Universitatea *Transilvania* din Braşov

HABILITATION THESIS

Energy and Informatics, toward Intelligent and Energy Efficient Applications

Domain:

Electrical Engineering

Author: Prof. Dr. Paul Nicolae BORZA

Universitatea Transilvania din Braşov

BRAŞOV, 2017

CONTENT

List of Abbreviations: **3**

A. Rezumat **6**

B) Scientific and professional achievements and the evolution and development plans for career development **8**

(B-i) Scientific and professional achievements **8**

Introduction 8

Why I applied? 8

Which are my research fields of interest and how there have evolved during my career? 9

Chapter 1. Bioengineering - Pathway for development of optimized and validated technical systems 12

Energy generation in living systems - paradigm for hybrid storage systems 13

Distribution in space of the energy storage elements (cellular distribution) 14

Programmability and dynamic energy budget mechanisms of living organisms 17

Technical system design based on biomimetic methodologies 20

Chapter 2. Energy and Informatics – The basis for development of the smart systems 23

Informational integration of measurement data 23

Intelligent control of technological processes 24

Remote Controlled Laboratories 29

From digital computers to quantum computers based on biological paradigms 32

Chapter 3. Toward Energy Efficient Systems using Smart Hybrid Storage Elements 37

Introduction of smart grids and electric or hybrid storage system 37

Electric Storage Systems – general aspects 38

Nanotechnologies the support of electric energy storage cells and systems 38

Supercapcitors versus batteries short overview 39

From taxonomy of the energy storage system to hybrid storage systems 43

Application and sizing of hybrid storage systems 46

Hybrid Electric Storage Systems Applications 47

Chapter 4. Education, teaching, coaching and training activities **53**

Educational activities 53

Coaching, training and tutoring of the young generations 54

(B-ii) The evolution and development plans for career development **56**

Generalities 56

Scientific research and technological roadmaps 57
Personal career development plans 62
Means to reach the proposed research and development objectives 65

(B-iii) Bibliography 66

Acknowledgements 71

List of Abbreviations:

a_{bike}	Acceleration of Electric Bicycle
ACM	Association for Computing Machinery
A_f	Frontal area of a biker
ADP	Acid Adenosine Diphosphate
ATP	Acid Adenosine Triphosphate
ARXIV	Papers' repository of Cornell University Data Base in Science
C	Capacity
c_d	Aerodynamic drag coefficient of the e-bike
c_r	Rolling friction coefficient of the e-bike
C_{SC}	Capacitance of a supercapacitor
C_{SCcell}	Capacitance of a supercapacitor cell
DAB	Automatic on Belt Dozing System
DBI	International Data Bases
DBLP	Computer Science Bibliography website of Trier University, Germany
DC	Direct Current
DUT	Device Under Test
EDLC	Electric Double Layer Capacitor
EESCAP'2015	5thEuropean Symposium on Supercapacitors 2015, Brasov Romania
EMvEM	Energy efficiency Management for Vehicles and Machines
ENEA	Italian National Agency for New Technologies, Energy and Sustainable Economic Development
ESR	Equivalent Series Resistance
ESR	Early Stage Researcher
ESS	Electric Storage System
EV	Electric Vehicle
FC	Fuel Cell
G	Gibss free energy
g	Gravitational acceleration
H	Entalpy
Δh	Variation of the elevation
HESS	Hybrid Electric Storage System
HMI	Human Machine Interface

I	Current
ICE	Internal Combustion Engine
IEEE	Institute of Electrical and Electronic Engineers
IFSTTAR	French Institute of Sciences and Technology for Transport, Development and Networks
IGBT	Insulated Gate Bipolar Transistor
IOE	Internet of Everything
IOSUD	Institution Organizing Doctoral Studies
ISI	Institute for Scientific Information a Thompson Reuters Company
IOT	Internet of Things
J	Momentul of Inertia
L-A	Lead-Acid Batteries
L-ATiO_2	Lead-Acid Titanatum Oxide
LEV	Light Electric Vehicle
$LiFePO_4$	Lithium Iron Phosphate batteris
Li-Ion	Batteries based on Lithium Ions
LLL	Long Life Learning
m	Mass
m_t	Total mass of the electric bicycle
m_{BT}	Number of battery cells in parallel connected
m_{SC}	Number of Supercapacitor cells in parallel connected
NASA	National Aeronautics and Space Administration
n_{BT}	Number of battery cells in series connected
n_{SC}	Number of Supercapacitor cells in series connected
NTUA	National Technical University Athens, Greece
NVH	Noise Vibration Harness
η_{EM}	Efficiency of the traction motor
OCV	Open Circuit Voltage
ω_{EM}	e-bike shaft rotation speed
P	Power
p	Pressure
PBE	Phase Berry Effect
P_{EM}	Power of the traction motor of the e-bike
PEM	Proton Exchahge Membrane

PEV	Personal Electric Vehicle
PV	Photovoltaic
R	Resistance
R&D	Research and Development
RES	Renewable Energy Source
R_{int_BTcell}	Series battery'cell internal resistance
R_{int_SCcell}	Series supercapacitor'cell internal resistance
R_{SC}	Series supercapacitor resistance
ρ_a	Density of the air
S	Entropy
SOC	Batteries State of Change
Siemens PSE	Siemens Program un Sistem Entwincklung Oestereich
SSC	Stacked Supercapacitor
T	temperature in Kelvin
T_{EM}	Torque of the traction motor
TEI	Technological Educational Institute of Western Greece, Patras
V	Volume
v_{bike}	speed of the e-bike
V_{Bat}	Voltage at the battery'terminals
$V_{OCBTcell}$	Open circuit voltage of the battery'cell
W	Mechanical work
W_C	Energy on a capacitor
W_k	Kinetic energy
U	Voltage
U_{BT}	Voltage of the battery
ZEB	Zero Energy Building

A. Rezumat

Teza de abilitare are drept obiectiv principal ilustrarea evoluției și preocupărilor ca cercetător și profesor a candidatului Prof. dr.ing. Paul Nicolae BORZA. Teza se bazează pe activitatea profesională, științifică și didactică a acestuia de mai bine de 35 de ani ca inginer electrotehnician în instituții remarcabile din Romania și străinătate, și anume: Întreprinderea de autocamioane Brașov în anii 1980-1982, Universitatea "Politehnica" București, perioada de doctorat 1990-1993, Universitatea Transilvania din Brașov din anul 1980 și până în prezent precum și în cadrul companiei Siemens Program and System Engineering, iar apoi în Siemens AG – Corporate Technology Group în perioada 2002-2009. Teza trece în revistă etapele evoluției candidatului, de la asistent la profesor, de la dezvoltarea unor aplicații în domeniile: mecanică, sisteme încapsulate, la dezvoltarea unor aplicații bazate pe mimetismul dintre biosisteme și sistemele tehnice de management energetic și cele de stocare a energiei. Sunt prezentate realizările candidatului în planul cercetării științifice din domeniul ingineriei electrice și electronice precum și felul în care acesta s-a implicat în pregătirea tinerilor ingineri sau a specialiștilor din domeniile mai sus menționate. A coordonat prin cotutelă un număr de 5 doctoranzi, 3 români și 2 străini. A înregistrat 3 brevete de invenție, dintre care unul este în faza de depozit legal. Sunt de evidențiat cele peste 35 de contracte de cercetare pe care acesta le-a coordonat sau în care a fost integrat, cele peste 40 de lucrări științifice publicate în jurnale sau proceedings-uri ale unor conferințe internaționale, din care 19 sunt ISI Proceedings. Indicele Hirsh este 6, cel i-10 este 3, fiind evidențiate un număr de 143 citări (iunie 2017, pe Google Scholar). A publicat singur sau în colaborare un număr de 3 capitole de carte în cadrul unor monografii apărute în edituri internaționale de prestigiu, și a fost co-editor al altor două monografii. Pe plan național a publicat în edituri recunoscute un număr de 9 capitole de carte, incluse în monografii stiințifice. A fost promotor activ al dezvoltării la nivel european al tehnologiei hibride de stocare a energiei și în calitate de vice-chair, a condus două proiecte COST și a organizat în anul 2015 Simpozionul European EESCAP 2015 dedicat supercapacitoarelor. A colaborat cu membri ai unor instituții precum INRETS/IFSTTAR (Universitatea din Poitiers Franța), Ikerlan IK4 (Spania), TEI și NTUA (Grecia), Universitatea Erasmus Rotterdam (Olanda), Universitatea liberă din Bruxelles (Belgia), Universitatea din Genova (Italia), Trondheim Institute of Technology (Norvegia), Universitatea Nouă din Lisabona (Portugalia), HassoPlatter Institute (Germania), National University of Ireland (Irlanda), fiind invitat fie în a susține cursuri pentru specialiști și tineri ingineri, fie pentru a colabora în domeniul cercetării științifice.

