Programe			CEEX/ Formular B
Module	Complex research&development projects	Type of Project	P-R&D
Proposal's Acronym	HYBRID	No.	

Thematic Fields S/T*) (**3 thematic fields**)	Code 1	5	Title 1	Energy
	Code 2	5.8	Title 2	Energy efficiency and savings
	Code 3	5.9	Title 3	Knowledge for energy policy making
Technological Platform **)	Code		Title	Motor Challenge Program (http://energyefficiency.jrc.cec.eu.int/ motorchallenge/

*) according to Annex 1 – Activities / Thematic Fields S/T
**) according to Annex 1 – Activities / Technological Platforms (for complex projects)

B – PROJECT PROPOSAL DESCRIPTION

1. PROPOSAL'S TITLE IN FULL

Proposal's Title in full, and its acronym :

Theoretical and experimental researches regarding the increasing of the efficiency of electro-mechanical energy conversion by decreasing the iron losses in electrical machines

1.1 Thematic fields S/T according to Annex 1: *5. Energy (5.8. Energy efficiency and savings)*
1.2 Proposal's abstract (max. ¾ pages, Arial 10, 1.5 lines)

The oldest "source" of energy is the saving of energy. Generally, the electrical machines represents the places where the losses of energy are producing in the process of energy conversion from primary mechanical energy into electrical energy and after that reconversion of this energy back to mechanical energy to the specific parameters requested by the industrial equipments (fans, pumps, compressors, machines tools, lifting equipment a.s.o.). In all of the electromechanical energy conversion based on magnetic fields an important component of the losses are due to the iron losses in the magnetic circuit. These losses are not depending on the load, and are representing about 25-45% from the total losses of the machine under rated load. The right appreciation of these losses in actual conditions and their decreasing are important actions because of the big volume of the magnetic circuits circulating the magnetic energy; The saved energy could an important part from the converted energy.

The decreasing of the iron losses could be made by extensive methods (increasing the volume of the iron and correspondingly getting lower magnetic loading, it means bigger investment costs) or by intensive methods, it means by optimization of the design and constructive modifications and qualities of the material which could lead, at the same volume of the iron, based on balancing the iron loadings in the magnetic circuit, improving the wave shape of the air gap magneto-motive force, at the global important effects on the iron losses. The researches in the project are related to these latest methods, being applicable to a large class of electrical machines (motors and generators) of small and medium power, the biggest class from the energy consumption point of view.

In the project it follows to make an exhaustive analysis, as fundamental research, of the cold rolled, non-oriented magnetic materials characteristics, (specific losses, magnetizing capacity, magnetic anisotropy, magnetic ageing) and the interdependence between the material characteristics and the performance of the electrical machines (such as efficiency, power factor) will be established. The analysis will be based on advanced experimentally investigation of the magnetic materials, and also design of the machines using new, advanced techniques of numerical analysis, on the experimental models in order to prove the new technical solutions which will be imposed to reduce the iron losses.

As a result of the research there will be developed new designs for the electrical machines in the frame 56-160 with constructive modifications as lamination and windings taking into account the best quality of the magnetic material for each machine. The expected result is the reducing of the iron losses up to 15-40%.

It is demonstrated in the proposal that reducing the iron losses in a conventional lot of small and medium power motors of 400,000 pieces (up to 7.5 kW) compared to the actual machines will result in a significant energy savings without additional investment costs, only based on more deeply analysis of the magnetic structure of the machines and associated optimization.

2. 2. PRESENTATION OF NATIONAL AND INTERNATIONAL CONTEXT WITHIN THE MENTIONED THEMATIC FIELDS:

In the manufacturing of the magnetic cores of electrical machines there are used electrical sheet with non oriented grains (rotating machines) or oriented grains (transformers), depending on how the basic magnetic properties (specific losses, magnetizing capacity) on the rolling direction. Romania had and still has an important sector of electrical machines manufacturing in different locations, such as ELECTROMOTOR Timisoara, IME-Pitesti, UME-Bucuresti, ELECTROPRECIZIE Sacele, IEP-Craiova. These manufacturers cover a big scale of electrical machines and power transformers. Correspondingly, it was developed in the years '80 a big capacity of electrical sheets manufacturing at Tirgoviste based on a license bought from United States Steel Company, still working today in order to partially cover the inner necessity.

Researches related to the losses in the ferro-magnetic materials and the ways to reduce them are taking place in the world on the two distinct levels.

The first level is those of the research of the magnetic material itself, by the manufacturers of the electrical steel sheet in order to integrating into the standardized qualities and to reduce the costs of the manufacturing. The development of the soft magnetic materials at industrial scale is itself a big energy consumer. During elaboration on the sheet there are applying a series of thermal treatments between the successive rolling stages and after that a final thermal treatment for re-crystallization. All of these treatments are big energy consumer. In this respect, finding the proper chemical composition, the alloying elements, (especially silicon and phosphorus), the final degree of de-carburizing, the speed of the movement of the sheet in the even, in order to obtain the smallest specific losses or energy savings are problems of big scientifical and economical interest. These type of researches are developed in the laboratories of the steel sheet manufacturers having the main aim to establish the quality of different sorts of the sheets and to obtain new, improved qualities.

