tested for its influence on electric filed intensity, Figure 2. The insulators design is not the subject of this paper, only the influences of the above characteristics are investigated, so the relevant results will constitute the trends, rather than absolute values.





(a) *(b)*

Fig. 1. (a) The insulators geometry; (b) The upper side of the housing with mounted insulators.

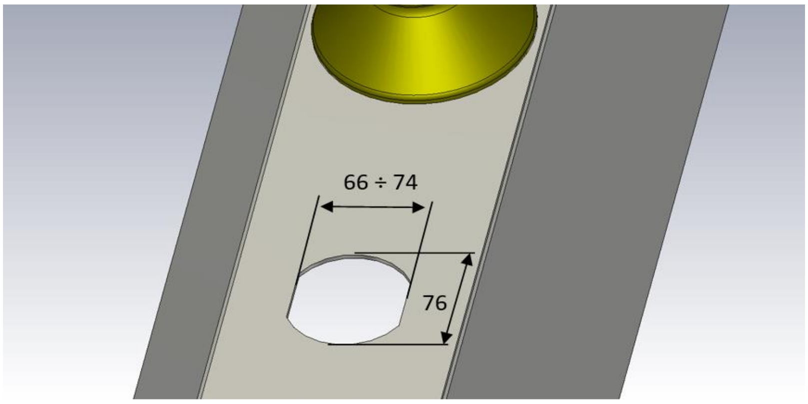


Fig. 2. The solution for stiffen the insulators against rotation.

2.1. Bushing diameter

For a preliminary computation of the bushing diameter, a coaxial cylindrical capacitor configuration will offer the electric field intensity values to be compared to the practical electric strength.

The major problem of the insulator passing through the housing is that always some space will remain between the metal frame and the insulators, so above capacitor will be with two dielectric layers, one consisted by epoxy resin, relative permittivity equal to 3 and the other, very thin, filled with SF_6, having the dielectric constant equal to 1.00203, Figure 3.

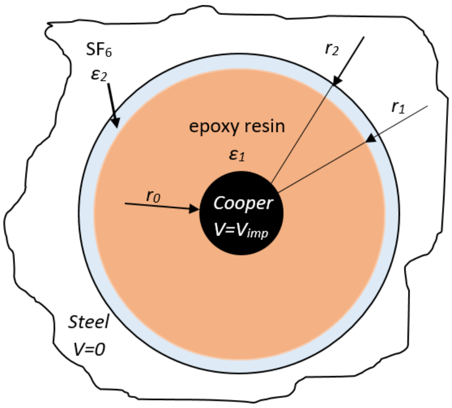


Fig. 3. Insulator crossing the upper side of the housing.

The values of the electric field in each point of the configurations could be computed based on:

$$E(r_i) = \frac{V_{imp}}{\varepsilon_i \cdot r_i\left(\frac{1}{\varepsilon_1} ln\frac{r_1}{r_0} + \frac{1}{\varepsilon_2} ln\frac{r_2}{r_1}\right)} \quad (4)$$

Selecting the value of r_2-$r_1 < 0.1$ mm, the minimum bushing diameter which goes to satisfy the practical electric strength is 65 mm. For this value, the electric field intensity on the exterior of the insulator reach a magnitude of 90 KV/cm. Keeping in mind that assessment of the roughness factor and the curvature factor is not very rigorously, the minimum distance between the cooper rod and the framework will be considered 66 mm. This distance will be the distance between carvings that stiffen the insulators against rotation. As conclusion the bushing diameter must be above 66 mm. To have a larger interval of variations, i.e. 66 to 74 mm, this goes to a ratio of lower area of insulator of 38 mm, Figure 2.

The next step is to perform different carvings on cylindrical models Figure 3, and analyze its influence on dielectric stress. For the beginning 2D planar problems are solved using David Meeker's Finite Element Method Magnetics, FEMM, [11]. For 72 mm between linear carvings, the electric field distribution looks like in Figure. 4.

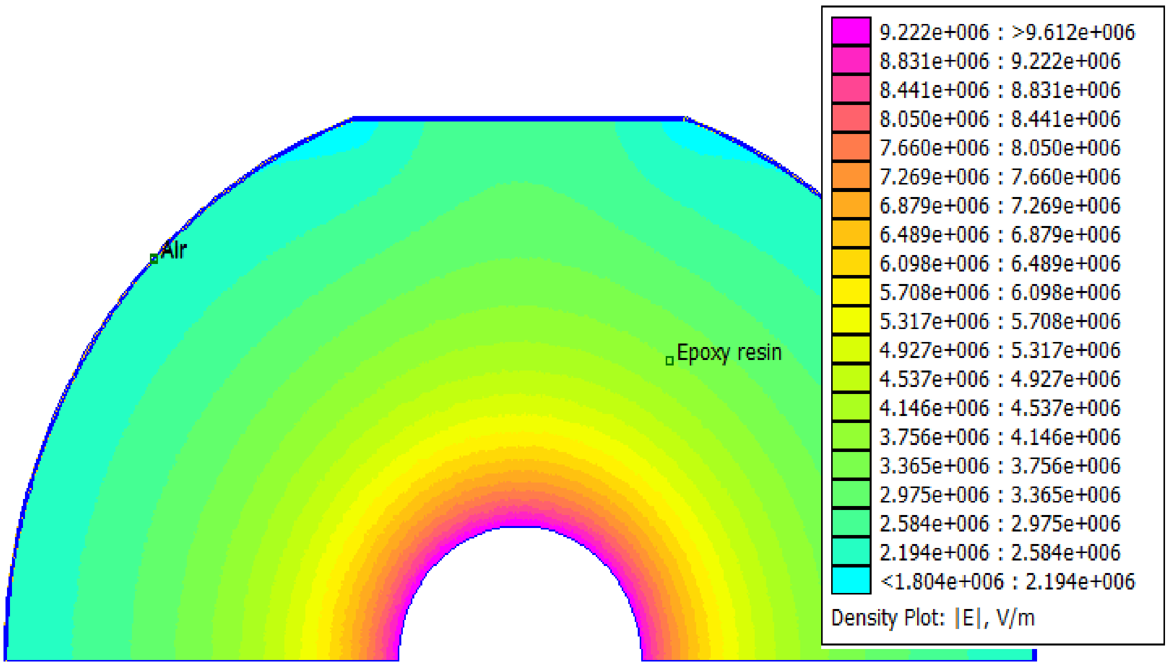


Fig.4. Electric field distribution.

The total computing time is approx. 2.5 minutes for 1669993 elements. The refinement process to achieve a good balance between accuracy versus the number of finite elements, i.e. computing time and hardware resources, was performed based on coaxial cylindrical configuration.

Due the speed of analyses it can be ran a very important number of FEA. The results are presented in Figure 5.

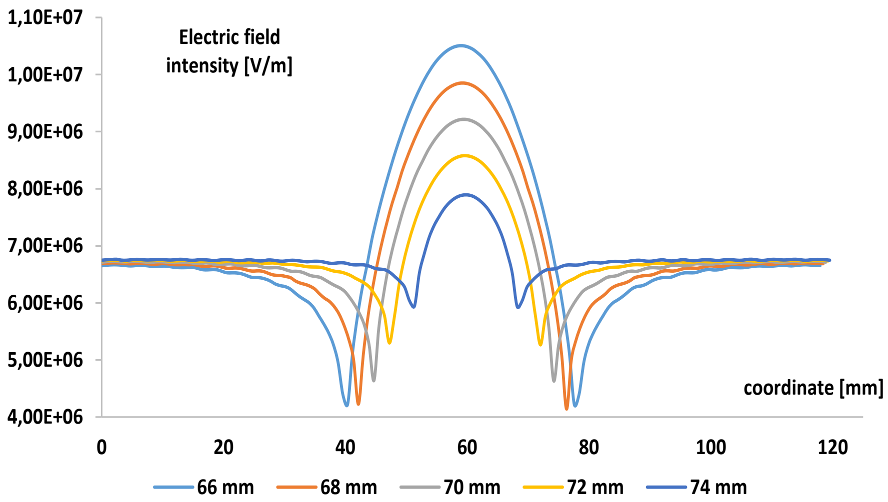


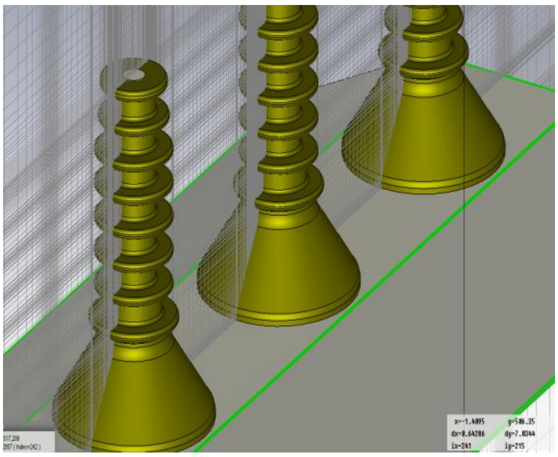
Fig.5. Electric field intensity on boundary between insulator and SF_6, for different insulator carvings in 2D FEA.

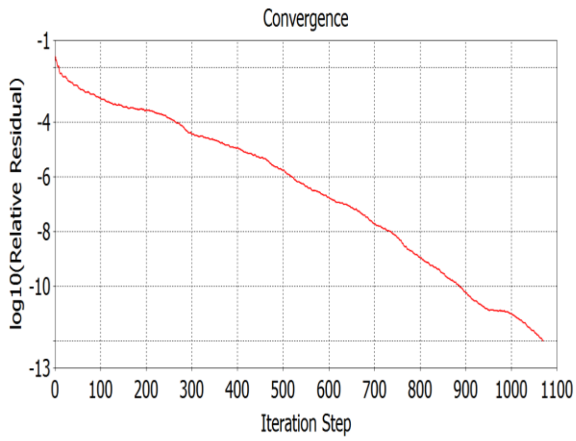
For 70 mm between carvings, the electric field is bigger than 92 KV/cm, a value bellow 90 KV/cm appears for 72 mm distance.

2.2. 3D FEA

Of course a 2D FEA do not reflect the real electric field distribution. 3D analyses must be done to take into account the entire region geometry. The configurations from Figures 1 and 2, with a test voltage applied to middle rod, all other conductive parts being putted to the earth, were considered.

The electrostatic FEA are performed using CST Studio Suite 2015, [12]. Approximatively 37.800.000 initial hexahedral cells are used with 10^{-12} solver accuracy and 2 refinement steps. The final number of mesh cells reached approx. 64.500.000, Figure 6 (a). On an Intel® Core™ i5 – 4590 CPU, 32 GB RAM based system, for one configuration the solving time is 1 hour and 32 minutes for 1070 iterations, Figure 6 (b).