Evoluția prof. Borza poate fi rezumată în trei mari etape: i). etapa desăvârșirii sale ca cercetător, când a luat contact cu domeniul biologiei și a finalizat teza de doctorat la Universitatea

„Politehnica” Bucureşti; ii). etapa dezvoltării deprinderilor tehnice şi a cercetării în domeniul sistemelor electrice încapsulate, precum și a desăvârșirii pregătirii sale în domeniul tehnologiilor educaționale moderne; iii). etapa dezvoltări cunoașterii în domeniul sistemelor electrice și hibride de stocare a energiei și a aplicațiilor acestora.

Teza de abilitare ilustrează evoluția profesională a candidatului, respectiv sunt rezumate primele lucrări științifice care s-au referit la dezvoltări în domeniul instrumentației medicale, apoi numeroasele implementări folosind sisteme dedicate, dintre care se remarcă implementarea primului sistem de măsurare a serviciilor de sistem având drept beneficiar Hidroelectrica.

Urmează descrierea dezvoltării cunoașterii în domeniul sistemelor de stocare a energiei electrice cu un accent special pus pe sistemele electrice hibride de stocare compuse din baterii, supercondensatoare și celule de combustie. Împreună cu prof. Louis Francois Pau, este propusă o soluție pentru dezvoltarea sistemelor de procesare a informațiilor care își bazează funcționarea pe ultimele cuceriri științifice și tehnologice din domeniul fizicii cuantice, materiei condensate și nanotehnologiilor. Această direcție, considerată profund originală, poate determina o schimbare radicală în aproape toate activitățile umane într-un viitor mai îndepărtat.

În planul de dezvoltare a carierei, sunt propune noi implementări ale sistemelor electrice și electronice bazate pe mimetismul dintre sistemele biologice și cele tehnice. Autorul consideră cunoașterea și utilizarea paradigmelor biosistemelor ca una dintre cele mai prolifice căi de dezvoltare de noi sisteme tehnice originale și performante. Dezvoltarea metodologiilor de proiectare, dimensionare, de fiabilizare a sistemelor de stocare a energiei, modelarea, predicția evoluției acestora, precum și dezvoltarea funcțiunilor de control aferente lor, sunt toate domenii în care consideră că aspectele inovative vor fi în mare măsură rezultatul dezvoltărilor bazate pe mimetismul acestora cu sistemele vii.

Fuziunea informație-energie, ca țintă și totodată mijloc fundamental de transformare în sisteme “inteligente” a actualelor sisteme de management vor forma ținta cercetării viitoare a autorului tezei de abilitare în domeniul ingineriei electrice.

B) Scientific and professional achievements and the evolution and development plans for career development

(B-i) Scientific and professional achievements

Introduction

Why I applied?

I am applying for habilitation in order to have the opportunity to be deeper involved into the research and teaching activities. Also, taking into account my research, teaching and life experience, to plenary valorize in favor of young students and researchers my scientific and professional experience in the frame of doctoral studies programs in electrical engineering. My entire scientific career has been built on three pillars: research, teaching and management activities in higher education and high-tech industry. I am dedicated to the Academic activities since 1975, when as I became student in electrical engineering atTransilvania University of Brasov. During my studies, I active participated at all teaching and research activities. The competition and the deeply understanding of principles and sciences laws were represented for me an essential goal to achieve. I won during bachelor studies National Awards in Mechanics 1976, and I have two successive years participated in the frame of "Traian Lalescu" competitions organized in the domain of electrical engineering (1977-1978). Since 2000 I am professor, serving as both as educator and researcher. For eight years (2002-2009) I have in parallel with my academic career led, built-up, developed in the frame of Siemens PSE Romania, a group of researchers, named "Energy & Information Group" that were oriented to R&D activities in informatics applied in power networks and automations. In 2006, I were awarded with the VIP Siemens AG Austria prize and I become member of Siemens Corporate Group contributing at the re-evaluation of the electrical storage technologies in the frame of Siemens AG Corporation.

In case of successful habilitation, I intend to apply to become part of the IOSUD: Transilvania University of Brasov – Doctoral School in Electrical Engineering.

Which are my research fields of interest and how there have evolved during my career?

During my profession activity, I evolved from electrical engineering to bioengineering and embedded systems applied in various applications. In shortduring my career, I have touched the following domains:

- **electrical engineering;**
- **bioengineering;**
- **embedded systems and software dedicated for different applications;**
- **intelligent sensors;**
- **electric energy storage systems.**

My activities have been predominantly bent on applied research, and technological development. I have participated at implementation of a wide variety of research contracts both within the university as the framework, but also, within other kind of institutions, organizations or enterprises. All of these activities were the source for papers published, patents and other communication forms, and not at least, was formed the basis of teaching activities in university.

Briefly, from the point of publications my activity is illustrated by: 3 chapters of books and 2 books where I was editor published by international editions. I have published 9 book or chapters of books published by recognized national editors in the fields of embedded systems, medical instrumentation and electric storage systems. I have filled a number of 3 patents: one published in 1987 containing the core of my doctoral thesis respectively, the methodology and system for testing the influence of information on human body. I have filed one European basic patent having as owner Siemens AG Austria – finally deemed to be withdrawn in 2010 because I have leave Siemens AG, and one patent having as owner Transilvania University of Brasov, published and being in legal depot stage. I have published one paper in an ISI indexed Journal and other 21 papers that were published in the proceedings volume of IEEE and ACM publication that are indexed on Web of Knowledge as ISI Proceedings. My publications are completed with 22 paper that are BDI indexed (Scopus, Google Scholar, DBLP, ARXIV, NASA etc.). I have also published many other papers, I have several presentations in the frame of winter and summer schools, talks in international conferences, teaching materials and lessons in other international publication that are not indexed. An important activity was related to managing and leading of several COST projects. An important part of my activities was represented by research and technological development project contracted in the frame of Transilvania University, Siemens PSE and other companies. Thus, I have participated as director for 2 international research projects (one in FP7 frame EMVeM -315967/2012 and another one as member in VEGA FP6 15565/2005 project). I was involved as researcher in other three international projects Leonardo da Vinci and Minerva. During

my career, I was involved as director in three national projects. One of these is in running phase and it is dedicated for research and development of an alignment system of an interaction chamber in a very high intensity gamma beam. This project is part of European ELI program. I have participated as collaborator in other 11 projects. During my activities in Siemens PSE I have an active contribution at the development of FENIX project FP6 - 5182672/2006 and also, I have developed on commercial basis the first European ancillary services metering system for Hidroelectrica Romania in collaboration with ECRO and Siemens Metering (Landis & Gyr) Switzerland. As result of my collaboration with ACIT SRL Romania, I have coordinated the technological development and retrofit of a cement line at CIMUS Campulung Arges where together with other four collaborators we have completely rebuilt the automation cement line. At ELCO Targu Secuiesc I have developed a dozing system for Kaolin and at Enterprise Scule Rasnov I have developed a full automatic line for thermal treatment of steel tools. Other several contracts I have led and developed within the National Institute for Potatoes Culture Brasov – Stupini and the Research Potatoes Station Targu Secuiesc. During the collaboration with these customers I have designed a mobile monitoring system for agriculture, respectively the system named: "Solanum Test" a mobile phyto-climate signal acquisition system (1983) and two measurement installation for starch content of potatoes (1989, 1993).

During my career evolution, my activities have suffered changes as result of my evolution as researcher and teacher but also as result of my different affiliation at departments and working groups inside university. As my curriculum vitae illustrates, the achievement of my academic studies was concretized with a diploma thesis entitles: "Design of a series of starting electric DC series motors dedicated of internal combustion engines in 4-6.5 HP". The thesis was applied at the development of two types of machines one for Romanian trucks and another one for Romanian tractors produced in the years 1980 in Romania.

During my career evolution (described in CV) I have known three major stages:

1. First period was represented by plenary development of engineering and teaching skills (1980 – 1997) in conjunction with discovery of the exceptional important domain of bioengineering. The first years I have dedicated mainly for development of bioengineering, the full of exceptional important paradigms surging from living systems in close collaboration with mechanics department of Transilvania University and Politehnica University Bucharest. Afterward, I have plenary developed the research activities oriented to medical instrumentation, and embedded systems.