The second level is that of the electrical machines and other electrical equipments designers and manufacturers. The electrical sheet itself may be characterized by a set of standardized experimental test of big reproducibility (for example the Epstein apparatus, Franklin apparatus for insulating testing). The sheet find its final place in the magnetic cores of the electrical machines after a series of manufacturing processes such as stamping, packaging, pressing, some machine tools processes on the armatures to obtain the final air gap. On the other hand the measurements on the sheet samples are made in the special conditions of sinusoidal magnetic flux but in the current machine the loadings are quite far from the sinusoidal shape because of the harmonics (space harmonics, time harmonics, saturation harmonics). Even initially the electrical sheet is provided by a thin insulation in order to reduce the eddy current component of the losses, in the actual machine there are some „accidentally" (parasitic) magnetic circuits because of the touching between the sheets at the level of the manufactured surfaces. The research of the magnetic properties modifications from the sample of sheet up to the final lamination in the magnetic core of the electrical machine, producing the iron losses which are measurable to the input with wattmeters, are problems of real interest for electrical machines manufacturers.

A more deeply understanding of how the main loadings in the magnetic cores, the applied technological processes and the initial quality (as it is defined by the standards of material, it means the silicon content, saturation flux density) do influence the total losses in the iron of the electrical machines are representing problems of a big scientific interest. These type of researches are performed in the laboratories of the representative manufacturers with the aim of finding of all the possibilities of reducing the iron losses, the main component of the total losses.

In Romania, the researches at the both of levels have been made in the period of buying the license from USS in the Research Institute for Electrical Industry (ICPE) for all of the electrical, magnetical, mechanical and insulating properties, with application to the rotating electrical machines and transformers and in the Research Institute for Metalurgical Industry (ICEM) for all the metallographic analysis and chemical analysis. The researches were developed in order to have an exhaustive characterization of the USS qualities, being known that that time, like in the present, there are differences between the system of guarantying the properties of the electrical sheets regarding the specific losses, and the magnetizing capacity, respectively.

Unfortunately, in the present in the manufacturer locations of electrical machines the only magnetic measurements on the sheet samples are regarding the reception, made statistically or in case of litigation, or individual tests on the motors such as no-load test and short-circuit test. Without having the necessary apparatus and equipments and also some knowledge about the magnetical properties of the laminations, the inner manufacturers are discovered in many aspects regarding, for example to the magnetical anisotropy (referring to the losses or

magnetizing capacity), magnetical ageing (increasing in time of the iron losses due to the working temperature) or by the properties of the insulation between the lamination. Some signals coming from manufacturers to the research centers when appear some litigation referring for example to the unbalancing of the currents or increased noise level for some delivery are representing a confirmation that more deeply researches are to be performed with the existing testing apparatus and equipments, with large dissemination to the industry.

It is obvious that the problem of reducing the iron losses should be related to the more general problem of increasing the energy conversion efficiency. Abroad, in the last years, the energy politics regarding the electrical machines had an evolution with institutional aspects. In fact there was an evolution from leaving all the freedom to the motor manufacturer to design, to manufacture and to sell their products, through an institutional politics (in case of USA a Government politics) to constraint the manufacturers to increase the efficiency of the electric motors. In USA it is known the so called EPACT[1] which established the minimum values of the efficiency of the motors to be manufactured and sold after one established dead line. In Europe the same politics was applied by CEMEP (European Consortium of Electric Motors manufacturers) being established the values of the efficiency of three classes of electrical motors of given rated power and also a time graphic to increase of efficiency. The main aim is to stop the manufacturing of eff-3 motors considered as wasting energy motors.

Thus it is to be remarked that in the vision of the CEMEP prescriptions the sales of 4-poles motors in the eff-3 design (standard motors, like the majority of the Romanian present manufacturing) should be progressively decreased and replaced by machines of eff-2 and eff-1.

In this respect developing the researches in order to identify all of the possibilities to reduce the iron losses in the electrical machines is very important, these type of losses occurring in the machine working at any load from no-load to full load, by simply magnetizing of the magnetic circuit for creating the technical conditions for electro-mechanical energy conversion.

3. OBJECTIVES

The general objectives of the proposal project are related to the general objectives of the CEEX Programme with direct reference to the European area of research regarding the energy (chapter 5), more concrete referring to the increasing of the efficiency of the energy conversion and saving the energy (chapter 5.8). At the same time there are considered the specific objectives of the module I (complex projects of design and development) referring to the fundamental researches in order to get advanced knowledge, for developing of new methods, techniques, procedures, theories for increasing the scientifical value and the visibility on the international plane.

The researches in the proposed theme will have the following objectives:

1. Researches concerning production of iron losses in the cores of electrical machines and the possible ways to reduce these losses.

In this respect it will be investigated the phenomenology of the producing the iron losses in the cores of the electrical machines during the electro-mechanical energy conversion. There will be emphasized the main physical and geometrical magnitudes which are influencing the losses and the ways to reduce them. There will be analyzed the producing and the ways of reducing the hysteresis losses, eddy current losses and also the so called “anomalous” losses” in the alternating field and in the rotational field in direct connection with the silicon content or another alloying elements and the volume resistivity. At the same time the iron losses will be analyzed in dependence with the quality of the exciting magnetic field, the space harmonic content and their influence on the phenomena of volumical dissipation of the energy.

Referring to the soft magnetic materials (magnetic sheets) which are manufacturing in COS Tirgoviste, these materials will be analyzed qualitatively in relation with the inner and international standardization (IEC documents 404-8) putting in evidence the qualities structure, basic magnetic properties (magnetizing capacity, losses, anisotropy and magnetic ageing), the interdependence between them.

Also, at the base of the research will be an analysis of the existing situation regarding the magnitude of the core losses in the currently manufactured electrical machines face to the used magnetic sheet quality. There will be performed tests on existing machines and compared with the calculated magnetic loadings in the magnetic circuit of the machine.