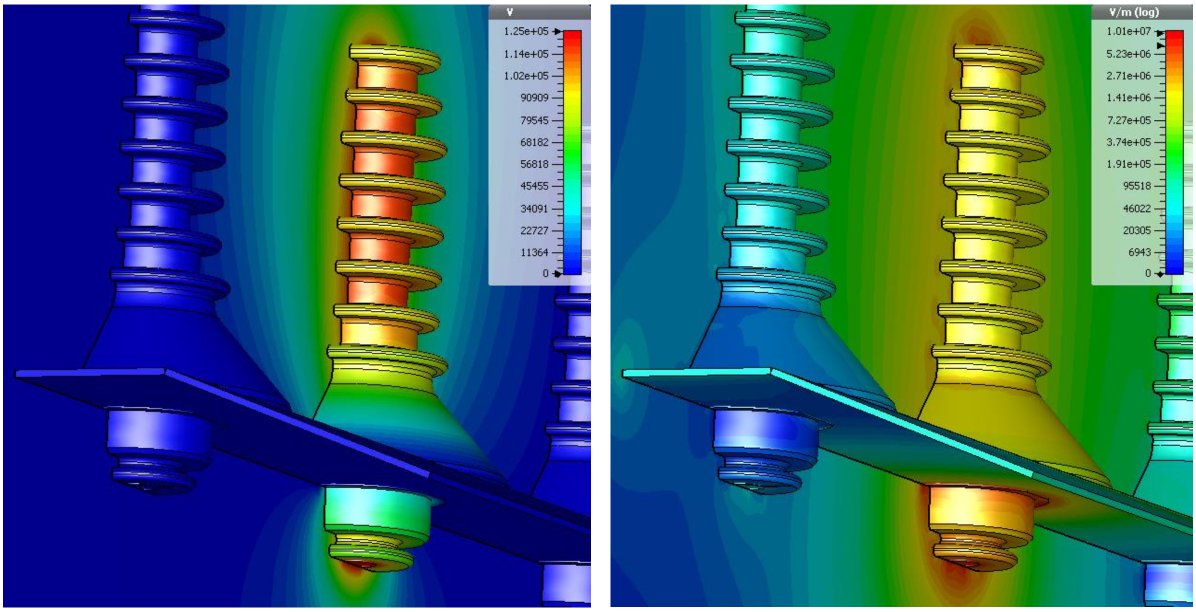




(a) *(b)*

Fig. 6. (a) Refined mesh; (b) Convergence versus iterations.

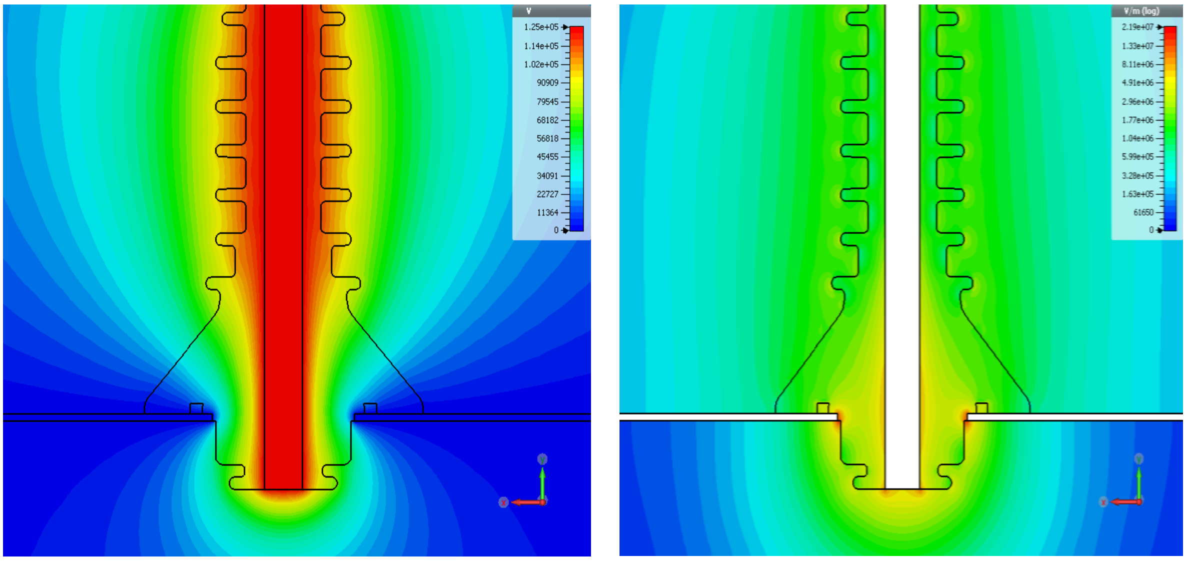
The potential and the electric field intensity in entire configuration are analyzed. In Figures 7 (a) and (b) there are presented the distributions of above variables in a longitudinal cutting plane for a bending angle of 160° and 72 mm between linear carvings.



(**a**) (**b**)

Fig. 7. (a) The potential distribution in the longitudinal cutting plane; (b) The electric field intensity distribution in the longitudinal cutting plane.

For a transversal cutting plane through the middle insulator, the distributions of the potential and of the electric field intensity are shown in Figures 8 (a) and (b). The red areas from electric field distributions are more electric stressed and these portions must be evaluate in detail.



(a) (b)

Fig.8. (a) The potential distribution in the transversal cutting plane; (b) The electric field intensity distribution in the the transversal cutting plane.

Figures 9 and 10 show the electric field intensity variations for all analyzed geometries. First, in Figure.9 is the electric field intensity for different insulators carvings and in Figure 10 is the electric field intensity, for different bending angle of the upper side of the housing. Remembering the computed value of the practical electric strength, (2) equal to 91.2 KV/cm the interpretation becomes simple and logically.

It can be seen that, for 66 up to 72 mm, the influence of the linear curving is very important and determines the maximum dielectric stress. For an electric field above the corrected practical electric strength, (2), this will lead to breakdown. As it can been seen from Figure 9 for bigger values than 72 mm, this influence vanishes. Due this fact, the configuration with 72 mm between carvings is kept for the next analyses.

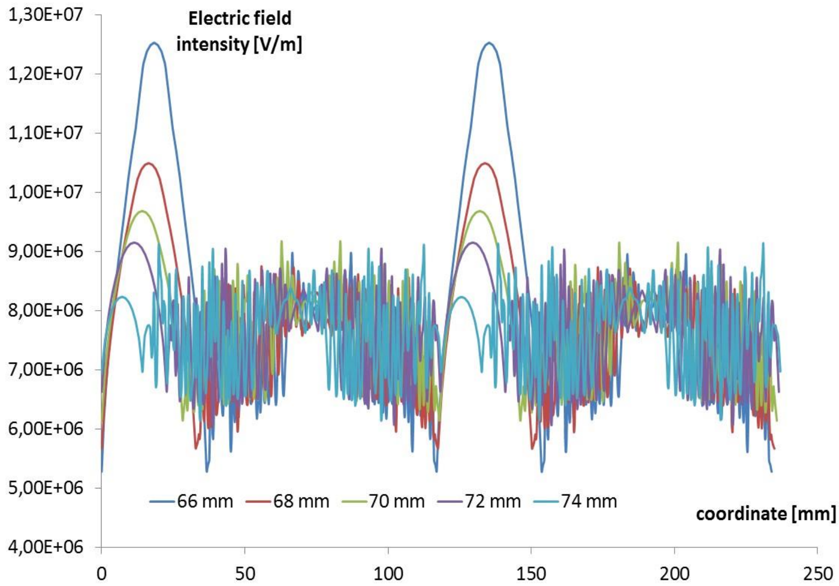


Fig. 9. Electric field intensity for different insulators carvings.

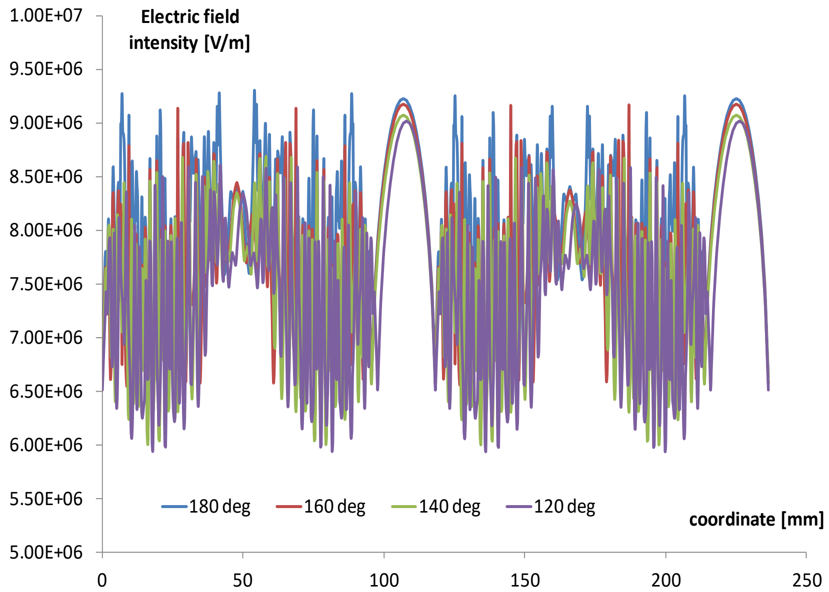


Fig.10. Electric field intensity for different bending angle of the upper side of the housing.

The bending angle has a very little influence on electric field intensity, causing a slightly reduction of it, following the variation from 180^o to 120^o, Figure 10.

3. CONCLUSIONS

Toward the method presented in [13], there are some improvements proposed in this paper. Consequently, to minimize the effort required to achieve an acceptable stainless steel housing, in the insulators area, for a medium voltage SF_6 switch disconnector, we propose the next algorithm:

- First of all, a 2D planar coaxial cylindrical capacitor configuration is created for computing the initial bushing diameter,
- The same structures, but with different carvings added to insulators, for stiffen them against rotation, are analyzed on a 2D Finite element environment,
- Only the solutions that fulfilled the dielectric requirement will be forwarded to 3D FEA for final validation/optimization.

The succession of: simple analytical, 2D FEA and 3D FEA offer the solutions of the problem in an efficient manner, regarding the computing time and the elimination process for inadequate configurations.

Based on FEA it is very simple and accurate to predict the dielectric behavior of the future prototype and some vulnerability can be corrected before the production phase. Also "countless" scenario regarding the geometries, materials and different applied voltages could be considered inside of the virtual environment.

Of course the electrostatic simulation is only one step, other electromagnetic, mechanic, thermal, etc. analyses could be performed and the results would generate a full and complex assembly of the future switchgear behaviors. The output of the process will be not just an available device, accordingly to standards, but could be also a close to optimum one.

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COMPARISON OF VARIOUS EPSON SMART GLASSES IN TERMS OF REAL FUNCTIONALITY AND CAPABILITIES

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Keywords: smart glasses, Epson Moverio, mobile streaming.

Abstract*: The article presents some experiences with the smart glasses developed by Epson, namely Movrio BT-200, BT-300 and BT-2000. We conclude that they are on the right track, good devices, however, are still in an incipient, before the market stage and need a lot of technical (both hardware and software) improvements to be up to the needs of the real market.*

1. INTRODUCTION

The wearable technologies are smart electronic devices (electronic device with microcontrollers) that can be worn on the body as implant or accessories. They are designed for specific practical functions and features [1]. At this moment, the most advanced wearable devices are the smart glasses, as they tend to be economically functional and useful [2]. However, the most widely-spread are smart watches and bracelets, used for step counting [3], heart beat measurement [4] or activity recognition [5].

Examples of other wearable devices include contact lenses, e-textiles and smart fabrics, headbands, beanies and caps, jewelry such as rings, bracelets, and hearing aid-like devices that are designed to look like earrings [6].

Smart glasses available on the market are:

- ✓ ODG R7-9, [7],
- ✓ Lumus Vision DK-50, [8],
- ✓ Epson Moverio BT 200, 2000 and 300, [9].

2. SMART GLASSES AT THE STAKE

Beyond the marketing messages, we needed a pair of smart glasses capable of apparently basic functionality, but in real world. The most widely known and used glasses are Google Glasses, respectively a suit developed by Epson. However, according to [7], Google dropped the project in 2015 and Epson improved his products. We preferd them also because they use Android and not proprietary operating systems. The three glasses are: Moverio BT-200, BT-2000 ad BT-300, detailed further.