2. The second period (1998- 2002) was dedicated to teaching, research and development of embedded systems, architecture of computers and automation. During this second period, I have progressed in the field of development of modern learning systems (remote and blended learning methodologies) and also in the field of implementation of major projects like full retrofitting of the old fashion automation systemsof a cement production lime with a complete customized new automation systems using embedded components and developed by my working team at CIMUS Cement Factory Campulung, Arges. Also, I have developed a new energy efficient automation systems for thermal treatment of mechanical tools at Rasnov Tools Factory, and an automatic dozing and control of moisture system for the raw materials (kaolin mainly) used for production of electric insulators at ELCO Targu Secuiesc. All these projects were permit me to reach a higher level of practical skills in electrical and electronic engineering in parallel with my academic formation.
3. In the period 2003- 2017 I was mainly involved in research and technological development activities oriented to electric storage systems and their applications for industry, power transmission & distribution networks and electric mobility. For eight years (2002-2009), in close collaboration with Siemens PSE and afterward with Siemens AG, I have contributed at development of research activities in fields of power transmission and distribution control using intelligent embedded systems and in plenary development of “smart” solutions that include hybrid and electric storage components. These activities were represented a harmonic achievement in the field of electrical engineering and embedded systems.

During all my professional evolution, I have felt the necessity to achieving my research and engineering’s working activities by building-up practical systems, many of these with clear original components and using novel methodologies. In majority of cases these systems still in use at the different industrial customers as living proofs. The teaching, coaching and transmitting of engineering knowledge for my students was signified an essential mode of life for me.

Chapter 1. Bioengineering - Pathway for development of optimized and validated technical systems

The living systems can be used as collection of ideal paradigms for all engineers, especially in the fields of electric engineering, science of materials and computers, because these living systems are resilient, ultra-stable and offer reliable and energy and functional efficient solutions. An important aspect is related on already validate examples, validated by the life itself. The bionic approach can represent a prolific way to go deeper in science and new technologies in the domain of electrical engineering. The variety of the living implementation, the extremely large example data bases that include biologic structures, individual living entities but also population of living entities, each of these, observed and well understand can be used by using mimetic methodologies to be applied in technical world. These were one of my first ideas that I have tried to following in my research. Thus, I have started by analyzing the conceptual differences between energy and information in case of living systems, by developing a methodology and a technical system able to discriminate between information transmitted to a living entity and how this have reacted at information. In my doctoral thesis and also in the patent[1] developed together with my collaborators from medicine[2], biology and chemistry we have developed an original methodology and technical system that were used for exciting but also for identifying the reactivity of living systems at quantity of information transmitted by the system. The experimental data proof the influence of bellow stress level of information transmitted to groups of mice's in them overall pathology and also, we have demonstrated that such level of information flows affect the 17th cetosteroides concertation in their blood, respectively an increasing of neural activity function of different information threshold.

The continuation of my investigation was done in the field of sport medicine where I have tackle two important aspects: *biofeedback methodology* applied for the sportsmen's in shooting disciplines and also in *building up experimental platform for training by biofeedback* of biped equilibrium of athletes.

The system allows us to improve significantly in years 1983-1985 the performances obtained by national team of trained sportsmen[3]. A second experimental system designed and built-up were an ergometric bicycle endowed with sensors for speed, torque, mechanical work, and duration of the effort. The system included also an electronic feedback loop control system

[1]A. Restian, **Borza P**., Daghie V.,Nicolau N., Patent „Metodă şi aparat de solicitare informaţională a organismelor vii", Brevet RO93122 OSIM 1987

[2]A Restian, "Medicina Cibernetica", Editura Dacia Cluj, 1983

[3]Borza P N, Demeter A, Instalatie pentru studiul stabilitatii punctului de ochire la tir, pg. 74-79, COMEFIN2 vol II Aparate Optice, Institutul Politehnic Bucuresti & ICSITMFS Bucuresti, 1986

able to preset and maintain constant the different resistant load for the sportmen during testing his performances (anaerobic and aerobics effort)[4].

The most important achievement is related to understanding of the energetic mechanisms that assures the necessary energy.

Energy generation in living systems - paradigm for hybrid storage systems

Thus, three fuels are used by our body in order to produce energy. The first and fastest fuel burn is ATP (acid adenosine triphosphate) normally stored in each living cell as mandatory energetic reserve that assures the preservation of cell's life. When a cell is excited and the excitation overpass the sensitivity thresholdthis will react by apparition of acting potential.

This potential is resulted as consequence of ATP oxidation and this amount of energy (30.5 kJ/link oxidized) is used for producing the acting potential. The energy resulted is:

$ATP + H_2O \rightarrow ADP + Phosphate - \Delta 30.5 KJ/mol$

(anaerobic energy generation)

Thus, for example, in case of running sportsmen at the 100 m competitions, the cellular ATP reserve will be oxidized without other oxygen molecule carried by blood (anaerobic oxidation). This energetic reserve is limited and individual cell specific and can't provide energy for more than 10÷12s. If the demand for energy continues a secondary chemical cellular reserve will be activated. This is ADP (acid adenosine diphosphate). As difference to ATP oxidation, ADP will consume the cellular oxygen reserves in order to provide energy.

This resource can assure the necessary energy for running 400m competitions, respectively less than 1÷2 minutes. The equation describing ADP generation is:

$glucose + 6\ O_2 + 30\ ADP + 30\ P \rightarrow 6\ CO_2 + 30\ ATP + 36\ H_2O$

(aerobic energy generation)

If the energy demand will be longer as this time, other biochemical mechanisms will be activated. These are described by Krebs cycle. The full cycles of glycogen oxidation, normally stored into the liver[5] is described in **Figure1**.

The main achievement resulted from these projects consisted in the deep understanding of biological mechanisms that assures the generation of energy based on stored reserves in living organisms. In the same time, this analysis reveals how the structural design, respectively the size of cell's energetic reserves and the chemical density of energy are adapted by the living systems

[4]Borza P N, Achim I, Bicicleta ergometrica cu compex de testare a capacitatii de efort la sportivi, pg-208-209, COMEFIN2 vol II Aparate Optice, Institutul Politehnic Bucuresti & ICSITMFS Bucuresti, 1986

5Eric P. Widmaier, Hershel Raff, Kevin T. Strang "Human Physiology The Mechanism of Body Function " 9th Edition

in order to provide a “flat response in time” at the energetic demands. Not only the specific time constant properties of energetic reserves are important for the living systems, but also the specific ratio between these “fuels” reserves in each cell.

Distribution in space of the energy storage elements (cellular distribution)

An important aspect is related to the spatial distribution of energetic reserves inside the organism, and how the transportation phenomena related the biologic fuels are produced inside the organism (the blood and circulatory system role in nutrition), the liver role as central storage element. All these issues can be considered as validated paradigms and applied for the control of power flows and necessary energetic reserves for different electric power systems. Thus, the ATP present in each cell will assures the short-term energy necessary for rest potential and also for acting potential in a short time windows. By oxidation of ADP new energetic APT reeserves will be generating, this situation will happen for medium-term. For long-term, the transport mechanisms between liver and the body cells will enter in function, assuring the regeneration of specific energy cells reserves.

This architecture illustrated by the distribution of energy storage elements will generate a minimized of the power excursion in case of effort provided.

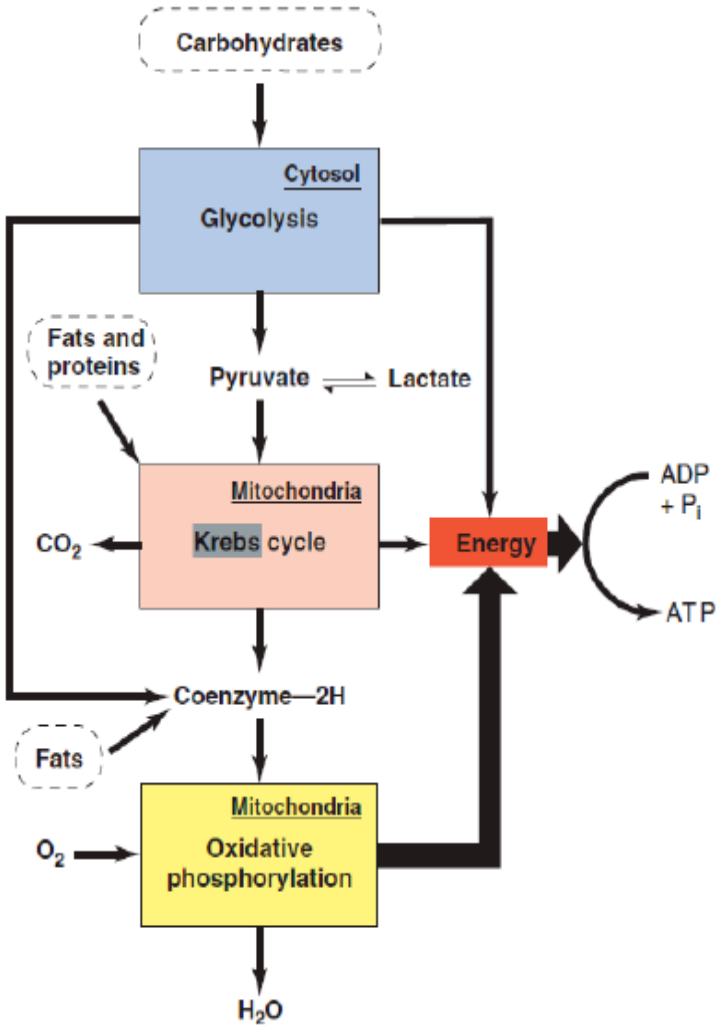

Figure1.Krebs Cycle – glycolysis, pyruvate + lactate, oxidative phosphorylation sees: Eric P. Widmaier, Hershel Raff, Kevin T. Strang "Human Physiology The Mechanism of Body Function " 9th Ed