[1] Please see http://www.acee.org/motors.epactapp.htm

2. Researches regarding the characterizing methods of the magnetic properties of the electrotechnical sheet and of the losses in the electrical machines. Experimental tests on the current samples of electrical sheet

In this respect it will be performed an analysis regarding the inner and international standardization referring to the conventional and unconventional methods of determining the magnetic properties in alternating and rotational fields. It will be emphasized the methods of determining the magnetizing capacity and the specific losses, of the magnetic anisotropy and ageing. A special attention will be paid to the comparative analysis of the methods of determining the a.c. and d.c. magnetizing capacity, in the alternating and rotational fields. Comparisons will be made between the industrial methods and laboratory methods of so called "single sheet" tester considering the reproducibility of the results.

Taking into account the computation methods in the cores of the electrical machines, the analytical procedures will be introduced based on the solving of field problem in the conventional structures of the actual machines and also the corrections due to the technological processes during manufacturing. The segregation method of measuring the core losses of rotating electrical machines (base core loss, additional core loss) will be re-considerate theoretically and experimentally taking into consideration the most recently IEC literature.

3. Researches on the electrical machines in the frame 90-132 as physical representative models having different level of the space harmonic content, experimentally investigation of the core losses. Elaborating the recommendations for using quasi-sinusoidal windings

In this respect there will be performed measurements of the core losses using standard methods and also unconventional methods with data acquisition system on the electrical machines manufactured with controlled levels of spatial harmonics of the air gap magneto motive force by introducing in the slots different types of sinusoidal windings. The effects of the technological processes on the magnetic quality of the sheets will be emphasized (cutting in length, stamping, stacking with different pressures, machine tools processes) and also the magnetic ageing will be investigated.

The "Epstein" apparatus will be used to measure special samples prepared so that to have different length of cutting and the influence of the disturbing the grains in the neighborhood of the edges due to stamping will be emphasized in relation with the magnetizing capacity and iron losses. The study follows to show even the influence of the stamping and ageing in dependence with the silicon content of the laminations. The complete set of recommendations regarding the association between the standard quality and the rated power of the machine will be elaborated.

4. Researches regarding the magnetic field distribution in the magnetic circuit of the electrical machines considering the local level of saturation. Elaboration of the methods of reducing the additional iron losses

Mathematical modeling 2-D and 3-D depending on the structure of the machine will be performed for three phase induction motors, auto-car alternators with claw poles. The distribution of the magnetic field (via magnetic potential) will be investigated depending on different winding structure, i.e. different wave shape of the air gap mmf. The critical points of high saturation will be emphasized in order to make improvements in the design.

The analysis using advanced numerical methods of the magnetic structure in the cross section of the machine will lead to the qualitative appreciations regarding the influence of the local point of saturation on the additional (stray) losses in the iron. The analysis will be parameterized referring to the different magnetic loading distribution between the teeth and the yokes in order to comprise a large number of laminations.

Also will be analyzed the interdependence between the air gap shape of the magneto motive force and the magnetic loadings in the different places (teeth, yokes) of the magnetic circuit. The iron losses in dependence on the saturation harmonics and the quality of the electrical sheet used for the laminations will be investigated.

5. Elaboration of the final recommendations for using the soft magnetic material with the aim of increasing the efficiency of the electro-mechanical energy conversion.

The researches will be straighten to the determination of the influence of basic characteristics of the soft magnetic material (magnetizing capacity and specific losses) on the energetical performances of the electrical machines (efficiency, power factor). In this respect analysis will be performed by computation and by experiment by using different type of magnetic materials in the same machine and by testing it on the bench. On this base final recommendations will be developed for all the manufactured unified series of electrical machines in order to maximize the efficiency.

Table 2. Measurable objectives, problems to be solved

Year	Problems to be solved	Measurable objectives
Year 2006 7 months	Phenomenological analysis on the iron losses during energy conversion using the magnetic field. Emphasizing the main physical and geometrical magnitudes influencing the iron losses and ways to reduce the iron losses. Analysis of the soft magnetic materials being in the actual manufacturing in respect with the inner and international standardization. The quality structure, magnetic properties and the dependence between them Analysis of the existing situation referring to the magnitude of the iron losses in the structure of the total losses in the actual unified series of electrical machines face to the quality of the used magnetic sheets Analysis pending the inner and international standardization referring to the conventional and unconventional methods of determining the magnetic characteristics of the sheet samples in the alternating and rotational fields Criticism analysis of the computation methods in the cores of electrical machines. Segregation of the base losses and the additional losses at no-load and full load	Hysteresis and eddy-current losses, anomalous losses; alternating field and rotational field, silicon alloy content and the volume resistivity; the quality of the excitation field, the influence of the saturation harmonic content on the iron losses The structure of the sorts of non-oriented cold rolled electrical sheets as in the IEC 404-4 documents; the magnetizing capacity and the iron losses; magnetic anisotropy and magnetic ageing, reciprocal influences Experimental tests on the actual motors in order to emphasize the iron losses, the magnetic loadings, the quality of the used material of laminations Methods of determining the magnetizing capacity, the iron specific losses, anisotropy and ageing; measurements in d.c. and a.c., in alternating field and rotating field; investigation based on the "single sheet" tester, the reproducibility of the measurement results Methods of calculation of the iron losses, considering the corrections due to the influences of the technological processes, losses in the teeth and in the yokes, additional losses and methods of measurements; reducing the errors in segregation method of determining the efficiency
Year 2007 12 months	Experimental determination of specific losses on the samples from the current structure of qualities having non sinusoidal flux density Researches on the electrical machines in the range 90-132 manufactured with special windings, by controlling the space harmonic content. Determination of the core losses. Elaboration of the recommendation on the using the quasi-sinusoidal windings Researches on the soft magnetic material samples regarding the influence of the technological processes and the magnetic ageing on the magnetic characteristics Mathematical modeling using 2-D and 3-D software of the conventional structure of the electrical machines (squirrel cage induction motor, claw poles alternators) with analysis of	Magnetic measurements on the samples by controlled disturbing of the magnetic flux density from the sinusoidal shape, the influence on the losses. Measurements in rotational flux, comparison with the alternating flux. Determination of iron losses by standard methods and unconventional methods using data acquisition systems on models of electrical machines having special windings with improved shape of the air gap magneto-motive force (quasi-sinusoidal windings) Experimental measurements using "Epstein" method for determining the influence of the structural disturbance of the grains near the edges of cutting on the magnetizing capacity and iron losses. Comparison of the cutting and ageing influence regarding the silicon content of the sheet; recommendation for using the right sheet