Table 1. Epson Moverio BT-200 characteristics

CPU	TI OMAP 4460 1.2Ghz Dual Core
RAM	1 GB
Internal Memory	8 GB
External Memory	microSD (max.2GB) / microSDHC(max.32GB)
Battery Type	Li-Polymer [2720] mAh
Wireless LAN	IEEE 802.11b/g/n with WiFi Miracast
Bluetooth	3.0
Camera	VGA
OS Version	Android [4.0.4]
LCD Size	0.42 inch wide panel (16:9)
LCD Pixel Number	518,400 dots [(960×540) x 3]
Sensors	Compass, Gyroscope, Accelerometer, GPS
Weight Headset	Approx. 88 g (without light Shielding and harness)
Weight Controller	Approx. 124 g

Figure 1. Epson Moverio BT-200

Table 2. Epson Moverio BT-2000 characteristics

CPU	TI OMAP 4460 1.2Ghz Dual Core
RAM	1 GB
Internal Memory	8 GB
External Memory	microSD (max.2GB) / microSDHC(max.32GB)
Battery Type	Li-Polymer 2x 1240mAh
Wireless LAN	IEEE 802.11b/g/n with WiFi Miracast
Bluetooth	3.0, BLE
Camera	5 megapixel stereo camera
OS Version	Android [4.0.4]
LCD Size	0.42 inch wide panel (16:9)
LCD Pixel Number	518,400 dots [(960×540) x 3]
Sensors	Compass, Gyroscope, Accelerometer, GPS
Weight Headset	Approx. 88 g (without light Shielding and harness)
Weight Controller	Approx. 124 g

Figure 2. Epson Moverio BT-2000

Table 3. Epson Moverio BT-300 characteristics

CPU	Intel Atom x5, 1,44Ghz Quad Core
RAM	2 GB
Internal Memory	16 GB
External Memory	microSD (max.2GB) / microSDHC(max.32GB)
Battery Type	Li-Polymer 2950mAh
Wireless LAN	IEEE 802.11b/g/n with WiFi Miracast
Bluetooth	3.0, BLE
Camera	5 megapixel
OS Version	Android [5.1]
LCD Size	0.43 inch wide panel (16:9)
LCD Pixel Number	921,600 pixels (1,280x720) x RGB
Sensors	Compass, Gyroscope, Accelerometer, GPS
Weight Headset	Approx. 69 g (without light Shielding and harness)

Figure 3. Epson Moverio BT-300

3. RESEARCH METHODOLOGY

Going from very specific, real life needs, we tested the glasses on an app developed by HOLISUN and Intellisoft Association. The app has been developed for recognizing a dominant colour in an image captured by the glasses. The app takes some sample frames (1 frame per second) and makes and histograma for that image to calculate the dominant color. After calculation of the dominant color the app show the dominant color and the name of color in a box.

The second app, more complex, has been used for audio and video streaming. The streaming app use WebRTC technology. **WebRTC** is a collection of communications protocols and application programming interfaces that enable real-time communication over peer-to-peer connections. This enables applications such as video conferencing, file transfer, chat, or desktop sharing without the need of either internal or external plugins. This app works on mobile(preferred 3G or 4G networks) and wifi networks(with or without proxy).

4. COLOUR DETECTION EXPERIMENTAL RESULTS

We detected many problems in using the Moverio BT-200 glasses for colour detection.

White colour - is not a colour and reflects the colours around. Although the wall in *figure 4* is white, the camera captures a bluish image, reflected by another, exterior, blue wall.

Figure 4. A white wall

The *figure 5* is with a strong blue wall. As you can see, there is no significant difference between the colour in *figure 4* and *figure 5*. The camera makes almost no difference between the two in terms of colour.

Figure 5. A blue wall

If the light is dimmed, the camera does not detect colours, but only grey-scale, as can be seen in *figure 6*.

Figure 6. A dimmed-lighted capture

The next three figures are a decomposition on 3 different chanels : Y, Cr, Cb.

Figure 7. The Y channel

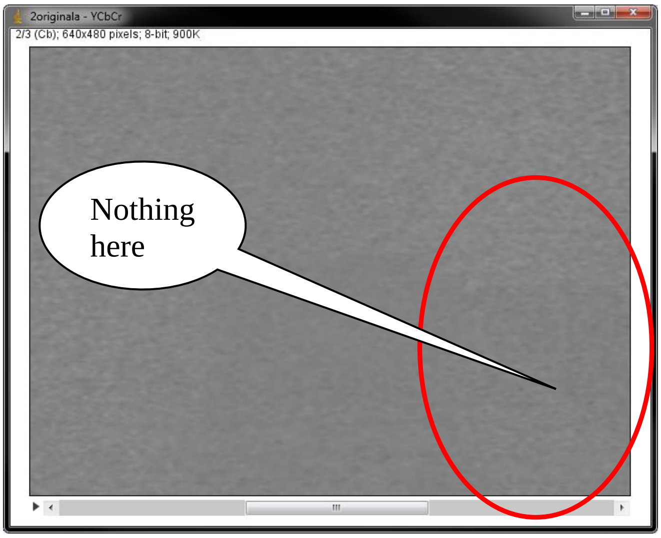

Figure 8. The Red channel

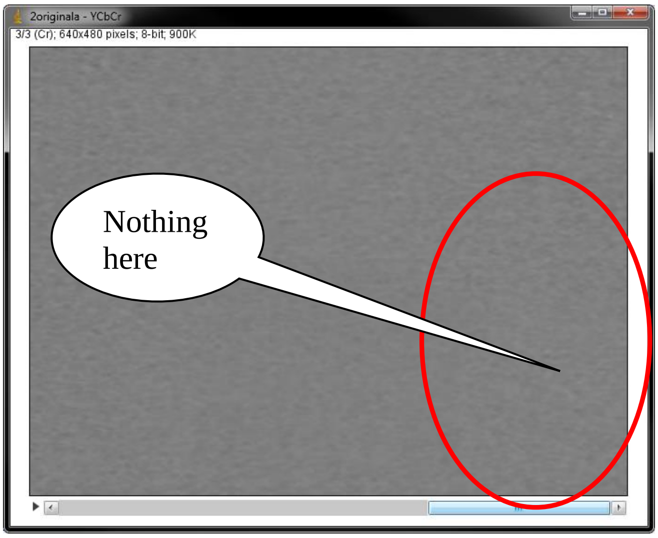

Figure 9. The Blue channel

Although the upper part of the stairs have a reddish colour, it is lacking the information on the two clour channels (Cb and Cr). A flat image on Cb or Cr means that there is no information about that colour on the specific channel. The only variations are given by the background noise.

As the camera of Moverio BT-2000 is 5MP but the quality of camera is poor, and of Moverio BT-300 is also 5MP but the quality is much higher than Moverio BT-2000, these problems do not occur. However, by default the camera of BT-2000 is overexposed and this is not possible to be adjusted with the input interface provided. An extra bluetooth mouse is needed for that.

5. CONCLUSIONS

In this article we compare three models of smart glasses developed by Epson, namely Moverio BT-200, Moverio BT-2000 and Moverio BT-300.

Our findings are concluded in Table able 4

Table 4. A comparison between the three models of smart glasses

Feature	**Moverio BT-200**	**Moverio BT-2000**	**Moverio BT-300**
Camera	VGA	5 mp	5 mp
Input device	touchpad	d-pad navigator	touchpad and d-pad navigator
Adroid version	4.0.4	4.0.4	5.1.1
Colour detection	Verry poor	Pretty good	Verry good

Table 5 presents the advantages, respectively the disadvantages of the three models.

Table 5. The advantages and disadvantages of the three models of smart glasses

Model	**Advantages**	**Disadvantages**
BT-200	1. Light comparing with BT-2000 2. Cheap (roughly 550 EUR)	1. Bad camera (VGA) 2. Android 4.1, with no native support for image processing 3. Bad hindges, easily brokable 4. Easily losable on the head
BT-2000	1. Very fixed on the head 2. Stereo cameras	1. Very heavy 2. input device makes the access to some visual objects impossible(ImageView), only buttons can be clicked 3. Impossible to adjust the camera exposure 4. Need of a bluetooth mouse or keyboard for fully using it 5. High and unjustifiable price (around 2800 EUR)

BT-300	1. Improved camera, therefore better quality of the images 2. Uses Android 5.1, which is a significant step forward for image and video processing comparing with Android 4.1 3. The lightest 4. More resistent 5. Reasonably cheap (700 EUR)	1. Does not support autofocus 2. No zoom 3. Easily losable on the head

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CONSIDERATIONS ABOUT ELECTRODYNAMIC FORCES ANALYTICAL COMPUTATION

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Keywords: electrodynamic forces, analytical computation, electromagnetic fields

Abstract*: The electrodynamic forces deped on the strength of the currents and conductors shapes and mutual positions. For simple configurations are available analytical solutions but for complex ones only numerical methods could be used. Anyway only the real-life tests will quarantee the accuracy in design process. So, the fastest method to predict the electrodynamic forces with acceptable error is desired. This paper deals with analytical solutions and the availability of each one regarding the imposed precision. The influence of filiformity and the infinite length is studied.*

1. INTRODUCTION

Electrodynamic forces are forces acting between two carying currents conductors or between a conductor and a magnetic field. There are three methods to compute the forces [1 - 3]:

- ✓ Laplace’s force,
- ✓ Virtual work method,
- ✓ Maxwell’s stress method.

1.1. Laplace’s force

Based on Laplace’s law, on an element *dl* of a circuit, through which a current of strength *i* flows, placed in a magnetic field *B*, an electrodynamic forces is exercited:

$$d\bar{f} = i \cdot d\bar{l} \times \bar{B} \tag{1}$$

To calculate the magnetic field, in a point situated at distance R from an element of circuit, *dl*, wich produces the field, Biot-Savarat's law could be applied:

$$d\bar{H} = \frac{1}{4\pi} \cdot \frac{i \cdot d\bar{l} \times \bar{R}}{R^3} \tag{2}$$

The Ampere's theorem also lead to the magnetic field in a point, generated by a current flowing through a conductor crossing any surface S bounded by the of contour C.

$$\oint_C \bar{B} \cdot d\bar{l} = \mu_0 \iint_S \bar{J} \cdot d\bar{s} = \mu_0 \cdot i \tag{3}$$

1.2. Virtual work method

According to the virtual work principle, the force exercited by in a physical system can be computed based on stored magnetic co-energy, W_{co}, change due a small displacement, x:

$$F = -\frac{\partial W_{co}}{\partial x}\bigg|_{\Phi=cst.} \tag{4}$$

or:

$$F = \frac{\partial W_{co}}{\partial x}\bigg|_{i=cst.} \tag{5}$$

For a very small variation of x the differential operator could be replaced by simple extraction:

$$F = -\frac{\Delta W_{co}}{\Delta x}\bigg|_{\Phi=cst.} \tag{6}$$

or:

$$F = \frac{\Delta W_{co}}{\Delta x}\bigg|_{i=cst.} \tag{7}$$

1.3. Maxwell's stress method

The third method for electrodynamic forces calculation is one of the most used in numerical analysis, especially in Finite Element Method postprocessing. The use of Maxwell's stress method asked an integration of the component of the stress over a surface passing entirely trough air:

$$\bar{F} = \oint_S \left(\bar{H}\left(\bar{B}\bar{n}\right) - \frac{1}{2}\left(\bar{H}\bar{B}\right)\bar{n} \right) dS \tag{8}$$

For a given configuration, one of the above presented method will be less difficult to be applied then others. However all approaches should produce the same result, but the small differences occurring are due to assumptions considered for each ones.