The living systems present intricate feedback and feed-before loops mechanisms that offer a very complex reactivity of living organisms at the environmental and internal excitation signals. This architecture was described as cybernetic system.

Programmability of the living organisms is reflected by existence of many predefined reaction mechanisms that are triggered by specific situations.

Many of these programs are related to the preservation of living organism integrity, and other are dedicate to the triggering of successive functions organized as reaction strategies. Especially in the last twenty years, the biologists have understood and reveal such mechanisms.

The lessons learned from biology and physiology indicate several typical features of the bio-systems. From structural point of view the organization of the element is cellular, distributed, intricated and whith a high degree or redundance. Have implemented specific functions relative to the element or signal processed, presents a high degree of intricate functions that are hierarchical organized. The redundancy degree is very high and adequate to the complexity of the element' or system' stages. The functions are not only specific for a type of action, but are in the same time able to assure compensation actions. In majority cases, the system reactivity is illustrated by activation of a matrix of functions applied on a matrix of interrelated elements, in which case the functions'weighting influence will be changed during their activation time. Also, the bio-systems are able to triggering, function of actual of the forecasted stage the activation of a series of

successive functions, each with specific duration, illustrating in fact, the programability feature of the bio-systems.

All of these paradigms can, or must be aplied in case of development by mimicity of the technical solution for some complex systems and teir applications. Partially, the applications bellow presented respect this characteristic.

Programmability and dynamic energy budget mechanisms of living organisms

An essential step made forward is related to the studies developed by S.A.L.M. Kooijman in his famous works[6], Dynamic Energy Budget Theory for metabolic organization. The main aspects that are very important also for the power networks, for electric mobile vehicles and also for other autonomous mobile systems is related to the description of metabolic paradigms related individual living organisms and for group of organisms too. As is shown in **Figure 2,** the principal energetic reserves are used for somatic work (current consumption), for structural system development (growing) and for self-reproduction (multiplication of organism). X represents the food ingested, P is defecation (garbage dispersion) and A represents the assimilation process (accumulation of matter and energy). By a simple similitude, our electrical systems can follow a similar model (biomimetic design strategy) in their "life" and the matter (energy sources or power lines), energy reserves (electrical and other type of storage elements with their capacitance), and the electrical sinks (seen as gametes) (different energetic and information exchange between system elements temporally organized) can support similar models. In this way, two aspects can be reproduced in technical systems: the structural and architectural paradigms borrowed from living system and the functionalities as set them self optimized functions and also organized as streams of functions –sequenced activated functions or programs, living in correlation with the adequate structures and system's elements. More that, the living organism schedulers (strategies) can bring specific function based on look up tables and paradigms for restoration of energetic reserves, and also for how to spend the existing reserves too.

6S.A.L.M. Kooijman, Dynamic Energy Budget theory for metabolic organisation, Cambridge University Press 2009, Third Edition, ISBN 0 521 45223 6

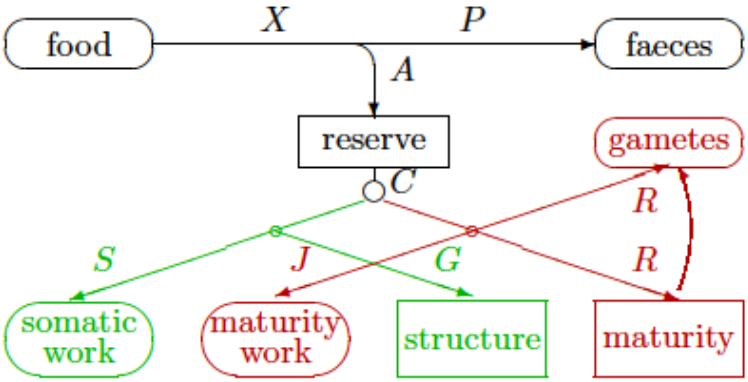

Figure 2. Energy flows in standard DEB model (after SALM Koijman Dynamic Energy Budget model in time length and energy pp 24); energy flows: S somatic development resources; A assimilation and G growing processes reflected by improvement of system's structure; J maintenance maturity; R reproduction process.

Especially, in case of mobile, energetic insulated systems, the type of energetic reserves, how this are spent and the strategies as adopted function of different behavioral conditions, relative thresholds, functions activated in direct correlation with the level of different energetic reserves. The variety of such functions reflects also compatible sacrifices related to supplying or exchanging of energy that can be reproduced also in technical implementations. By analyzing the group strategies (species behavior) and also starvation stages, all of those will determine the adoption of the compensation phenomena and will be revealed by triggering of the new control strategies. Similar phenomena can be implementing and managing in case of technical systems especially by hybridization and dynamic exchange of energy sources at different time moments during achievement of transport missions for electric vehicles. In case of biosystems the main parameters that are considered are related to the weight, length and mass of organisms that determine the feeding, metabolic processes and/or the catabolic processes.

Thus, the state variables are considered: maturity energy, reserve energy density and structural volume[7] growing of mass function of energetic content of food is considered in the equilibrium equation. By analogy, the electric energy reserves of electric vehicles can be considered as a mild or severe starvation process occurred in case of living organisms.

A very interesting analogy can be done by analyzing the energy necessary for muscles to provide mechanical work[8] and the three different storage elements that together can be used to

[7]S.A.L.M. Kooijman, Dynamic Energy Budget theory for metabolic organisation, Cambridge University Press 2009, Third Edition, ISBN 0 521 45223 6

[8] Brooks, G. A., Fahey, T. D., White, T. P., Exercise physiology: human bioenergetics and its applications, ISBN 1-55934-365-6 Myfield 1995

provide energy in case of electric vehicles: supercapacitors, batteries and fuel cells[9]. In this sense is interesting to illustrate the different time constants in both cases **(Figure 3**, and Figure **4**).

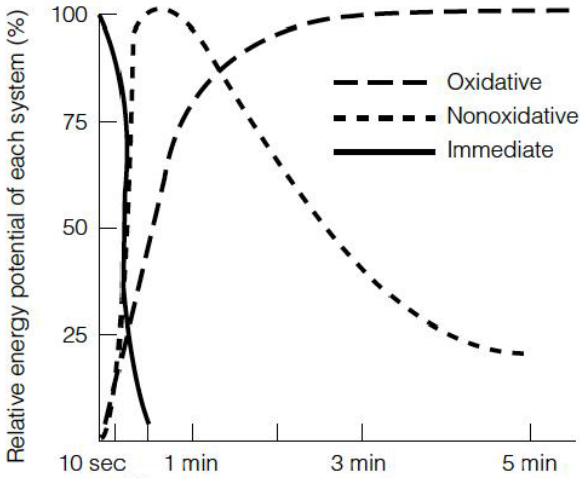

Figure 3. Energy sources for muscle as a function of activity duration

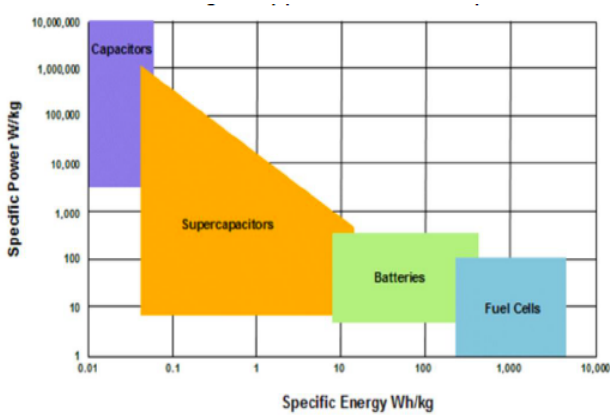

Figure 4. Ragone Diagram[10]

Bio systems illustrate the intimate relation established between the structure of the system and the generation of potential functionality.