	the distribution of magnetic flux density taking into account different degree of disturbing the air gap field; emphasizing the critical point of local saturation	quality for different rated power of the machines. Analysis by computation methods of the magnetic field structure in the cross section of the rotating machine. Appreciation on the influence of the local points of saturation on the additional (stray) losses in the iron due to the load; parameterized analysis referring to different ratio of the magnetic loadings between the teeth and yokes.
Year 2008 (7 months)	Analyze the interdependences among form of wave magnetic tension from air gap and the magnetic solicitations from different portions ale magnetic circuits(teeth, yokes) and influential loss in iron and saturation harmonics. Researches concerning influential basic features ale magnetic flabby materials (magnetizability and miss specific) about power performances(efficiency and power factor) of electrical machines.	Analyze on different magnetic structures from the current makes with advert to the magnetic tensions from teeth and yokes, hold over forms of wave magnetic tension from air gap; The study possible effects about loss from iron and method of reduce of saturation harmonics; The effect magnetic material quality from angle of magnetizability about deformation of the field. Analyze comparative on a series of electric machines with advert to the power performance, efficaciousness and factor of power, through the of a utilization discrepant material magnetic class below the appearance magnetizability and perished specified; The elaboration of final recommendations

4. SCIENTIFIC AND TECHNICAL PRESENTATION OF THE PROJECT:

The problems of the losses in the ferromagnetic materials situated in the cyclically variable magnetization is one of the most interesting and deepest from electromagnetic field theory. Enounced first as the theorem of Warburg, the development of losses take place following the time delay between the two magnitudes characterizing the magnetic field in the material: the field intensity H[A/m] and the magnetic flux density B [T]. The finding that besides the saturation shape of the magnetizing curve B-H of ferromagnetic materials there is a degree of equivoque related to the „memory" of the magnetic materials, materialized in an hysteresis cycle on which the current point, defining the state of magnetization, is going in the CCW sense of rotation, was done even from the beginning of the a.c. electrical applications because of the heat developed in the material loaded by variable fields. This conclusion have led to the development of the new materials, based on the deep investigation at the level of the grains and the degree of decarburizing and also different element of alloying such as silicon and phosphorus in order to obtain hysteresis cycles as narrow as possible.

On the other hand, the ferromagnetic cores have an electrical conductivity which is non-zero supposed to the variable field. In this case there will be some paths of the eddy-currents following the lines of the electric field, according to the law of Ohm. To control the volumic losses due to the eddy currents, depending on the square of the variable field frequency and square of the gauge of the sheet one can decrease the thickness of the sheet in order to reduce the length of the eddy current's paths, but another way is to reduce the resistivity, it means to add more silicon content in the initial alloy.

The technological process of elaborating the soft ferromagnetic materials for the electrical machines cores, are determined by these to enounced aspects. The hot rolled technology, used formerly was later replaced by the technology of cold rolling, with big advantages not only from the speed of manufacturing the material but also in obtaining the higher magnetizing capacity at the same values of the specific losses. Of course there are some accepted disadvantages inevitably induced by the higher dispersion of the magnetic characteristics of the sheets, bigger anisotropy, it means sensible differences between the magnetic performances measured on the rolling direction or perpendicular to it. Last but not least, there is a pregnant predisposition of the sheets to the magnetic ageing (increasing the losses due to the running temperature).

In the relation between the manufacturer of magnetic materials and electrical machines these performances of the sheets represent an real scientific interest because they have an important influence on the iron losses and also

on the global efficiency of the energy conversion. From this reason these aspects should be studied and had in view during electrical machines manufacturing and running.

Thus, considering the basic magnetic performances of the sheets, they are defined in the group of standards IEC 404-8 by ***total specific losses*** (including hysteresis and eddy currents losses, W/kg), guaranteed to the value of 1.5 T flux density, 50 Hz, sinusoidal magnetization, and by ***magnetizing capacity***, given by the magnetization curve of the material, measured in d.c. or a.c. (maximum values), defined by a series of points but the most important (in our opinion, for cold rolled, non-oriented grains, rotating electrical machines) is the value of B_{25} it means the minimum value of the flux density in the material excited by a magnetic field of 25 A/cm. For the cold rolled grain oriented sheets (for power transformer applications) this value use to be B_8. In respect with these two basic performances the magnetic sheets are elaborated in a wide quality sorts having as parameter the silicon alloy content starting from non-alloyed sheets (residual silicon and phosphorus) up to the maximum value of 3.3 % silicon content, covering a scale of specific losses from at 1.5 T/50 Hz from 10 W/kg (thickness 0.65 mm) up to around 2.5 W/kg (thickness 0.35 mm). The magnetizing capacity of these sheets is, in the same scale, from 1.58 T up to 1.49 T.