2. TWO PARALLEL FILLIFORM RECTILINEAR CONDUCTORS

2.1. Infinite lenght

For this configuration, *fig. 1*, relations (1) and (2) lead to one of the most known elecrodynamic force formulae, named Ampere's force:

$$F_{12} = F_{21} = \frac{\mu_0}{2\pi} i_1 \cdot i_2 \frac{l}{d} = 2 \cdot 10^{-7} \cdot i_1 \cdot i_2 \frac{l}{d} \tag{9}$$

Force F_{12} is the force exercited by conductor 2 on conductor 1 and viceversa.

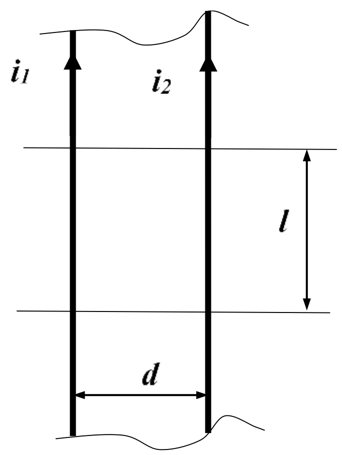

Fig. 1. Two parallel filiform rectilinear infinite length conductors

Relation (9) is a very simple one and it is important to use it for as much configurations as it is possilble. In the next paragraphs, the influence of the finite length and the shape of conductors will be studied.

2.2. Influence of the finite lenght

In real-life, conductors have finite length. If the lengths of conductors are equal and the conductors are spaced as in *fig. 2*, relation (9) has to be altered by a length function *C(d/l)*, [3-4]:

$$C = \sqrt{1 + \frac{d^2}{l^2}} - \frac{d}{l} \tag{10}$$

The force will be computed as:

$$F = \frac{\mu_0}{2\pi} i_1 \cdot i_2 \frac{l}{d} \cdot C = 2 \cdot 10^{-7} \cdot i_1 \cdot i_2 \frac{l}{d} \cdot C \qquad (11)$$

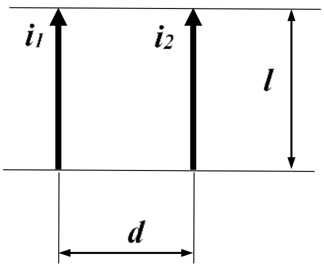

Fig. 2. Two parallel filiform rectilinear finite equal length conductors

Compareing relations (9) and (11) it is import to outline the error produced for a given arranjaments of the conductors. This could be easelly done trough a simple graphical representation of the function *C(d/l)*.

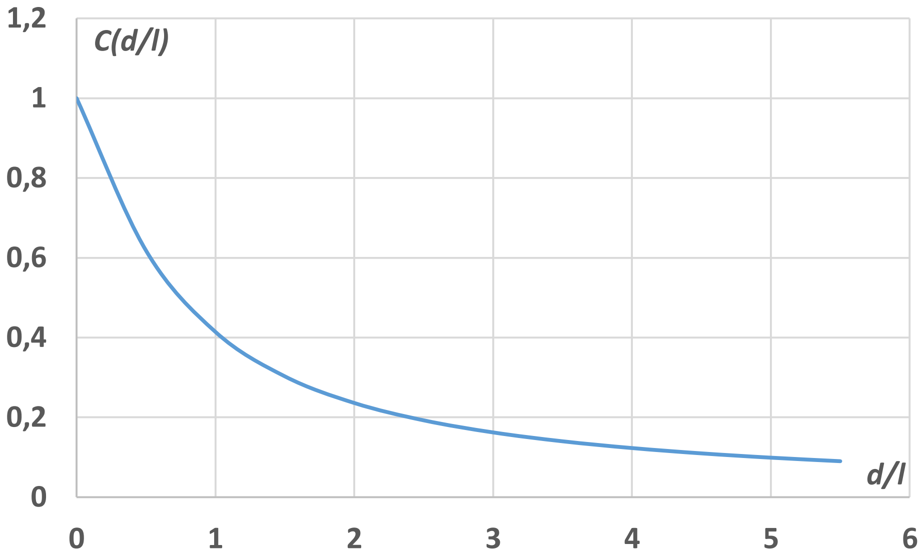

Fig. 3. C(d/l) graphical representation

Also if the relative error is considered:

$$\varepsilon = \frac{F_{finite} - F_{\inf inite}}{F_{finite}} \cdot 100[\%] \qquad (12)$$

with F_{finite} being the force computed with (11) and $F_{infinite}$ the Ampere's force (9), it is simple to set up an desired error and find the appropriate assumption of C that fulfill it. Applying in (12) relations (9) and (11) will get:

$$\varepsilon = \frac{C-1}{C} \cdot 100 = \left[1 - \frac{1}{C}\right] \cdot 100 \qquad (13)$$

It is obviouslly that the error is negative, the force per length is bigger for an infinite length conductors than for finite length conductors.

From (13), the ratio *d/l* goes to:

$$\frac{d}{l} = -\frac{1}{2} \cdot \frac{\varepsilon \cdot (200-\varepsilon)}{100 \cdot (100-\varepsilon)} \tag{14}$$

The graphical interpretation of (14) for an error between 0 and -10%, *fig. 4,* shows a very intuitive way of limitation of Ampere's force when finite length conductors are involved. E.g. for a desired error bellow 5% the ratio *d/l* must be above 1/20, meaning a length of 20 times bigger than the distance between conductors and 1% weeoe leads to a $d/l \geq 1/100$.

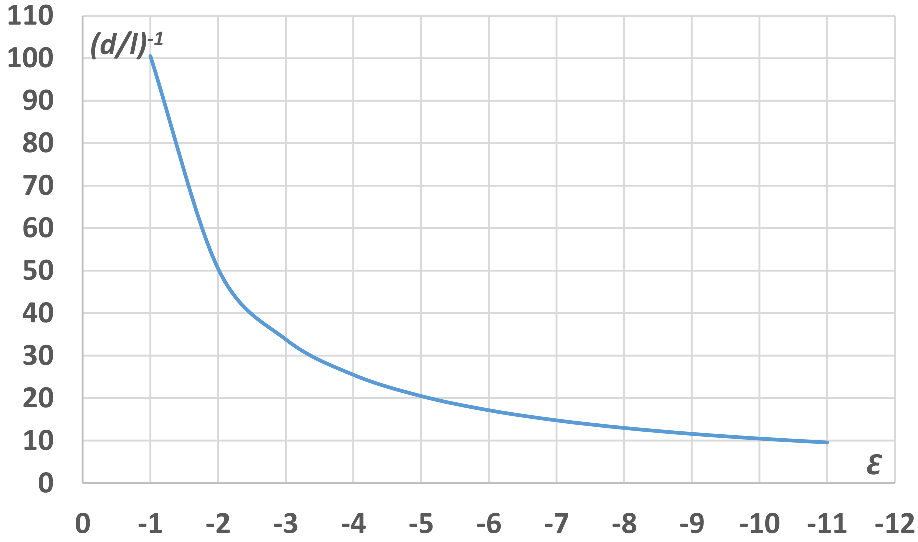

Fig. 4. $(d/l)^{-1}$ in terms of ε, graphical representation

For two parallel filiform rectilinear finite unequal length conductors, *fig. 5,* relation (11) must be completed with two lenght functions, denoted C_1 and C_2, [4]:

$$F = \frac{\mu_0}{2\pi} i_1 \cdot i_2 \frac{l}{d} \cdot (C_1 + C_2) = 2 \cdot 10^{-7} \cdot i_1 \cdot i_2 \frac{l}{d} \cdot (C_1 + C_2) \tag{15}$$

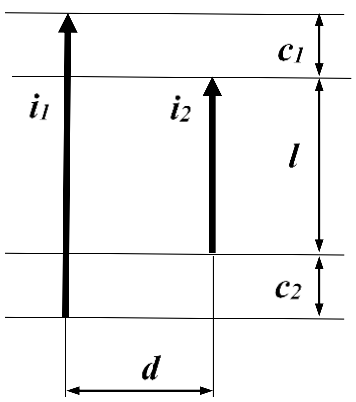

Fig. 5. Two parallel filiform rectilinear finite unequal length conductors

The values of C_1 and C_2 could be computed using (16) and (17), [4] or can be read from *fig. 6* [4]:

$$C_1 = \sqrt{\left(1+\frac{c_1}{l}\right)^2 + \frac{d^2}{l^2}} - \sqrt{\frac{c_1^{\,2}}{l^2} + \frac{d^2}{l^2}} \tag{16}$$

$$C_2 = \sqrt{\left(1+\frac{c_2}{l}\right)^2 + \frac{d^2}{l^2}} - \sqrt{\frac{c_2^{\,2}}{l^2} + \frac{d^2}{l^2}} \tag{17}$$

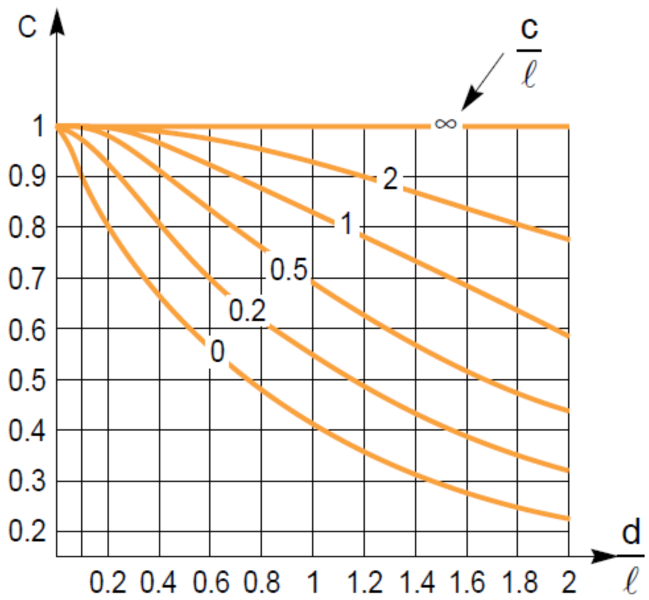

Fig. 6. C(c/l, d/l) graphical representation

As it can be easlly seen, for c_1 = 0, C_1 = *f(d/l)* from (10). For simplicity the value of *f(d/l)* can be selected, for a given *d/l*, from *fig. 6*, choosing *c/l* = 0.

Anyway, for an existing configurations of conductors, the value of lenght function C_1+C_2 or *C* can be computed in term of the error, from (13), as:

$$C = \frac{100}{100-\varepsilon} \tag{18}$$

$$C_1 + C_2 = \frac{100}{100-\varepsilon} \tag{19}$$

Imposing an error of -5%, goes to a value of lenght factor equal to 0.95. Supposing that *c* = 0, from fig. 6 the requested *d/l* is close to 0.05, meaning the same result as from (14) or *fig. 4.*

2.3. Influence of conductor shape

For conductors having specific shapes, i.e. non filiforms, the electrodynamic forces are computed based on virtual work principle.

For configuration shown in *fig. 7*, reassumed infinite lengths, the force is, [3]:

$$F = \frac{\mu_0}{2\pi} i_1 \cdot i_2 \frac{l}{(d-r)} = 2 \cdot 10^{-7} \cdot i_1 \cdot i_2 \frac{l}{(d-r)} = 2 \cdot 10^{-7} \cdot i_1 \cdot i_2 \frac{l}{d} \cdot k \tag{20}$$

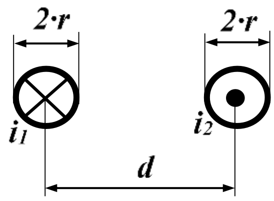

Fig. 7. Two parallel circular infinite length conductors

In (20) k is a shape function, used to maintain the simplest relation in force calculation:

$$k = \frac{d}{(d-r)} = \frac{1}{1 - r/d} \tag{21}$$

The graphical representation of (21) is shown bellow.