Two types of functionalities can be revealed: Homeostasis[11] and Allostasis[12]. Every living being in this world has its own system which could be perceived as the inspiration of the next era of technology. Comparison of two alternative models of physiological regulation for the inspiration of electrical energy storage advancement is a way to design and build-up new models for the smart grid and intelligent transportation systems too. The first model corresponds to homeostasis ("stability through constancy"), which has dominated physiology and medicine since Claude Bernard declared, "All the vital mechanisms... have only one object – to preserve constant the conditions of ... the internal environment". Allostatis ("stability through change") reflects virtually the opposite view. It suggests that the goal of regulation is not constancy, but rather, *fitness under natural selection*. Fitness constrains, regulation to be efficient, that implies preventing errors and minimizing costs by the controlled system. Even if these two phenomena are common for biologists, however their paradigms may constitute the essential key phenomenons for the design of the technical systems.

[9]**PN Borza**, I. Prasad, S. Sanchez-Mateo, M. Kadar, A Biological Approach for Energy Management in Smart Grid and Hybrid Energy Storage Systems, pp 821-829, International Journal of Scientific & Engineering Research, Volume 7, Issue 3, March-2016, ISSN 2229-5518

[10] D. Ragone, Review of Battery Systems for Electrically PoweredVehicles, Society of Automotive Engineers, (1968)

[11]Bernard C., An Introduction to the Study of Experimental Medicine, Dower Pub. Inc, New York, 1957 –first published in 1857

[12]Sterling, P. (2004). Principles of allostasis: optimal design, predictive regulation, pathophysiology, and rational therapeutics. Allostasis, 1– 36. doi:citeulike-article-id:2392029

Another aspect very important is related to the organization of structural and functional redundancies of the systems that is extremely important for obtaining optimized performances for living organisms. The *hybrid* nature of the systems elements *improves its reliability and availability*. Also, the control loop functions specialization on variety of signals (information flow) and source of the signals are essential. The feed-before loops will prevent the apparition of some simultaneously worst, dangerous stages that can generate system's instabilities. The significant complexity of storage systems behavior obliges the designer to look around classical methodologies and outside electric domain in order to prevent premature aging of the storage devices and also to keep the implementation price low as possible. Among several works illustrating the analogies and methodologies resulted from the biologic system, it is remarkable which presents the pathway for innovation of technical systems inspired by biological systems and their paradigms. A methodology based on biological system mimicry is applied to the technical systems.

Technical system design based on biomimetic methodologies

An application where we have applied the above-mentioned principles was presented at CISTEM 2016 in Morocco[13].The problem solved, illustrates from form a side, the importance of structural design in order to assures a highly stability and reliability by combining two kind of storage elements: batteries and supercapacitors, and from the other side the role played by controlling functions. These functions are based on feedback combined with feed before control in order to achieve a maximum energetic efficiency and in the same time to respect the Artemis[14] standard urban cycles specific. The design process starts from the assessment of the load variety during the urban cycle, finding the appropriate ratio between the fast and medium-time energy release elements (batteries, respectively, supercapacitors). The thermal behavior was also taken into account when the batteries and supercapacitors were sized. The application chosen was an e-bicycle endowed with a hybrid storage system where the dimensioning of the storage subsystem satisfied the constraints of reliability for the whole lifetime bike, and with a supplementary condition that oblige a minimum of 60km daily range. In the block diagram is shown in Figure 5. The DC/DC converters play different roles: first, to assure the stationary regime of the e-bike by supplying or sinking energy from/to battery system. The second DC/DC converter is programmed

[13]Prasad I., **Borza P.N.,** Herrera V.I., Milo A., Energy Management of Hybrid Energy Storage System for e-bike application, CISTEM 2016 –IEEE Conference, Marrakesh, Marocco.

[14] Andre M. et all, The Artemis European tools for estimating the transport pollutant emissions, seen on Internet https://www3.epa.gov/ttnchie1/conference/ei18/session6/andre.pdf, July 2017

to provide or sink the necessary power function of dynamic demands and, assures a realiable implementation of the hybrid storage system avoiding its heating. In case of DC/DC that link the two different storage packs (batteries and supercapacitos), the converter will permit the implementation of load forecasting based algorithms which allow a feedbefore implementation based on programmed route analysis. The e-bike supervisor will decide about the route function based on the on-line traffic monitoring and also function of different possible routes that can be adopted.

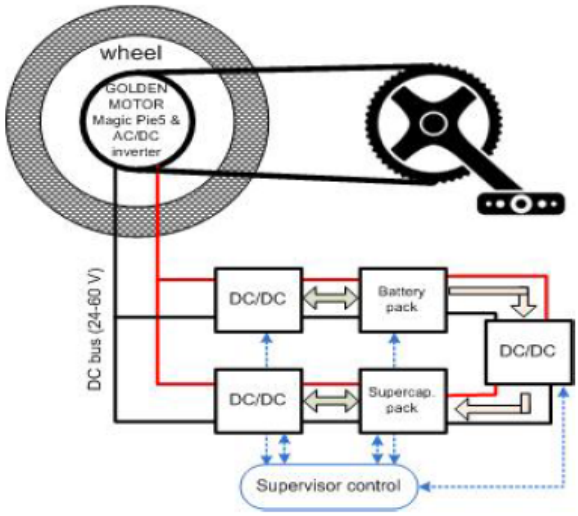

Figure 5.e-bike Block diagram, details related the hybrid storage system implementation

where m_t is the total inertia mass of e-bike the bicyclist, a_{bike} is the acceleration of the bike, c_r is the rolling friction coefficient, g gravitational constant, ρ_a the density of the air, A_f is the frontal area, c_d is the aerodynamic drag coefficient and v_{bike} is the e-bike speed. Using the motor characteristic map and putting in evidence the its two different regimes: motor and recuperative braking generator the P provided/sink are respectively:

$$P_{EM} = \omega_{EM}(k) \cdot T_{EM}(k) \cdot \frac{1}{\eta_{EM}}(\omega_{EM}(k), T_{EM}(k)) \text{ [motor]}$$

and in generator regime:

$$P_{EM} = \omega_{EM}(k) \cdot T_{EM}(k) \cdot \eta_{EM}(\omega_{EM}(k), T_{EM}(k)) \text{ [generator]}$$

where: ω_{EM} and T_{EM} are the rotation speed of the wheel and the torque on the main shaft.

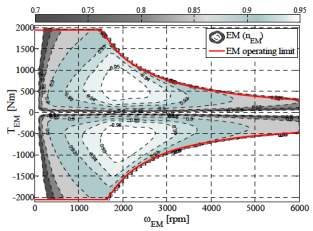

Figure 6. Electric machine characteristics (KAF source of characteristics)

The battery model and the supercapacitor (**Figure 7**) models where chosen in accordance with the desired precision for determination of the system control parameters.

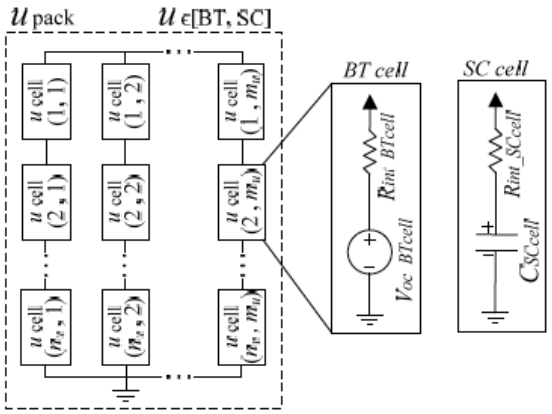

Figure 7. Models for battery and Supercapacitor

Equations for battery and supercapacitor models:

$$U_{BT} = V_{oc_{BTcell}}(SOC_{BTcell}) \cdot n_{BT}\ [V]$$

$$R_{BT} = n_{BT} \cdot R_{int\_BTcell}/m_{BT}\ [\Omega]$$

[Battery model]

$$C_{SC} = m_{SC} \cdot C_{SCcell}/n_{SC}\ [F]$$

$$R_{SC} = n_{SC} \cdot R_{int\_SCcell}/m_{SC}\ [\Omega]$$

[Supercapacitor model]