What has to be underlined is that, increasing the silicon content in order to get the lower specific losses, it results a lower value of saturation flux density of the sheets, it means the two basic performances of the sheets are contradictory: decreasing the losses, will lead to the decreasing of the magnetizing capacity. ***This fact lead to a first area of scientific investigation*** in order to consider how the basic performances of the sheets are influencing and are found in the basic performances of the electrical machines. Depending on the rated power and type of the service of the machine it should be used that quality of the magnetic sheet which will maximize the energetical performance of the machine, i.e. the efficiency and the power factor. In this respect there are some citations in the technical literature, which need to be extended and deepen about classes of electrical machines in which applying „better sheets" from the point of view of the losses lower global energetical performance of the final machine will result. It is the case of the machine with big quantity of the iron needed to be magnetized.

Corroborating with the using of the optimal quality of the sheets, it should be mentioned ***a second area of scientific investigation*** related to the manner in which the dispersion of the sheets magnetic performances are found in the dispersion of the energetical performances of the electrical machines. This problem is very actual and should be connected to the iron load additional losses and the admitted tolerances in case of individual test of the manufactured machines, recent modified in the prescriptions in IEC 60034/1.

Taking into account that the basic performances of the sheets are defined, from the reasons of reproducibility, in the sinusoidal magnetic fields, and in the machine's core there are another conditions of magnetization due to the slotted structure, distributed winding, it appear a ***third area of scientific investigation*** of the study of the possibilities to reduce the space exciting field harmonics in order to reduce the total iron losses in the cores. In this aim in the project will be made experimentally investigation of new winding systems which will produce rotating magneto-motive forces with low space harmonic content.

Finally, a close attention should be paid to the experimental determination of that three above mentioned „negative performance" of the sheets namely ***magnetic anisotropy,*** in case of the non-oriented sheets, ***magnetic ageing,*** modifying the losses during running because of the running temperature, ***and the possibility to have remaining internal mechanical stresses*** having negative effects from the technological point of view. Scientifical investigation of these aspects, which is neglected usually by the inner electrical machines manufacturers, needs special testing equipments, experimentation on the samples after different thermal treatment, investigation on the finite electrical machines.

Thus, the ***magnetic anisotropy*** which is reflected in differences in both ***specific losses*** and ***magnetizing capacity*** between rolling direction and cross to the rolling direction may have negative influence by inducing some counter-clock wise (CCW) components of electro-motive force and currents, with negative influence on the efficiency of energy conversion. Definition of the anisotropy and his limitation values has oscillated, in the present in IEC 404-8-4 it is established characterization of the anisotropy on the losses. However, at least for a large class of electrical machines (small power induction machines) is the anisotropy reflected in the magnetizing capacity, leading to unbalance in the no-load and full-load currents and also in the additional losses and local temperature rise. In the project it is considered the experimental investigation of the anisotropy itself on the sheet samples and also as influence on the electrical machines tested on the bench.

The magnetic ageing are producing in time, after the machine is delivered, during load running, due to the stabilized temperature rise. It is happening because of some internal transformation at the structure of magnetical material. If the decarburizing is not right performed during the final re-crystallization annealing or it is made too quickly, there is a tendency of precipitation of some components (nithrurs, charburs, sulphurs) and migration

through the limits between the magnetic grains. The effect of silicon as alloying element is usual in order to inhibit the magnetic ageing, it means the low losses sheets are less ageing possibilities. However, for a large class of un-alloyed sheets, with low carbon content, used in small power electrical machines (cold rolled commercial quality – CRCQ) the effect of the ageing may be extremely dangerous and should be studied on the samples and on the electrical machines.

Finally, the ***internal stresses,*** when they are not intentionally introduced (the case of some grain oriented sheets used for transformers, in order to reduce the initial losses) should be watched and limited in case of rotating machines where the lamination could modify the shape after stamping, the circles will transform into ellipses and the complications are big enough with negative influence on the performance, even affecting the possibility to rotate.

There is an aspect which is not at all covered in the standardized techniques of investigation, of ***the iron losses due to the rotational magnetization.*** The fact that there are differences in losses between the alternative and rotating excitation field was concluded after specialized measurement and comparisons by using special rotameters base don thermal detecting of the losses. These investigation should be made in the project in order to better characterize the losses in the yokes of the rotating electrical machines where the field is mainly rotational. The problem, even it is not quite knew, it is frequently found in the actual technical literature being in attention of both sheet and electrical machines manufacturers[2]. This is the reason why in the project will be investigated rotational behavior of the losses in round samples on the special two-direction, two-phase magnetization. In this respect special equipments will be developed by the research team. As principle of measurements will be so called thermo-mechanical measurements[3] and the results will be systematized on the sorts qualities in order to be used in the process of electromagnetic design.

5. PROJECT JUSTIFICATION:

The project is relevant for the area of electrical general-purpose and specialized machines in the sense of research of magnetic materials behaviors in the electric machines as energy converters. The main aim is decreasing of the iron losses in the machines cores. The experimental research of the behavior of electrotechnical sheets in the magnetic cores of the machines including the technological processes influences and their inclusion in the design procedures does represent an important reserve in decreasing the losses in iron and expenditures of exploitation.