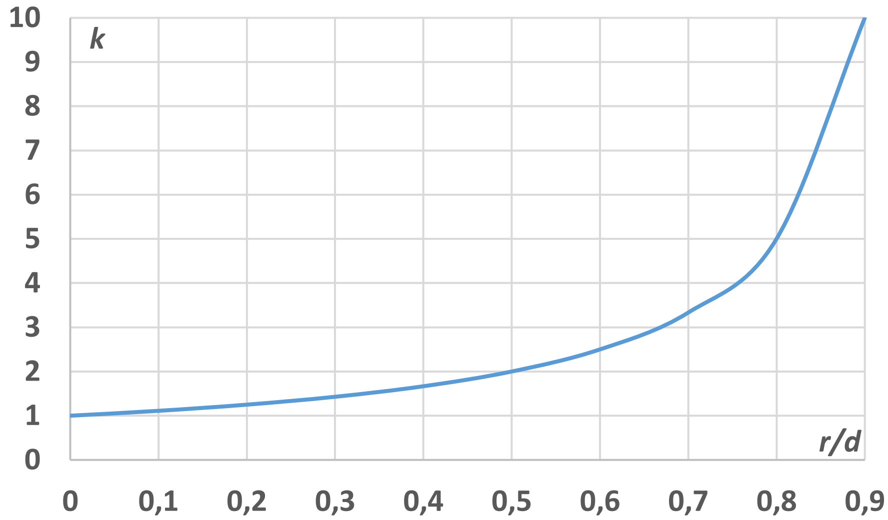

Fig. 8. k(r/d) graphical representation

Considering, again, the relative error regarding the Ampere's force:

$$\varepsilon = \frac{F_{shape} - F_{filiform}}{F_{shape}} \cdot 100[\%], \tag{22}$$

it is easy to find the ratio between the conductor radius and the distance between the wires that fulfill an imposed value of error:

$$\frac{r}{d} = \frac{\varepsilon}{100} \tag{23}$$

For a desired error of 1% the distance between conductors must be 100 times bigger than the radius of the cross-section of the wire.

If the conductors have rectangular cross-sections, *fig. 9, upper right corner*, the shape function, denoted *k*, is more complex and depends by the actual position of conductors. To avoid complex calculus, k could be chooses from Dwight's chart, fig. 9, [4].

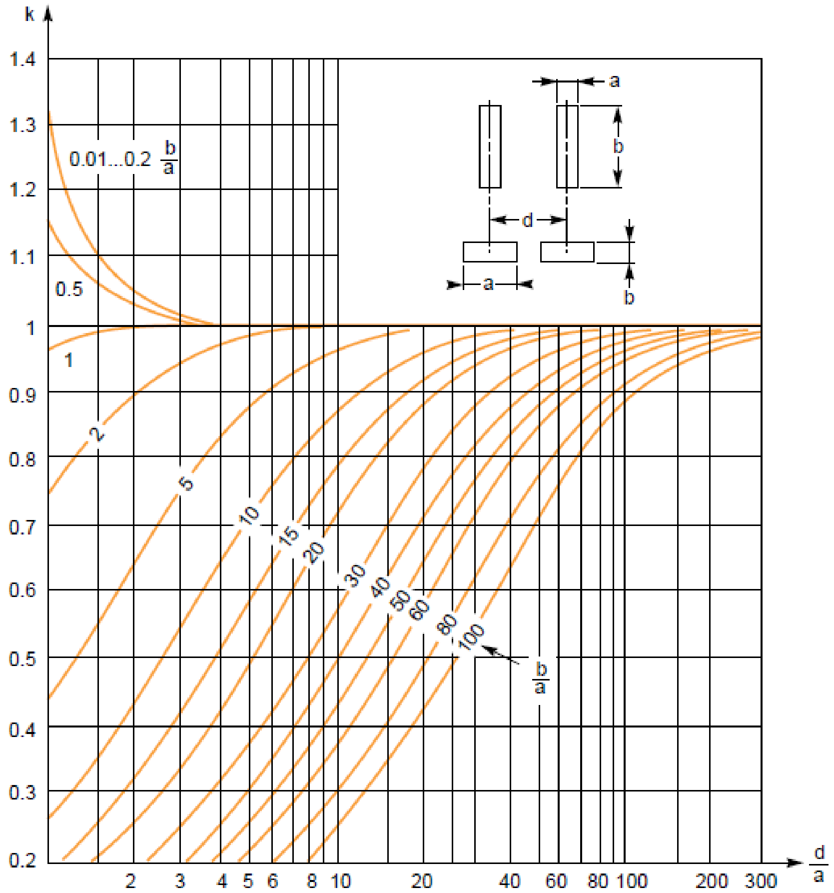

Fig. 9. Dwight's chart

The force exercited on conductors is:

$$F = \frac{\mu_0}{2\pi} i_1 \cdot i_2 \frac{l}{d} \cdot k = 2 \cdot 10^{-7} \cdot i_1 \cdot i_2 \frac{l}{d} \cdot k \tag{24}$$

Changing in (18) *C* with *k*, all remarks are applied also for shape function.

2.4. Influence of both conductor length and shape

Composing above presented configurations, a general relation for parallel wires configurations can be written:

$$F = \frac{\mu_0}{2\pi} i_1 \cdot i_2 \frac{l}{d} \cdot C \cdot k = 2 \cdot 10^{-7} \cdot i_1 \cdot i_2 \frac{l}{d} \cdot C \cdot k \quad (25)$$

for equal length, and, for unnequall length:

$$F = \frac{\mu_0}{2\pi} i_1 \cdot i_2 \frac{l}{d} \cdot (C_1 + C_2) \cdot k = 2 \cdot 10^{-7} \cdot i_1 \cdot i_2 \frac{l}{d} \cdot (C_1 + C_2) \cdot k \quad (26)$$

Again, changing in (18) C with $C \cdot k$, or C with $(C_1 + C_2) \cdot k$ all remarks are applied also for combined length and shape functions.

3. CONCLUSIONS

In this paper have been presented some considerations about analitycal computation of the electrodynamic forces for parallel wires. All relations have been written based on Ampere's force relation, because of simplicity and easy of use. All the length and shape functions are graphically interpreted and the limitation in Ampere's force is depicted in term of relative error.

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INVESTIGATION OF ELECTRICAL ENERGY EFFICIENCY USE IN AN AUTOMOBILE ASSEMBLY INDUSTRY

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Abstract*: This research work investigated the electrical energy efficiency improvement and cost saving potentials for automobile assembly plant; a case of Peugeot Automobile Nigeria Limited. The study identified lighting system as a major source through which energy is being wasted, hence efficient energy saving lighting systems are being proffered; also saving accrued were determined to justify their deployment. In the course of this work, an energy saving calculating tool was developed to calculate energy saving capabilities using energy efficient lamps. With ample devotion to the implementation of the recommendations made, the cost of energy per car will be drastically reduced while profits are also made simultaneously. In all, more cars will be produced thus translating to more employment opportunities in the industry.*

1. INTRODUCTION

Energy for obvious reasons is regarded as the prime mover of any economy, and the engine of growth around which all sectors of the economy revolve [1]. Thus it becomes imperative that its development, management, and improvement must have predetermined plans and strategies that are capable of driving the economy towards a sure path of sustainable development [2], [6]. By imbibing energy–efficient practices, all energy consuming systems are consistently monitored, cleaned, adjusted, maintained and operated to ensure the most efficient use of energy [3][5]. The major aim of industries around the globe is to make profits, increase productivity, reduce waste, conserve resources and enhance image. With ample devotion to tenets of cost reduction and deployment of energy efficient technologies and practices, all of these can be achieved by proper energy management as articulated by [4].

As a result of technologies usually deployed in automobile industry, induction motors are often referred to as “factory workhorse” which are mostly used. These motors, being inductive loads require current flow to create magnetic fields to produce the desired work; this brings about low power factor. A low power factor is expensive and inefficient. Utility companies charge their customer additional fees when their power factor is less than 0.95 because it reduces electrical system’s distribution capacity by increasing the current flow and causing voltage drops. Power factor correction brings the power factor of an Alternating Current (AC) system closer to 1. It is believed that improving power factor will increase energy efficiency and reduce cost. Also by acquiring energy efficient motors, 2% to 8% efficiency can be gotten compared with standard motors. They owe their higher performance to key design improvements and more accurate manufacturing tolerances.

Another system of note in an automobile industry is lighting system. About 21% of the world’s electrical energy is used for lighting. That equals a whopping 12 Billion KWh per day. By replacing inefficient fluorescent fittings with LED and compact fluorescent lighting, a lot of energy can be saved with associated cost reduction.

Employment of efficient energy programmes in an automobile manufacturing industry can bring about reduction in fossil fuel use by 12% with attendant reduction in greenhouse gases by more than 70,000 tons of CO_2. The emission reduction which can be of help in fighting climate change is equal to the emissions from the electricity use of more than 80,000 homes in a year [7].

It is a known fact that the industry consumes an average of 1 million litres of diesel annually, translating to a minimum of 33000 litres monthly. Going by the high cost of the commodity in Nigeria, a sum of N90 million was used for its procurement in 2010. It is on factory records that a whooping sum of N 110 million was used to provide electrical energy in 2008 as shown in *fig 1*, the breakdown of which shows that N70.12 million was used to buy diesel, another N37.57 million was used to pay electricity bills while maintenance of generating sets gulped N2.47 million; in the same year, the cost of electrical energy per car was N 200,000.

The manufacturing sector in Nigeria has been bedevilled by this negative trend. This also majorly accounts for the closure of some factories in Nigeria while a couple of others are relocating to other West African countries where cost of energy is affordable in order to break even. Undoubtedly, the aforementioned situation has to be reversed for the continuance of business in the factories. Going by the climate changes occasioned by ubiquitous emissions of green house gasses, there is however the need for this research work towards ameliorating the negative trends by examining the various patterns through which electrical energy in Peugeot Automobile Nigeria (PAN) is being consumed. The sources of energy wastage were identified and the significant technologies that exist to reduce energy utilization were proferred.

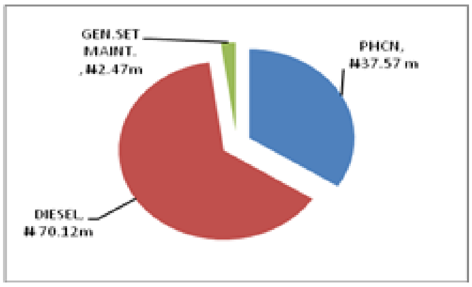


Fig. 1. Cost of Electrical Energy in 2008

2. METHODOLOGY

The method adopted for this research work was to review the current electrical energy consumption in the different unit of the company in order to identify improvement opportunities. Some of the data needed `for the improvement process were directly collected from the nameplate of the site equipment and company record books. Statistical evaluation of the energy and cost-saving potential were then carried out and the results presented in charts and graphic forms. The major improvement opportunities considered in this research were power factor correction, identification of inefficient electric motor in use and the possibility of replacement. Lastly we considered the possibility of energy efficient lighting system and recommended possible ways of reducing energy consumption.

The electricity supply to the factory is from the 33/11kV feeder line of the electricity utility company and three units of 2MVA 11kV Wilson generator. The two sources of electricity supply are terminated in the power control room. The factory loads are shared through five sets of 11/0.415kV transformer (T1, T2, T3, T4 and T5) in three different switch rooms (SW_RM) named SW_RM_A, SW_RM_B and SW_RM_C.