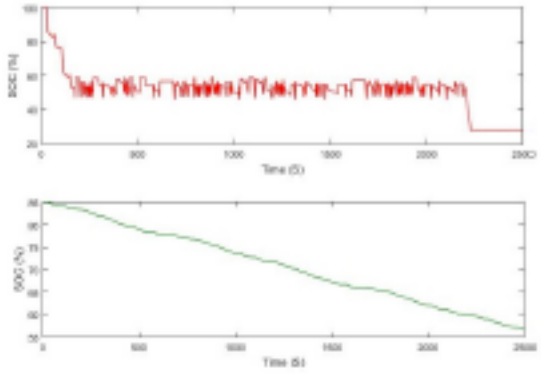

Fig.11: Battery and Supercapacitor SOC profiles (Artemis Dense)

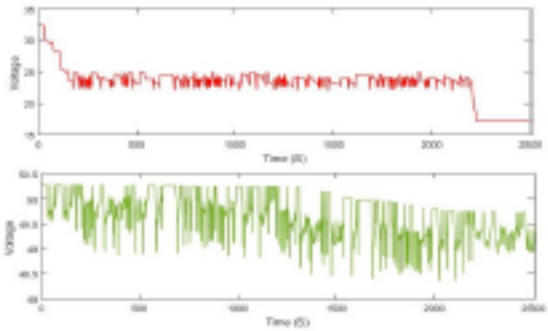

Fig.12: Battery and Supercapacitor voltage (Artemis Dense)

Figure 8. Artemis dense cycles battery's SOC and energy stored on supercapacitor (Hybrid Electric Energy Storage System)

Using a customized scheduler for storing/releasing the power to/from hybrid storage system the simulation of the whole system illustrates a significant improvement of the reliability and life span of the e-bike energy source in case of load demands corresponding to Artemis dense cycles (urban case) as is shown in Figure 8.

The hybrid energy storage system brings more flexibility, reliability and availability to the e-bike. It also increases the e-bike range. The life span of the storage system is also increasing significantly.

The combination of batteries and supercapacitors allow the better harnessing of the energy onboard the e-bike. On one hand, absorbing the power peak in the regenerative braking phase and injecting the peak power during the acceleration phase. On the other hand, the storage system allows supplying the energy to propel the e-bike during most of the operating range. Thus, the development using mimicking methodology illustrates the optimized performances brought by bio-inspired adopted methodology.

Chapter 2. Energy and Informatics – The basis for development of the smart systems

Informational integration of measurement data

Since 1981 I have started the development of embedded applications using many varieties of microprocessors and microcontroller. My evolution in this sense was synchronous with the technological evolution in the field of programmable digital devices. The families of the processors from 8 to 32 bits I have used in application implementations. In the first period, I have interconnected different laboratory or medical devices to the computers, in order to improve their functionalities and performances. Thus, I have implemented the hardware and software interfaces of SPECORD M40 and M80 spectrophotometers[15]in order to connect Carl Zeiss Jena optical instruments to the computers by serial interfaces. The interfaces created, based on Z80 family devices, allowed the transfer of data acquired to computers (Romanian microcomputers) and also the processing, storing and integrating of the data acquired to the common data bases used in laboratories. The project has permitted the development of the standard communication, based on m-bus standard protocol, and also, the implementation of a data base that was exploited by a program able to store, recognize and process the spectrum of samples (majority liquid) used in clinical laboratory and in bio-technological industry.

The first applications implemented allowed to develop a hierarchical concept of laboratory apparatus that are interconnected in order to create an integrated environment able to collect, store and process correlated data from a large set of analysis[16].

Achievments obtained consists in implementation of communication protocols on wire based buses between different kind of instruments and the computers. Also, the management of measured data was developed, by automatic correlation, during analysis process, between the samples and their patiens names or identifiers.

A second area of applications was related to the agriculture, especially for potatoes culture. Using MADS system (Z80 modular embedded system, produced by Microelectronica Bucharest) I have developed on a Junior computer, a complex phyto-climate data acquisition system named "Solanum Test"[17] which were beign mounted on a mobile platform and that were being able to collect data about, temperature, humidity (psychrometric methodology), solar radiation, growing

[15]Dumitriu A, **Borza P,** Marin I, Solutii pentru cuplarea spectrofotometrelor la calculatoare externe, pg88-91, COMEFIN2 vol II Aparate Optice, Institutul Politehnic Bucuresti & ICSITMFS Bucuresti, 1986

[16]**Borza P N,** Matlac I, Principii ale implementarii tehnicii de calcul in aparatura de laborator, pg.210-214, COMEFIN2 vol II Aparate Optice, Institutul Politehnic Bucuresti & ICSITMFS Bucuresti, 1986

[17]Cercetarea, experimentarea şi echiparea laboratorului mobil cu sistemul de achiziţie şi prelucrare automată a datelor de fitoclimat din cultura cartofului (153-1986), director Borza P.N., valoare 500.000 ROL, ICPC Brasov

of plants by using the determination of plant's sap' speed. The system implemented was used several years on the different production fields of National Institute of Potatoes for improving the agricultural technologies at the different environmental culture conditions. The system developed, has managed around twenty sensors that were connected to the data acquisition central point. The energy management and the power supply necessary for the mobile laboratory were also done. The system was included a lead-acid battery based power supply with DC to AC inverter necessary for energizing the Junior computer. The autonomy of the system was better as 2 days.

Also at IPCP Brasov and at Research and Production Station Targu Secuiesc I have developed two measurement systems for starch concentration in potatoes, based on relative potatoes'density determination. The project was consisted in implementation of a finite state machine systems and a precision weight measurement system that allowed the automatic successive measurements of potatoes weight in air and water and calculus based on look up tables of the potatoes'starch content[18].

Intelligent control of technological processes

In a series of contracts with CIMUS SA I have led the retrofit all the old fashion automated dozing systems for a cement production line (raw materials and cement). Thus, the system has included the modified DAB101 dozing systems on belt for each raw material that must be dozed. Also on this system was developed an original electronic ear able to acquire the noise made by the raw materials mill and a Xray spectrophotometer. All the intsllation components (see Figure 9) were linked using RS485 communication lines. The system function based on periodical sampling the raw material composition. Using a pneumatic carrier system, each raw material samples were transmitted to a X ray spectrometer for determination of it's chemical composition. The measured data wereautomatically transmitted to the supervisor system. The supervisor system recalculates for each sampling period the new recipe that is transmitted to DAB systems as settled values for each raw material on the belt dozing system in order to re-correlates in real-time the raw material flows. During grinding process, the artificial ear acquires the noise produced by the mill. This, based on a prior calibrated characteristic and taking into account the aging of grinding balls, provides to the supervisor the information about the levels of materials inside the mill.

Correlating the whole data: from X-ray analyzer, from artificial ear, from the DAB systems the supervisor, and also in accordance with the technological recipes, the supervisor commands in real-time the presets values for each belt dozing system.

[18] Cercetarea, experimentarea şi realizarea unei instalaţii de determinare automată a conţinutului de amidon din cartof (147-1987), director Borza P.N., valoare 350.000, ICPC Brasov

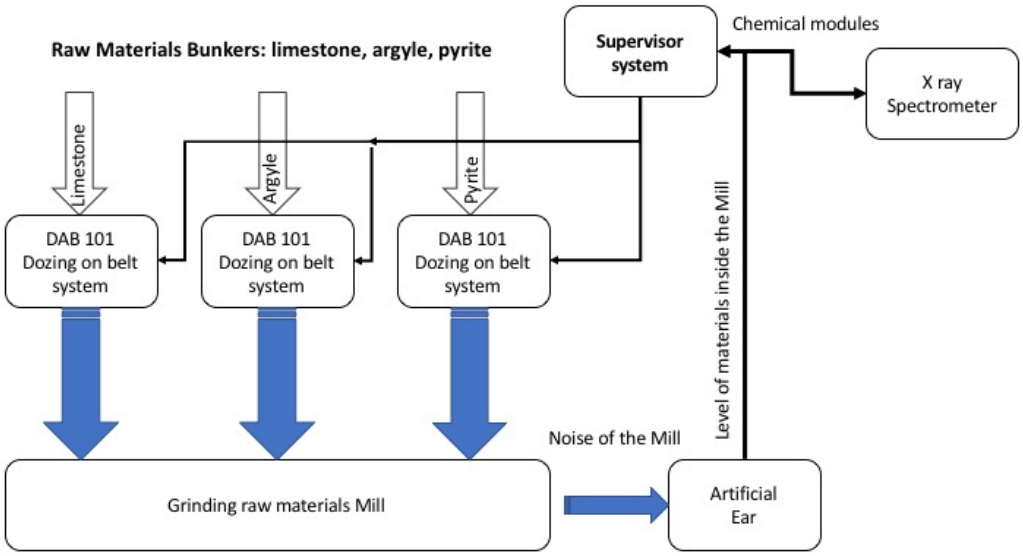

Figure 9. Block diagram of grinding of raw materials Mill

Using fast Fourier transform (version Cooley Tukey), the power spectrum of the grinding machine noise where used for calculating the level of raw materials inside the mill and also the shifting of frequency as result of mill's balls aiging. By an empirical methodology in chosing of the number of the Fourier transform coeficients, the real level of materials inside the mill was calculated. Some achievements can be emphasized: the development of an original, artificial ear for raw material level determination inside cement raw materials mill, based on analysis of the mill noise. Using the artificial intelligence principles (support vector machine), the raw materials flow inside cement mill was closely (less that 2% error) in real time, controlled. That have assured a significantly improvement of the energy efficiency of for the whole grinding and dozing process.