The project is justified, besides the necessity to increase by any way the efficiency of the energy conversion, ***firstly by the existing endowment*** referring to the scientifical equipments for magnetic materials investigation (oriented and non-oriented steel sheets, full magnetic cores, permanent magnet systems) and also the possibilities to make special experiments on electrical machines by means of detailed energy efficiency analysis (measurement of the iron losses in different constructive conceptions, cross section of the laminations, winding systems).

Thus, the magnetic materials may be investigated by equipments type “hysteresis-graph” for all the hard magnetic materials (AlNiCo, SmCo, NdFeB, hard ferrites and bonded magnets), soft steel and other soft materials in the range of frequency from 0 to 10 kHz, Epstein apparatus with standard samples of 30/280 mm, in exciting magnetic field from 1A/m up to 30.000 A/m leading to the flux densities, depending on the silicon content, up to 1.95 – 2.06 T.

For investigation of the magnetic anisotropy there are magnetometer with vibrating sample in a large scale of measurement and for operational measurements there are equipments type „single sheet tester” offering good results and reasonable errors.

As analytical methods for determining the magnetic field configuration in the specific structures are concerned, in order to localize the strong and critical points of saturation, there will be used some specialized software programmes to calculate the magnetic field in magneto-static regime (field calculation in the so called “harmonic”

[2] To see for example the analysis made by the Japanese company KAWASAKI, one of the biggest electrical steel manufacturer all over the world: “Electric steel for motors of electric and hybrid vehicles”, Kawasaki Steel Giho, **34(**2002), 2, p.85-89 to be found at www.jfe-steel.co.jp/archives/ en/ksc_giho/no.48/e48-033-038.pdf

[3] To see for example the paper of Chikara Kaido from *Electrical Steel Research Laboratory, Nippon Steel Corporation, Kitakyushu-city, 805, Japan* “Mechanical method of iron loss measurement in a rotational field and analysis of iron loss in a motor” published in Journal of Applied Physics -- April 15, 1991 -- Volume 69, Issue 8, pp. 5106-5108

regime). The software is of type MagNet (Infolytica) in order to solve the Maxwell equation in the specific configuration in 2-D or 3-D situation as the situation is imposing. It should be noted that by using these software packages the static field can be determined around the injected currents as sources of the field, allowing the linear or non-linear behavior of the materials, neglecting the eddy-currents induced in variable fields and also the possibilities of considering each part of material having given coercitivity, it means modeling of the structures including permanent magnets..

Secondly, referring to the viability of the project, it should be mentioned the ***experience, the competence and the previous achievements of the research team.*** Adding together the individual efforts towards the final objectives of the project, in order to obtain new, high quality machines, does represent a guarantee of the success.

The project director has sustained a PhD thesis in the field of optimal design of the unified series of motors related to three phase squirrel cage short-circuit induction motors. He held as inventor more than 20 Romanian patents and has published tens of papers regarding the design, manufacturing and testing the electrical machines and materials. ***The research team from ICPE-ME*** has as endowment one of the best and complete testing platform for electrical motors and has previously designed many series of electrical machines which are manufactured today in Romania. ICPE-ME is the holder of many Romanian patents in the field of a.c. motors with or without permanent magnets and has published many scientific paper related to the topic.

ICPE-CA as main partner in the consortium has a very valuable and complete experimental endowment in the field of magnetic materials measurements covering almost all of the scientifical equipments of investigation from the magnetic, electric, chemical magnetical, electrical, chemical and metallographic structure point of view. In the Institute are activating valuable, internationally recognized senior researchers having results in the inner and abroad literature. It is to be noted the preoccupations in the field of solid state physics, magnetic materials development and characterization, special techniques of experimental investigations.

The partners from the well known ***Universitary Excellence Research Centre*** (UPB,) are the holder of many technical information and experience in the field of electrical machines and materials based on developed PhD thesis and also advanced equipments for testing electrical machines. Last but not the least, the ***Romanian Electrotechnical Committee*** is an international recognized institution being the interface between the International Electrotechnical Committee and inner industrial, research and educational institutions, dealing with the harmonization of the Romanian standards in the electrical engineering fields with the IEC norms.

It has to be underlined that in the working team, especially from the Universities, there are many young researchers (under 30) which will contribute to the research work and will prepare their doctoral thesis based on the obtained results.

6. DIAGRAM OF PROJECT EXECUTION:

The diagram of the project with the activities and dead lines is presented in the table 2.

As it can be observed from the diagram of the project execution, all the partners are involved in all of the project stages, the weight depending on the type of activity and the specific of each partner. Thus, the involving of the partners may be more specific detailed as follows:

ICPE-ME (Research Institute for Electrical Machines) has mainly the responsibility the study and technical analysis, establishing the constructive solution, the electromagnetic design, manufacture and testing of the experimental models analysis of energetical efficiency on the sets of motors of given application, the integration of all the works during the project and co-ordination of the activities.

ICPE-CA has responsibilities related to experimental investigations on the magnetic materials, considering the main magnetic performances as magnetizing capacity, specific losses, anisotropy, magnetic ageing), the influence of the technological processes on the magnetic performances, alternating and rotational fields.

UPB, (Technical Universities from Bucharest) will be responsible on the problems related to technical analysis, development of specific methods of computation, non-conventional methods of testing the experimental models, participating to the development of the final technical solution.