3. ENERGY EFFICIENCY ANALYSIS

A. Power Factor Improvement

The factory being an automobile industry consists of various sizes of electric motors ranging from 1hp to 160hp. Going by this, loads are mainly inductive. *Figure 2* shows the distribution of electric motors in relation to their power rating. While *Figure 3* shows the percentage distribution of electric motors in the factory, paint shop alone contains about 100 motors representing 69% of the total induction motors in the industry. The motors in the industry are the major electrical load used for various applications including treatment of car body, air intakes for humidification system of spraying cabins, fans used for blowing oven, extraction system for spraying cabins, ground and aerial conveyor.

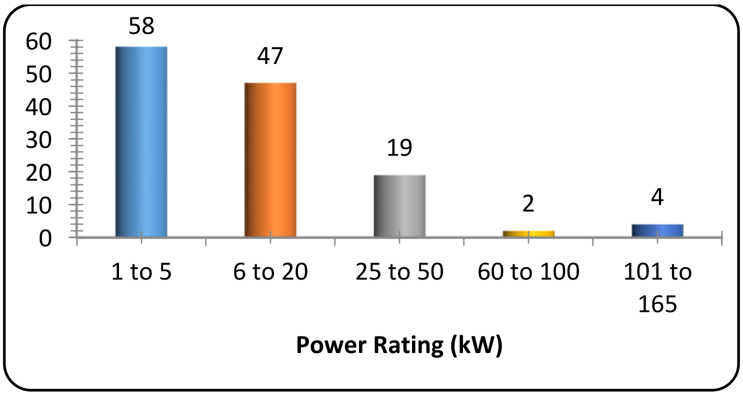


Fig. 2. Electric Motor Distribution by Sizes in Horsepower

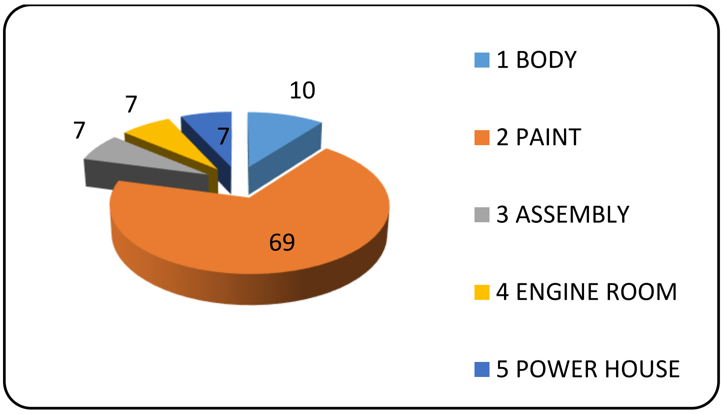


Fig. 3. Percentage Distribution of Electric Motors in the Factory sub units

The switch room A of the industry have the loads' pattern with low power factor of 0.71, 0.78 and 0.80 while switch rooms B and C have 0.78 and 0.92 respectively. Due to this low power factor, the system is grossly inefficient. Hence, there is need to improve the power factor by using capacitors' banks connected across the supply at the point closer to the equipment. Table 1 shows the desired improved power factor PF_2 as against the present power factor PF_1 in each of the switch room of the factory.

Table 1: Desired improved power factor as against present power factor

	SW_RM_A			SW_RM_B	SW_RM_C
	T1	T2	T3	T4	T5
KW	673	400	423	387	420
PF_1	0.71	0.78	0.80	0.78	0.92
PF_2	0.95	0.95	0.95	0.95	0.95

B. Determination of kVAr of Capacitor banks.

The diagram in *figure 4* shows the simple way power factor improvement can be determined.

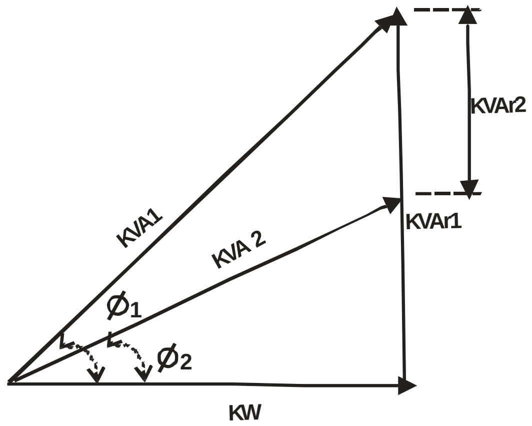


Fig. 4. Power Factor Improvement Triangle.

In *Figure 4*:

kW = Power consumed by the system

kVA_1 = Apparent power before correction.

kVA_2 = Apparent power after correction.

$kVAr_1$ = Inductive kVAR

$kVAr_2$ = Capacitive kVAR

$Cos\ \varphi_1$ = PF before correction.

$Cos\ \varphi_2$ = PF after correction.

$$\cos\varphi = kW / kVA \tag{1}$$

$$\tan\varphi = kVAr / kW \tag{2}$$

$$kVAr = kW \times \tan\varphi \tag{3}$$

From equation 3,

$$kVAr_2 = kW \times (\tan\varphi_1 - \tan\varphi_2)\,. \tag{4}$$

To determine the required KVAr to raise PF from 0.71 to 0.95

$$\phi_1 = \cos^{-1} PF_1 = \cos^{-1} 0.71 = 44.76° \tag{5}$$

Also,

$$\phi_2 = \cos^{-1} PF_2 = \cos^{-1} 0.95 = 18.19° \tag{6}$$

By using (4)

$$kVAr_2 = 673 \times (\tan 44.76° - \tan 18.19°) = 445.12 kVAr \tag{7}$$

Therefore 445 KVAr capacitor bank would raise the PF from 0.71 to 0.95.

C. Energy Efficiency Analysis of Motor

Motor energy efficiency is defined by the motor manufacturer as how efficiently a motor turns electrical energy into mechanical energy. To the end user, motor efficiency is important because it is directly related to the cost of operating the motor. The higher the motor efficiency, the less power is required; using less power conserves energy and saves money. The efficiency of a motor is the ratio of the mechanical power output to the electrical power input [1]. The industry was established in 1975, it means virtually all the electric motors are very old and of standard types. All these dovetail into low efficiency of the motors used in the industry and lead to high cost of production. To reduce the energy cost we either improve on the power factor of the motors or replace the old motors with recent energy efficient once. Energy saving potential for a typical situation is demonstrated, following the same procedure for the motors in the industry the results for Cataphoresis oven tunnel motors are tabulated in table 2.

Determination of annual energy saving for motor

$$kW_{saved} = (kW \times (L / E_{st})) - (kW \times (L / E_{pr})) \quad (8)$$

$$kW_{saved} = kW \times L \times (100 / E_{st} - 100 / E_{pr}) \quad (9)$$

where,

E_{st} = Efficiency of a standard motor,

E_{pr} = Efficiency of a premium motor,

L= load factor.

For example, for a 9KW motor, E_{st} =86%, E_{pr} = 90%, taking L =75%, using (9) above:

$$kW_{saved} = 9 \times 0.75 \times (100/86 - 100/90) = 0.35 \text{ KW}.$$

$$kWh_{saving} = kW_{saved} \times A_{oh} \quad (10)$$

where A_{oh} is the annual operating hour taken as 1840 hours

$$kWh_{saving} = 641.86 \text{ kWh/Year}$$

$$\cos t_{saved} = kWh_{saving} \times E_{charge} \quad (11)$$

where E_{charge} is the local energy charge taken as N12.9

$$cost_{saved} = 641.86\text{KWh/Yr} \times \text{N}12.9 = \text{N}8279.99\text{K}$$

D. Energy Efficient Lighting Analysis

It has been recommended that working areas where visual tasks are only occasionally performed be illuminated with Illuminance in the range between 100-150lm/m^2. For example, Toyota, a pacesetter in the automotive industry sets a standard of 100lm/m^2 in the quality check areas. With this, Toyota is saving about 30% on lighting energy use. Ford, as part of assessment programs, announced to the world that it would invest over $25 million (nearly €20 million) in energy-efficient lighting, is aiming to reduce energy costs of the company by as much as 70%. More precisely, the automaker expects to save around 56 million kilowatt-hours annually. Typical 56W fluorescent lamps has luminous efficacy of 66lm/W, this translates to 3696 lumen. Assuming surface area to be illuminated corresponds to the working height of 2.5 m^2, [8]:

$$Illuminance = \frac{Luminous\ flux\,(Lumen)}{Surface\,Area\ (m^2)}$$

$$= \frac{3696}{2.5^2} \quad = \quad 591.36 lm/m^2 \tag{12}$$

Also, 22W LED fluorescent has luminous efficacy of 40lm/W. Hence, 22W produces 40lm/W x 22 = 880lumen.

In the same way, Illuminance is

$$Illu\min ance = \frac{880}{2.5^2} \quad = \quad 141\, lm/m^2$$

The resultant value falls within the range recommended for energy efficiency that is void of waste. The result is better than that specified by Toyota Production System (TPS).

Calculation on replacement of 56W fluorescent fitting with 22W LED bulbs unit

Fluorescent Fitting (56W):	Fluorescent Fitting (22W):
$\text{Power}_{76\text{ units}}$ = 56 × 76 = 4256W	$\text{Power}_{76\text{ units}}$ = 22 × 76 = 1672W

$$Energy_{saved} = 4256 - 1672 = 2584W \tag{13}$$

Energy saved per day (10hours)

$$Energy_{saved/day} = 2584 \times 10 = 25.84 kWh \tag{14}$$

Energy saved per Annum (184 days average)

$$Energysaved\ /\ annum = 25.84 \times 184 = 4754.56 kWh \tag{15}$$

Amount saved in Naira per annum (N12.9/kWh)

$$\text{Amount saved annually} = 4754.56 \times \text{ N12.9} = \text{N61,333.82} \tag{16}$$

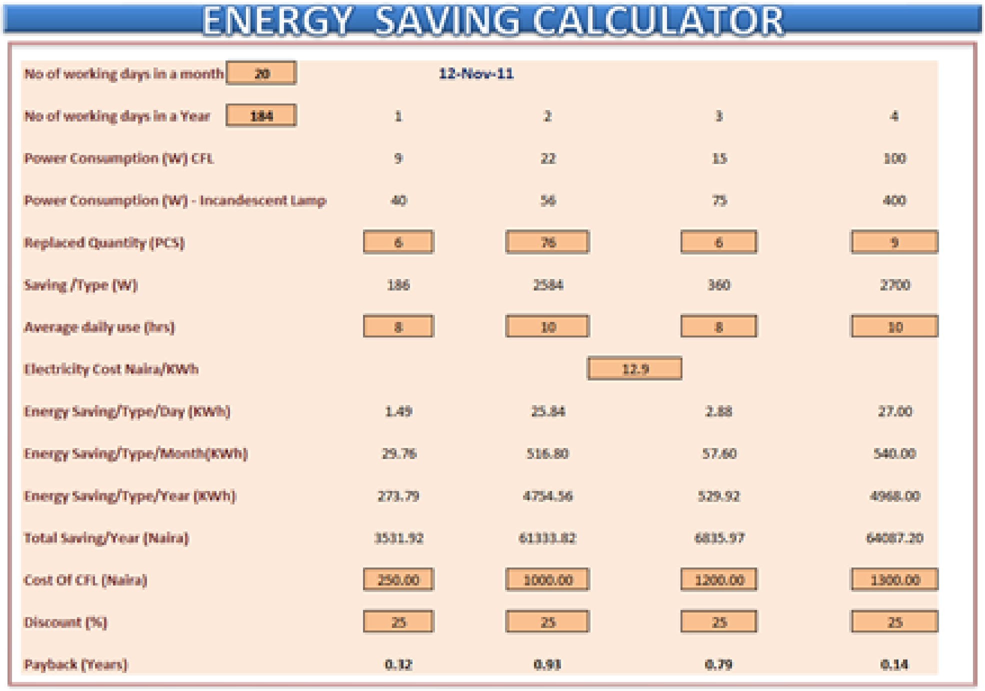
Payback is given by:

$$\text{Cost of energy saving units} \times \text{Discount/Annual saving} = \tag{17}$$

= N 76000 × 0.75/ N 61,333.82 = 0.93Years, 1 yr Approx.