Using this system, in conjunction with the supervised DAB101 hierarchical control, the whole grinding line was optimized. Thus, the three-main dozing systems DAB101 were updated. The designed embedded system for supervising the grinding process was connected by a RS485 interface to a X ray spectrophotometer. The hardware elements based on Z80 controllers allowed the real-time control of the ratio between limestone, argyle and pyrite raw material during grinding process[19]. The main result of this modernization was considered in perfect homogenization of raw materials composition for principal modules of cement fabrication: silica, magnesium, aluminum and iron. A second important factor was represented by the improvement of the control of the raw materials level inside the grinding mil with important savings of energy for the production of the cement. The most important energy saving resulted as implemnentation of the new system for the

[19]**Borza PN** Director proiect - Cercetarea, proiectarea şi execuţia sistemului de urmărire a încărcării morii de făină şi integrarea acestuia în sistemul de supervizare a dozării materiilor prime pentru o linie de fabricaţie in industria cimentului (106-1994)

cement line modernization, was consisted in completely elimination of a production stage of cement technological process, generating very important energy savings (5x55kWhx8h/day net savings)[20].

Continuing the works at CIMUS Factory, the dozing system for the principal cement calcination line furnance was supervised by correlating the temperature gradient along the cement rotative oven with the supervised feeding system for the natural gas provided for oven's burner. Using a laser IR scanner, the temperature field on external wall iluustrate two aspects: first where is starting of the process of calcination; the second element that was revealed is related to any defects in the rotating furnance jacket. The position of maximum temperature values along funrnance was represented the leading signal for controlling of the fuel injection into the furnance burner. By this automation the whole energetically efficiency of the calcination process was significantly improved.

The last stage on cement fabrication line was also modernized. This modernization was consisted in supervising and managing of energy applied for the grinding process. These processes have supposed to closely control the mixing of the clinker materials with the adding on of crystalline shales in order to produce different cement qualities.

A series of original elements were included into the design of the original embedded automation systems, like: development of grinding noise analysis based on Fourier transform methodology in correlation with the modelling of mill's balls shape variation and their aging during the grinding process. The real-time control of the weight of cement grain baed on a combined methodology consisting in measurement and correlation of weight cement grains and centrifuge force appeared on the mill tray has permitted to obtain a very precise cement recipe. The development of a series of empirical correction coefficients applied for better adaptation of the time constants along the cement manufacturing process. Development of an original supervising system for management of energy based on detection of the real-time load of the mill motor and correlation of it with the dozing of powders on the cement mill.

As result of confidentiality agreement, I haven't had the possibility to published the results related these contracts implementations.

Another contract consisting in a dozing system was developed in close cooperation with FESTO Co. at ELCO Targu Secuiesc. In this case, I have designed, implemented, and testing the dozing on manufacturing line of the kaolin powder with different mixedliquids used for production

[20] Cercetarea, proiectarea şi execuţia sistemului de urmărire a încărcării morii de făină şi integrarea acestuia în sistemul de supervizare a dozării materiilor prime pentru o linie de fabricaţie cu posibilitatea de extindere la trei linii în industria cimentului (106-1994), director Borza P.N., valoare 13.000.000 ROL CIMUS SA Campulung Arges

of the new electric insulators. The system designed have allowed the exceptional precise measurement and dosing of two components: kaolin and barbotine respecting of very strict humidity of the mixed raw material. The developed system was based on usage of Philips 80C552 processor and high-resolution analog to digital converter for acquisition of weight signal from installation mixer[21]. The problems of Electromagnetic field compatibility in condition of a very high resolution of measurements made from this implementation a very useful and performant application.

At Tools Factory Rasnov, I have led the project for retrofit of thermal treatment of steel tools using molded salt solutions. The implementation consisted in supervising of three thermal owns: two in air and, the third one using molded salt solutions. Also, the power electronics necessary to closely control the temperature and his gradient in time for the treatment of steel tools were developed. In this sense, the system implemented assured a very precise thermal treatment diagram using supervised power electronics inverters having 150kW/ power/furnace. The implementation of the inverterswas used SCRs and their corresponding control circuitries necessary to assure the close control of the power flow.

Taking into account the variate and the number of implementations using embedded systems, in order to standardize the design of these systems I have supervised the development of a versatile and cheap solution able to implement the programmable digital control systems[22]. This system was based on the cheap ATmega128 microcontroller and around it analog to digital converter, programming interface, and serial RS232 and RS485 interfaces was implemented. Using this embedded solution, several new implementations like: remote monitoring of the vital signs of patients[23,24], dozing systems, monitoring and management of energy for remote supervising of hydro-aggregates in hydro-electrical power plants were implemented. Thus, the new design was efficient used for boosting the new solutions based on standard embedded components.

---

[21]**Borza P.N**, director proiecte - Proiectarea, realizarea, testarea unui sistem de dozare automată a materiilor prime utilizate la fabricarea pastei ceramice pentru izolatorii de joasă şi medie tensiune la EL-CO SA Tg. Secuiesc. Precizia de dozare 0,05%. Valoare 1.900.000 ROL, beneficiar EL-CO Tg Secuiesc

[22]M.C. Carp, **Borza P. N.,** Puscas A.M., Smart Development Platform For Embedded Systems, pag 217-222, , Conference Proceedings ISSN 1843-5122, International Symposium for Design and Technology of Electronic Packages 14th Edition, Brasov, Romania 2008

[23]A. Stavăr, **Borza P.N**., Carp M.C., Puşcaş A.M., Pulse oximetry, a method of monitoring heart disease patients, pag. 232-237, Conference Proceedings ISSN 1843-5122, International Symposium for Design and Technology of Electronic Packages 14th Edition, Brasov, Romania 2008

[24]A. M. Puscas, **Borza P.N**., Carp M, Pana Ghe. Energy Efficient ECG Signal Acquisition Channel for Ambulatory Patient's Monitoring, pag.212-217, Conference Proceedings ISSN 1843-5122, International Symposium for Design and Technology of Electronic Packages 14th Edition, Brasov, Romania 2008

One of the most interesting applications was the development of the first ancillary services metering system developed for the main national power grid services provider, respectively Hidroelectrica, Romania based on a R&D contract[25]. In case of this very large project (see Figure 10, illustrates the system overview), I was involved in supervising the design and implementation of the specific metering data concentrators used in hydro-power plants and in the control of hydro-generators by remote from the national dispatch center point. With this occasion, the embedded development consisting in several data acquisition boards and data communication sub-system has implemented standard protocols complying to IEC60870-5-101 and 102. These systems were complied with 61000-4-2 (Electrostatic Discharge standards). The data processed, voltage, currents, frequencies of hybro-generators and many other control signals were used in conjunction with programmed tariff tables were used to calculate the price of electric energy produced for system services.