CER (Romanian Electrotechnical Committee) will be responsible on the problems related to studies and analysis referring to the national and international standardization in the field of the project, development of the technical specification (data sheet) of the motors, the substantiation of the legislative initiative to be forwarded to the responsible forum in Romania regarding the “waste” energy and the proposal for type of incentives to be given to

the manufacturers of eff-1 motors as help from the state.

Table nr. 2

Year	Stages/ Activities/ Partners	Dead lines	Results/ Documents to be presented	Amount from budget	
				Total lei	Valori relative %
2006	**Stage I.** **RESEARCH CONCERNING THE IRON LOSSES IN THE ELECTRICAL MACHINES. POSSIBILITIES TO REDUCE THE IRON LOSSES**	**30 SEPT 2006**	**Studiu** **Raport tehnic de cercetare**	**150.000**	
	Activity I. 1 Study and phenomenological analyses of how the iron losses occur in the iron of electrical machines during the process of electromechanical energy conversion. Emphasis of main physical sizes the geometric which and influence the production loss and pathes of reducing them.	30 SEPT 2006.	Studiu Raport tehnic de cercetare	**50.000**	
	Activity I. 2 Analysis of the soft magnetic material used in the electrical machines manufacturing. International standardization in the field. Sorts quality, basic performances and interdependence between them.	30 SEPT 2006	Studiu Raport tehnic de cercetare	**70.000**	
	Activity I. 3 Analyse the existing situations with advert to the size loss in iron in structure loss total to series of electric machines finded out the in current make in report with the quality used-up sheet-irons.	30 SEPT 2006	Studiu Raport tehnic de cercetare	**30.000**	
2006	**Stage II.** **Researches CONCERNING METHOD OF CHARACTERIZES THE MAGNETIC BASIC PROPERTIES OF ELECTROTECHNICAL STEEL SHEETS MISSED THE IN THE IRON ELECTRIC MACHINES.** **EXPERIMENTATIONS ON SAMPLE FROM CURRENT MAKE OF BLACKBOARD ELECTROTECHNICS**	**15 DEC 2006**	**Study.** **Technical report of research.** **Bulletins of attempt**	**225.000**	
	Activity II. 1 Analyse concerning the internal standardization the international si with advert to the conventional method the unconventional si of cause the magnetic features in cimpuri alternative and vorticular.	15 DEC 2006	Technical report of research.	**100.000**	
	Activity II. 2 Analyse the criticism concerning calculation procedure and of experimental missed the in the iron electric machines. The separation basic loss and celor supplement of empty the si of task.	15 DEC 2006	Technical report. Methodology and adding result. Bulletin of attempt	**125.000**	

2007	**Stage III.** **Researches EXPERIMENTALLY ON MATERIAL MAGNETIC DIP PREAS AND ON ELECTRIC MACHINES CONCERNING influential REMAKINGS, FORMS OF WAVE AND CHARACTERS ALTERNATIVELY OR VORTICULAR OF MAGNETIC CIMPULUI EXCITATOR ABOUT MISS THE IN IRON**	**30 MAI 2007**	Study. Technical report of research. Bulletins of attempt	**320.000**	
	Activity III. 1 Experimental missed specific in iron on esantioane of material magnetic from sortimentatia standard in report with magnetic induction aplicate nesinusoidale.	30 MAI 2007	Technical report. Bulletins of comparative attempt	**90.000**	
	Activity III. 2 Researches On electric machines from gab. 90-132 Realizate as physical illustrative fashion with niveluri contained of harmonic spatial the si the experimental missed the in iron. The elaboration recommendations considering the realization of winding-ups quasi power in the operation models.	30 MAI 2007	Technical report. Report of attempt in accordance with foresee Caietului of tasks of models. Recommendations	**130.000**	
	Activity III. 3 Researches On esantioane of material magnetic flabby with advert to influential technological specific remakings and imbatrinirii thermic about magnetic features		Raport tehnic. Buletine de masuratori	**100.000**	
2007	**Stage IV.** **Researches CONCERNING CASTING MAGNETIC CIMPULUI IN THE MAGNETIC CIRCUIT OF ELECTRIC MACHINES AND EMPHASIS NIVELURILOR LOCALLY OF SATURATION. THE ELABORATION METHODS OF MISSED THE SUPPLEMENTATION IN IRON.**	**15 OCT 2007**	**Raport de cercetare** **Studiu privind metodele de reducere a pierderilor in fier**	**250.000**	
	Activity IV. 1 Modelarea mathematics 2-D(3-D) of a conventional structures of electric machines(asynchronous engine with impeller in short-circuit; Alternatoare synchro with poles in clutch) with analysis castings cimpului of magnetic induction in report with different degree of deforms cimpului of excitation and emphasis critical points of magnetic saturation	15 OCT 2007	Raport de cercetare Modele matematice si rezultate de analiza	**125.000**	
	Activity IV. 2 Analyse the interdependences among form of wave magnetic tension from air gap and the magnetic solicitations from different portions ale magnetic circuits(teeth, yokes) and influential loss in iron and armonicelor of saturation	15 OCT 2007	Raport de cercetare. Studiu privind armonicele de saturatie	**125.000**	
2008	**Stage V.** **The elaboration RECOMMENDATIONS FINAL OF UTILIZES MATERIAL MAGNETIC DIP THE IN THE AIM BREED THE EFFICIENCIES ELECTROMECHANIC CONVERSIONS ENERGIES.**	**30 IUL 2008**	**Raport de cercetare** **Recomandari finale si concluzii**	**150.000**	