E. Development of Energy Saving Calculator

The energy saving calculator developed *figure 5* automatically calculates the energy saving capabilities of replacements done. This is achieved by changing the variables indicated by the rectangles. The tool was developed using Excel application software.



ENERGY SAVING CALCULATOR

No of working days in a month	20	12-Nov-11		
No of working days in a Year	184			
	1	2	3	4
Power Consumption (W) CFL	9	22	15	100
Power Consumption (W) - Incandescent Lamp	40	56	75	400
Replaced Quantity (PCS)	6	76	6	9
Saving /Type (W)	186	2584	360	2700
Average daily use (hrs)	8	10	8	10
Electricity Cost Naira/KWh	12.9			
Energy Saving/Type/Day (KWh)	1.49	25.84	2.88	27.00
Energy Saving/Type/Month(KWh)	29.76	516.80	57.60	540.00
Energy Saving/Type/Year (KWh)	273.79	4754.56	529.92	4968.00
Total Saving/Year (Naira)	3531.92	61333.82	6835.97	64087.20
Cost Of CFL (Naira)	250.00	1000.00	1200.00	1300.00
Discount (%)	25	25	25	25
Payback (Years)	0.32	0.93	0.79	0.14

Figure 5. Energy saving calculator

4. RESULTS AND DISCUSSION

A. Result of Power factor Correction and the use of efficient motors.

The result in table 2 shows the compares kVA demand after power factor was corrected with the one before the correction. There is a mark reduction in the demands. The resuilt shows the electric motors in relation to their sizes for the Cataphoresis Oven tunnel of the industry. A total gain of 48.0 kVA is recorded.

Table 2: A reduction in kVA demand with Premium energy efficient motors and power factor improvement from 0.8 to 0.95 in Cataphoresis Oven tunnel of the industry.

PROCESSES	Hp	RPM	RATING (kW)	Avg. Eff. Std.%	Avg. Eff. Prem. %	kVA DEMAND BEFORE CORRECTION (PF=0.8)	kVA DEMAND AFTER CORRECTION (PF=0.95)
Air intake	50	1800	37	91	93	50.8	41.9
Air intake	12	1800	9	86	89	13.1	10.6
Air intake	5	1800	4.05	83	87	6.1	4.9

PROCESSES	Hp	RPM	RATING (kW)	Avg. Eff. Std.%	Avg. Eff. Prem. %	kVA DEMAND BEFORE CORRECTION (PF=0.8)	kVA DEMAND AFTER CORRECTION (PF=0.95)
Exhaust VE1	15	1800	11	86	90	16.0	12.9
Exhaust VE2	15	1800	11	86	90	16.0	12.9
Exhaust VE3	15	1800	11	86	90	16.0	12.9
Exhaust VE4	15	1800	11	86	90	16.0	12.9
Exhaust VE4	5	1800	3.5	83	87	5.3	4.2
Exhaust VE5	1	1800	1.1	77	83	1.8	1.4
Burner	1	1800	0.76	77	83	1.2	1.0
Burner	15	1800	11	86	90	16.0	12.9
Burner	15	1800	11	86	90	16.0	12.9
Oven seal VRA 1	10	1800	7.5	86	89	10.9	8.9
Burner	1	1800	0.76	77	83	1.2	1.0
Burner	20	1800	15	88	92	21.3	17.2
Cooler unit	22	1800	16.2	89	93	22.8	18.3
Oven seal VRA 2	20	1800	15	88	92	21.3	17.2
					TOTAL	**251.7**	**203.7**
						GAIN	**48.0**

Table 3 shows the total amount of electrical energy saved per year and the corresponding amount of money that will be saved in each of the production line in the industry when using energy efficient motors. The cost saved is based on the tariff of electricity in Nigeria based on kilo watt hour.

Table 3: Total Amount to be saved Per Annum in Each Production Line as a Result of Using Energy Efficient Motors.

Production line	kW/Year (Saved)	Cost Saved (N)
Cata Oven Tunnel	10848.60	139946.94
TTS	15149.40	195427.26
Antigravel	5205.20	67147.08
Primer line	16008.20	206505.78
Top Coat 1	10795.00	139255.50
Top Coat 2	8532.70	110071.83
	Total	**858354.39**

B. Results of using energy efficient lighting

The following results shows the effect of using energy saving fitting of 22W LED bulbs as against 56W fluorescent fitting and halogen bulb in the Body shop, paint shop and assembly units of the industry. Table 4 shows energy saved, cost saved and payback of using energy saving fittings in Body shop, while Table 5 and Table 6 shows that of the Paint shop and Assembly units of the industry.

Table 4: Energy Saved, Cost Saved and Payback by Using Energy Saving Fittings in Body Shop

Sub-units of the Body shop	Fitting in use (W)	No. of fitting	Power consumed (W)	Power consumed Using 22W	Cost (N)	kWh saved	kWh Annual	Cost Saving	Payback
307 main line	56	76	4256	1672	76000	25.84	4754.56	61333.82	0.92
406 main line	56	98	5488	2156	98000	33.32	6130.88	79088.35	0.92
Metal Finish line	56	252	14112	5544	252000	85.68	15765.12	203370.04	0.92
UEP Zone	56	24	1344	528	24000	8.16	1501.44	19368.576	0.92
Retouch zone	56	16	896	352	16000	5.44	1000.96	12912.384	0.92
Maintenance zone	56	162	9072	3564	162000	55.08	10134.72	130737.88	0.92
Maintenance office	56	78	4368	1716	78000	26.52	4879.68	62947.872	0.92
Jig shop	56	44	2464	968	44000	14.96	2752.64	35509.056	0.92
Engine room	56	14	784	308	14000	4.76	875.84	11298.336	0.92
Halogen	400	324	129600	32400	324000	972	178848	2307139.2	0.10
	TOTAL		**172384**	**49208**	**1088000**	**1231.76**	**226643.84**	**2923705.536**	**8.46**

Table 5: Energy Saved, Cost Saved and Payback by Using Energy Saving Fittings in Paint Shop

Sub-units of the Paint shop	Fitting in use (W	No. of fitting	Power consumed (W)	Power consumed Using 22W	Cost (N)	kWh saved	kWh Annual	Cost Saving	Payback
Hanging TTS & Cata	56	57	3192	1254	57000	19.38	3565.92	46000.37	0.92
Mastic	56	66	3696	1452	66000	22.44	4128.96	53263.58	0.92
Antigravel	56	114	6384	2508	114000	38.76	7131.84	92000.74	0.92
Dry Sanding/Primer	56	234	13104	5148	234000	79.56	14639.04	188843.6	0.92
Wet Sanding	56	344	19264	7568	344000	116.96	21520.64	277616.3	0.92
Wet Sanding Retouch	56	20	1120	440	20000	6.8	1251.2	16140.48	0.92
Top Coat 1	56	582	32592	12804	582000	197.88	36409.92	469688	0.92
Top Coat 2	56	204	11424	4488	204000	69.36	12762.24	164632.9	0.92
Top Coat retouch	56	39	2184	858	39000	13.26	2439.84	31473.94	0.92
Omia Oven	56	69	3864	1518	69000	23.46	4316.64	55684.66	0.92
Rest Zone	56	10	560	220	10000	3.4	625.6	8070.24	0.92
Halogen	400	86	34400	8600	8600	258	47472	612388.8	0.01
	TOTAL		**131784**	**46858**	**1747600**	**849.26**	**156263.8**	**2015804**	**10.23**

Table 6: Energy Saved, Cost Saved and Payback by Using Energy Saving Fittings in Assembly

Sub-units of the Assembly	Fitting in use (W)	No. of fitting	Power consumed (W)	Power consumed Using 22W	Cost (N)	kWh saved	kWh Annual	Cost Saving	Payback
Trim line	56	312	17472	6864	312000	106.08	19518.72	251791	0.93
Chassis line	56	288	16128	6336	288000	97.92	18017.28	232422	0.93
ACOM	56	402	22512	8844	402000	136.68	25149.12	324423	0.93
Quality Acceptation	56	24	1344	528	24000	8.16	1501.44	19368.	0.93
Wheel Alignment	56	16	896	352	16000	5.44	1000.96	12912.	0.93
UEP Zone	56	24	1344	528	24000	8.16	1501.44	19368.	0.93
Halogen	400	270	108000	27000	270000	810	149040	192261	0.11
		TOTAL	**167696**	**50452**	**1336000**	**1172.44**	**215729**	**278290**	**5.68**

C. Discussion of Results

The results show that by improving the power factor in Cataphoresis oven tunnel of the industry from 0.8 to 0.95 and replacing standard motors with premium energy efficient motors, kVA demand drops from 251.7kVA to 203.7kVA translating to the saving of 48kVA. Also, in TTS, kVA demand drops from 380.4kVA to 300.8kVA. In paint shop, total gain of 396.3kVA is achieved; this results to a saving of N162, 027.25.

In the same vein, using energy efficient lighting fittings in Assembly shop, 1172kWh will be saved translating to 215729kWh annually with cost saving of about N2.7million. Also, N2 million and N2.9million will be saved in Paint shop and Body shop respectively. It is on record that in 2010 alone, PAN spent about N90 million on provision of electrical energy for her services. Going by the aforementioned, more savings can be made with attendant increase in annual productions thus improving national Gross Domestic Product (GDP).

Industries all over the world are established in order to garner profits; this is also attainable if maintenance cost subsides, a situation occasioned by reduction in breakdown of power equipment, without which the aim would be a mirage. Efficient electrical power supply will reduce downtime, rework duties in the production facilities will be greatly abated; all resulting to increase in production, and hence more energy will be channeled into production of cars.

Industrial electrical energy efficiency do dovetails into reduction of carbon dioxide to be emitted into the atmosphere, this is because the higher the unwanted loads, the greater the activity of prime movers of the generators to meet the demands, also more diesel is consumed. In PAN's case, when a set of 2MVA is on load, in order to meet higher demand, other generating units automatically come on to shoulder the new demands, thus translating to higher emissions of carbon dioxide, one of the culprits of global warming and climate change. If the proffered solutions are adhered to, the efficiency will be improved while our environment will be saved from pollutions and their resultants.

5. CONCLUSIONS

Investigation of electrical energy saving potential of Peugeot Automobile Nigeria Limited has been carried out in this research work. The results obtained from the study undoubtedly justify the need to improve poor power factor and replacement of aging standard motors with premium energy efficient motors. Also, the proposed replacement of ballast fluorescent fittings and halogen bulbs with energy saving types will bring about major reductions in energy consumption for lighting. This coupled with implementation of Total Productive Maintenance (TPM) methodology is sine qua non to improvement of electrical energy efficiency in the industry.

The developed energy saving calculating tool provides a very useful tool for energy auditing particularly, for lighting systems. This tool can be used by engineers and consumers alike to calculate energy consumption and gains accruable from lighting energy saving.

It has also been shown that reduction in energy consumption will bring about reduction in cost of producing cars in the factory with affiliated profits. The investment in energy saving technology will have short period of payback and can as well propel the development of modern cars.

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EMERGENCY STATUS MANAGEMENT IN ENERGETIC FIELD . RISK TRANSFER

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Keywords: risk, insurance,

Abstract: *The state of emergency in the energy sector generates technical problems such as: disruption in the operation of machinery and equipment, replacement of equipment or others needs. Besides the technical problems which appear, also intervene economic and financial issues that generate costs for the replacement of machines, equipment and installations and expenses of compensation to third parties who have suffered losses by disconnecting the power supply or lack of electricity over a longer or shorter period. Modern methods of risk management include also economic solutions. Some of these solutions will be treated in this paper.*

1. INTRODUCTION

Energy sector development and implementation of the latest solutions in the energy field lead to significant decreases failures for production transportation and distribution of electricity to final consumers will appear more risk categories. If risks from the design phase and the construction phase have been removed remain risks in the operational phase.

Reduction or minimization of hazards in companies in the energy field is very important. Dispersion of risk or allocating them to who can control is one of the objectives of risk management departments within these companies. The risk of accidental damage is classified operational risks. It occurs both in-warranty and post warranty period in machinery and power plants.

2. RISK AND RISK TRANSFER

2.1. The risk of accidental damage

The dispersion of accidental damage risks is through many forms. One of these forms is that with new participants at risk. Two new participants at risk are more commonly used in today's economy, they are: insurance companies and investment funds [1]. Risk transfer to insurance companies is more operatively to achieved. About transferring risk to insurance companies we will talk further on.

2.2. Risk transfer to insurance companies

It is relevant to approach classes of insurance by which risks can be underwrite on the Romanian insurance market. Currently, in accordance with Law No. 32/2000 amended and supplemented, on the Romanian insurance market risks can be subscribed for 18 insurance classes. These risks are taken by 42 insurance companies or insurance and reinsurance companies that are authorized by Financial Supervisory Authority [2]. Risks are subscribed directly by insurance companies or insurance brokers. There are cases where risk underwriting capacity is exceeded by an insurance company. In this case there are two variants: the insurance company gives some of the risk on the foreign reinsurance market or several insurance companies are grouping and forming an insurance pool. The insurance pool is set up only for large investment objectives. Regarding the energy sector, this is the only area of the Romanian economy where an insurance pool was created. It was established to ensure fully cover the energetic objective from Cernavoda nuclear power plant [3].

Within the 18 insurance classes to which we referred are insurance policies grouped under various commercial forms. To know the main insurance contract terms and insurance policies that can be used to cover risks in the energy sector we will do an overview of these insurance classes.

2.3. Risk transfer through insurance policy for accidental damages to machinery and industrial equipment

Insurance policies for machines, installations and equipment covering risks of accidental damage are made only for legal entityes, in energetic sector or other fields as well. The policy concludes on the basis of general insurance conditions. Under contracts of insurance of machinery, plant and equipment can meet a deductible franchise. This is a portion of the damage, established as a fixed amount or a percentage of the sum insured. This is supported - payed- by the policyholder / beneficiary for each event. Insurance compensation or indemnity represents the amount that the insurer pays the insured or beneficiary after the occurrence of the insured risk [4].

Insured risk represents an uncertain bad event covered by the insurance policy. It can cause damage both to the insured and to third parties. The period of compensation is the agreed period of time for which the insurer will compensate the additional operating expenses in case of damage covered by the insurance policy.

The loss is a damage suffered by the insured or third party after the insured event. In the case of machinery, installations and equipment damage can have partial and total loss. Total loss means that the asset assured was fully destructed. Therefore repair is not possible, or the cost of the repair would exceed the insured amount. Partial loss means that the asset insured is partialy destructed. By repair, restoration or replacement of (a) parts, it can be restored to its working order. Cost of repair does not exceed the insured amount of the insurance policy and neither the real value of goods at the time of damage.

Negligence in operating is the manifestation of the insured fault or his servants, who did not foresee the possibility of damage to property or goods subject insurance policy. Major force under insurance contracts is defined by law as an unpredictable situation at the date of the insurance conclusion [5].

At the conclusion of an insurance policy for machinery, installations and equipment for accidental damage, the insured objective should be defined by the insurance. On the insurance contract are insured machinery, equipment and plant which corresponded after carrying out operation tests, or under the following conditions: are during operation or break in operation;are in a state of disassembly for cleaning , adjusting or repairing; during moving to another place in the same location;

The insurance covers only the equipment, machines and equipment that are in the location mentioned in the insurance policy.

In the insurance policies for machinery, installations and equipment for the risks of accidental damage are specified also the insured risks. Therefore are covered during the insured period, damages occurred or destruction of machinery, equipment and facilities or their components, which are specified in the insurance policy.

The insurer pays compensations to the insured for equipment, machinery and facilities that have suffered losses from: casting defects or material; errors in installation and / or installation,design errors; negligence in operation; other accidents as: breaking, dismantling, defects or malfunctions of devices of protection, penetration of foreign bodies; pressure; short circuit, electrical or mechanical failure;

For all risk insurance policies, coverage may extend also to: flood, earthquake, landslide, fire, theft.

At the conclusion of the insurance policy insurers states what are the exclusions for which it will not pay any compensation. No liability for damage caused by: operations of war, whether war was or not declared, invasion, action of an external enemy, civil war, rebellion, revolution, insurrection, strike, civil unrest, dictatorship, military or usurped power, groups of persons malicious or acting connection with any political organization, confiscation, conspiracy, requisition, destruction by order of any government law or fact, or any political authority; nuclear reactions, nuclear radiation or radioactive contamination; willful action or gross negligence of the insured or their representatives; overcharging or forcing machinery and equipment over the maximum allowed capacity; failure by the deadlines provided for periodic revisions in line with the recommendations of the manufacturer or supplier of machinery or equipment provided; damage arising during operation or operation having such as wear, erosion, corrosion, rust; explosion when chemical phenomena; aircraft crash or uninsured buildings collapse; Sonic boom; risks which, by law or contract manufacturer or supplier responsible; defects of the insured property existing at the commencement of validity of the insurance contract; burglary or theft; injury suffered by employees if they were not insured. A part of the insurance policy exclusions for accidental damage to machinery and industrial equipment are covered by all risk insurance policy [4].

The parties may jointly bring changes to the insurance contract, which entered into force on the date agreed in writing by the parties. Within indemnities payed to the insured, the insurer is subrogated its rights against those responsible for producing and increasing the damage.

3. CONCLUSIONS

We can conclude that in addition to constructive technical solutions and cyber surveillance solutions we have also economic solutions to cover potential hazards for energetic domain. Risk insurance policy for accidental damage to the machinery and power plants, insurance policy for professional liability of operators in the energy sector and "all risk" insurance policy are economic solutions at reasonable costs. These insurance products are present in the insurance companies portofolio offer and can be released in a short time to the managers in the energy industry.

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Keywords: List 3-4 keywords *(aligned to the left, 10 pt. bold, separated by commas; please choose keywords from IEEE Approved Indexing Keyword List)*

Abstract*: Abstract of max. 200 words, justify, 10 pt. regular.*

1. INTRODUCTION

The paper must be written in English. It shall contain at least the following chapters: introduction, research course (mathematical algorithm); method used; results and conclusions, references.

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Use DIN A4 Format (297 x 210 mm) MSWord format. Margins: top, bottom, left and right 2.5 mm each. The text should be written on one side of the page only. Use Times New Roman fonts, line spacing 1.3. The font formats are: paper title: 14 pt, bold, italic, capital letters, author's name(s): 12 pt, regular for name and 12 pt., bold, for surname; Affiliation: 11 pt., italic; key words: 10 pt., bold; Abstract: 10 pt., italic, word Abstract in 10 pt., bold; chapter titles (do not use automatic numbering): 12 pt., bold, capital letters; subtitles: 12 pt., bold, lower case letters; subsubtitles: 12 pt., italic, lower case letters; body text: 12 pt., regular; tables and figures caption: 11 pt.; italic; references: author 11 pt.; regular, title 11 pt. italic, year, pages, ... in regular.

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2. FIGURES AND TABLES

Figures have to be made in high quality, which is suitable for reproduction and printing. Don't include photos or color prints if there are not clearly intelligible in gray scale option. Place figures and tables at the top or bottom of a page wherever possible, as close as possible to the first reference to them in the paper. Use either *fig. 1* or *figure 1* when necessarily.

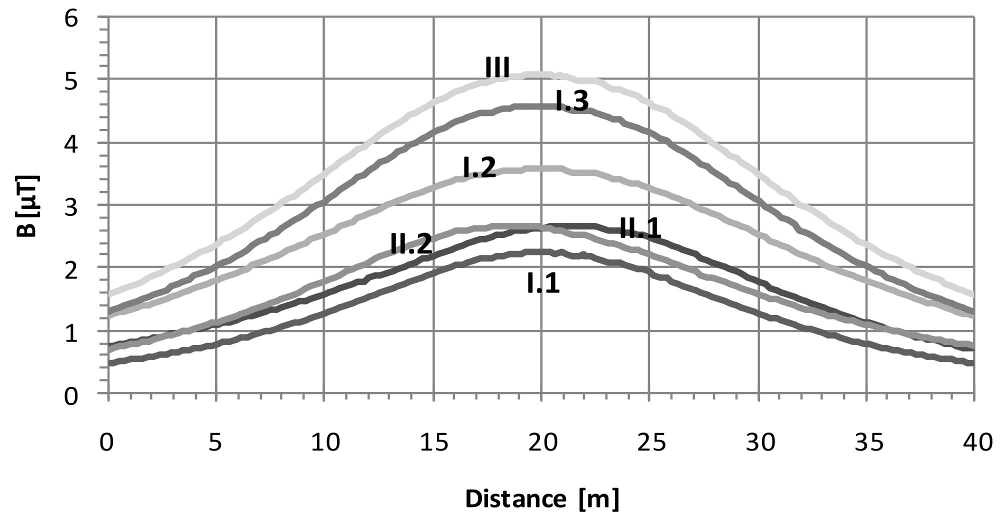

Fig. 4 - Magnetic flux density at 1 m above the ground

Table 1. Transposing principle

	Circuit											
	1	*2*	*1*	*2*	*1*	*2*	*1*	*2*	*1*	*2*	***1***	***2***
1/3	*R*	*T*	***R***	***R***	*R*	*S*	*R*	*T*	*R*	*S*	***R***	***R***
line	***S***	***S***	*S*	*T*	*S*	*R*	*S*	*R*	*S*	*T*	***S***	***S***
length	*T*	*R*	*T*	*S*	***T***	***T***	*T*	*S*	*T*	*R*	***T***	***T***
1/3	*T*	*S*	***T***	***T***	*T*	*R*	*T*	*S*	*T*	*R*	***T***	***T***
line	***R***	***R***	*R*	*S*	*R*	*T*	*R*	*T*	*R*	*S*	***R***	***R***
length	*S*	*T*	*S*	*R*	***S***	***S***	*S*	*R*	*S*	*T*	***S***	***S***
1/3	*S*	*R*	***S***	***S***	*S*	*T*	*S*	*R*	*S*	*T*	***S***	***S***
line	***T***	***T***	*T*	*S*	*T*	*S*	*T*	*S*	*T*	*R*	***T***	***T***
length	*R*	*S*	*R*	*T*	***R***	***R***	*R*	*T*	*R*	*S*	***R***	***R***
Name	***I.1***		***I.2***		***I.3***		***II.1***		***II.2***		***III***	

3. EQUATIONS

Equations are centred on page and are numbered in round parentheses, flush to right margin.

$$a = b + c \tag{1}$$

Between equations, not interfered by text, there is only one empty line:

$$a = b + c \tag{2}$$

$$a = b + c \tag{3}$$

In text respect the following rules: all variables are italic, constants are regular; the references are cited in the text between right parentheses [1], the list of references has to be arranged in order of citation.

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