	Activity V. 1 Researches Concerning influential basic features ale magnetic flabby materials(magnetizability and miss specific) about power performances(efficaciousness and factor of power) ale electric machines. Recommendations of utilization	30 IUL 2008	Raport de cercetare Recomandari de utilizare a tablei electrotehnice din punct de vedere sortimental	**100.000**	
	The activity V. 2 The elaboration Conclusions, Ultimate recommendations the si the dissemination on the large scale results	30 IUL 2008	Diseminare larga la fabricantii de masini electrice Lucrare de sinteza publicata in EEA - ELECTROTEHNICA	**50.000**	
2006 - 2008	**Stage VI (SUPPORT ACTIONS) are willed specified to perfectarea contracts max. 5 From value his contract are willed emits the additional papers of early stipulation fiecarui calendar year of research. Assist in INTERNATIONAL FAIR(EXAMPLE: HANOVRA) 2007 2008. assist in THE INTERNATIONAL CONF. (EXAMPLE INTERNATIONAL CONFERENCE ON ELECTRICAL MACHINES ICEM'2006, 2008)**	**2006-2008**	Rapoarte tehnice de deplasare Lucrari stiintifice elaborate si acceptate in tematica conferintei cu referire la tema de cercetare	**55.000**	

	TOTAL AMOUNT OF CONTRACT (2006-2008):	**1.150.000**	**100%**

7. RESULTS/ PROFITS AND DIAGRAM/CAPITALIZATION PLAN/ DISSEMINATION

The results of the research are materialized in the information related to the basic properties of the magnetic materials as components of the electrical machines magnetic circuit (electrical sheets, permanent magnets, other soft magnetic materials). These information follows to be used in new designs of electrical machines or improvements in older designs of currently manufacturing with the main aim to reduce the iron losses and increasing the efficiency of energy conversion.

In order of results of the research to be used, it is foreseen a special action of dissemination to the magnetic materials and electrical machines manufacturers after each stage of the research. Finally it will be published a synthetic paper in the revue EEA-ELECTROTEHNICA.

8. TECHNICAL, ECONOMICAL AND SOCIAL IMPACT

The technical impact is defined by introducing in manufacturing in the next years of the new series of low and medium power (frame 90-132 and 160-280) hybrid synchronous machines (motors and generators) having high efficiency (eff-1 or higher) as it is requested by the European tendencies and prescriptions related to the CEMEP consortium of electrical machines manufacturers and the European “Motor Challenge Program”. The impact will be also the association of the Romanian manufacturers to the “European Joint Research Centre” from Brussels by including the high efficiency manufactured motors in the data base EuroDEEM. It is clear that the implementing costs, sometimes with dimmed character, have to be distributed to all of the involved parts. The impact on the environment for example, considering the improvement in the quality of the life due to the less CO_2 emissions have to be supported by the society and in this respect the state has an important role.

The research has also the aim to put in value the existing distributed scientific potential in the different research centers in order to work together for better results; it could be an impact on the future research and on the research market in Romania.

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9. PROJECT MANAGEMENT

The management of the project will be mainly a task of the research unit (ICPE-ME) which has a long time experience in designing the unified series of electrical motors. The research team is deeply specialized in the field of optimal design of electrical motors and also in the economical analysis and technological design.
It is stipulated that monthly the research team will analyze the steady state of the researches compared to the diagram of the project and discrepancies will be immediately solved. Measures will be taken as the results to be put in value as soon as possible inner the team but also in order to disseminate them.

Having in view the collaboration between the research and execution compartments of the research team, the responsibility will be distributed depending on the stage of the research. Any time will be performed corrections in order to obtain the proposed results as soon as possible. The team involved in the research activities is an heterogeneous one, having specialists in electrical machines, power electronics, electromagnetic design, mechanical design, the quality engineering and technico-economical analysis.

In order to be informed regarding the other manufacturers products as technical conditions, it was stipulated in the project's activity list some „support actions" (up to 5% from the total financing amount) representing expenditures for participating to the international fairs (example Hanover fair) or international conferences (example „International Conference on Electrical Machines", ICEM-2006, 2008).

10. DESCRIPTION OF REQUIRED RESOURCES FOR PROJECT EXECUTION

Taking into account the execution plan of the project presented before considering all the eligible activities and deadlines, it is requested from the programme's budget the total amount of 1.150.000 lei covering the material and human resources necessary for developing the analysis, experimental testing on materials, experimental testing on models design, manufacturing and computations.

As the endowments are concerned, it is to be mentioned that there exist the main equipments necessary to test experimentally the magnetic materials and the new designed motors taking into account the standard's prescriptions such as sources, dynamo-brakes, measuring equipments, computing equipments in ICPE-ME, ICPE-CA and the research centre of UPB. A detailed list of these equipments is given in the annex A2.3.

However, in order to create the possibilities of scientifical investigations as it is planned, it follows to use a part of funds to buy the following equipments:

-Fluxmeter with triaxial coil
-Module Program for field computation 3D
-Personal computer P IV
-Multifunctional printer
-Agilent VEE 7.5 PRO language of programming
-Acquisition data module VXI (5 placi : bus CT-310A, VXI-USB , VT1563A , 4 channels, 32 entries)
- Preamplificatoare (2) (DC-1 MHz , amplificare variabila de la 1 la 50 000, doua filtre de semnal
- Amplificator de putere bipolar, domeniu de frecvente 0 – 1 MHz, amplificare variabila
- Digital lock-in amplifier, domeniu de frecvente 1 mHz – 102,4 kHz, 0,001 grade rezolutia fazei, smoothing, curve fittine & statistics RS-232, Auto-gain