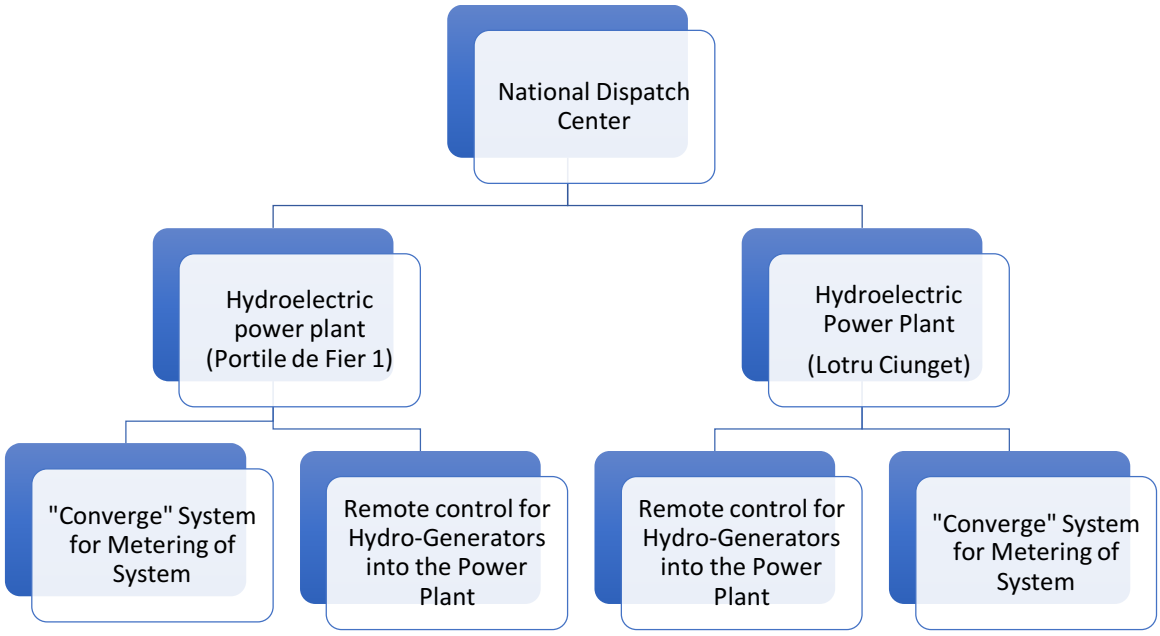

Figure 10.Simplified Block Diagram of the system conceived for Hidroelectrica SA

The "Converge" and the control system were produced and installed on the first ten most important hydropower plants of Romania, being at the moment of installation the first such system implemented in Europe.

The embedded system that was developed includes three parts: the first assures the similar functionalities like an energy counter, storing the metered data with time-stamps and tariffs; the second part is a control part able to parse the telegrams received from the National Dispatch Center

[25]Contract Hidroelectrica : Sistem de metering al serviciilor de sistem beneficiar Hidroelectrica Romania nr.490-11.2003 (aplicaţia S7-120R), responsabil de proiect din partea Siemens PSE –**Borza P.N**., in colaborare: Siemens PSE, Landis & Gyr Elvetia si ECRO Bucuresti

and to transmit these as commands addressed to the electronic and electric system controls of the hydropower plants generators; the third part is dedicated for implementation of a redundant wire/optical fibers/wireless communication system between each power plant and the National Dispatch Center. The main achievements are related to the implementation of an Automatic Metering Infrastructure the first step on the pathway to implementation of a smart grid at national level in Romania. All these implementations were adapted in the ten hydropower plants at the existing equipments that also represented an important effort in the domain of standardization protocols that were implemented on the supplied embedded systems.

Remote Controlled Laboratories

Starting from 1990, a special attention was paid for the development of modern tools necessary for the modernization of the electric and electronic higher education laboratories[26,27].

By observing from one side, the incomplete set of infrastructure support for laboratories, and from the other side, looking at the necessity to open for the students the access to laboratories, from every where and 24 hours per day, together with Prof. Sandu we have proposed and have developed new, remote accessed laboratories using the frame of European Leonardo da Vinci programs[28]. Thus, we have implemented ubiquitous systems, accessible by Internet and available for the students studying in the domain of electronics and of the electrical engineering too. These implementations started from the development of reconfigurable test benches for study of basic electronic devices that was connected with measurement instruments with the possibility to control the test bench topologies, command the measurements and transfer all the data to a laboratory server, used as intermediate node between the laboratories apparatus and test benches and the Internet. The works done during two years permitted at the authors to publish several pionnering-papers together with prof. Kayafas from NTUA Athens, Greece[29,30, 31].

A block diagram of developed test bench with remote control and automatic transfer of measured date through Internet is shown in Figure 11.

---

[26] Cercetarea, realizarea şi omologarea a două pompe peristaltice cu şi fără sistemul microprocesorizat de control (84-1988), director de proiect **Borza P.N**., , MI-Directia de mijloace de invatamant (OCMI),, Bucuresti

[27] Construcţia de aparate de laborator industriale (24-1991), director de proiect **Borza P.N**., valoare 1.6000.000 ROL, MI-Directia de mijloace de invatamant, (OCMI) Bucuresti

[28]Leonardo da Vinci, proiect Nr. RO/99/2/07267/PL/II.1.2b/FPI, TECH-REDIVIVA , **Borza P.N**. membru, (1999-2000)

[29]Sandu F, W. Szabo, Borza P.N, Automated Measurement Laboratory Accesssed by Internet, Proceedings of the XVI IMEKO World Congress, 2000, Vienna, Austria

[30]Kayafas E., Sandu F., Patimiotakis I, Borza P.N., Approach to programming for Telemeasurements, Proceedings of the XVII IMEKO World Congress, 2001, Lisbon, Portugal

[31] Sandu F, D.N. Robu, Borza P.N., Szabo W., Twin-microcontroller GSM MODEM Development System, Proceedings of the 8th Internationala Conference of Optimization of Electric and Electronic Equipment OPTIM2012, Brasov, Romania

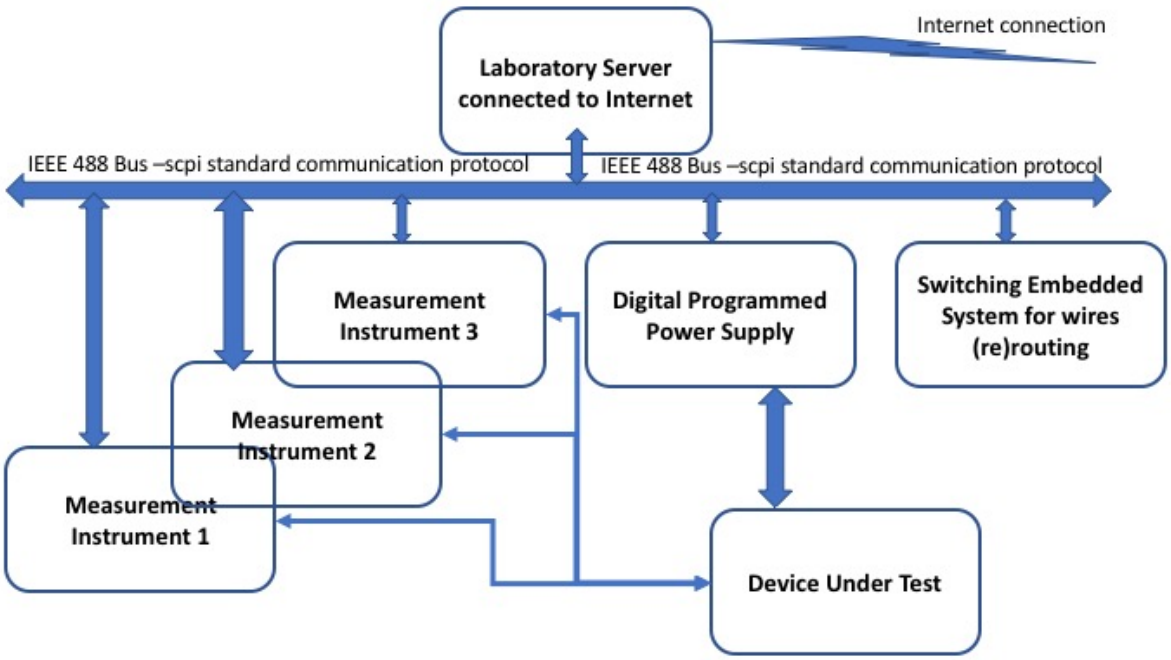

Figure 11lock Diagram of the Remote Accessed Laboratory through Internet

The measurement instruments where interconnected using IEEE488 bus with a laboratory server, formed by a PC used as measurement server. Using the parallel interface of the PC and the IEEE488 bus the necessary measurement instruments, programmable power supply wascommanded using SCPI (Simple Commands for Programmable Instruments) communication protocol and on parallel PC's interface were connected the embedded system dedicated to switching, routing and re-routing the connection wires between the Device Under Test (DUT) and instruments were implemented.

The software implementation was mainly based on LabView graphical programming language and this implementation assures a relatively fast software implementation and testing. Some parts of software were developed in assembly and C languages in order to permit the fast switching between the different signal pathways on the complex multiplexers/demultiplexers used in front of measurement instruments and programmable power supplies for connect the DUTs to the electronic instruments

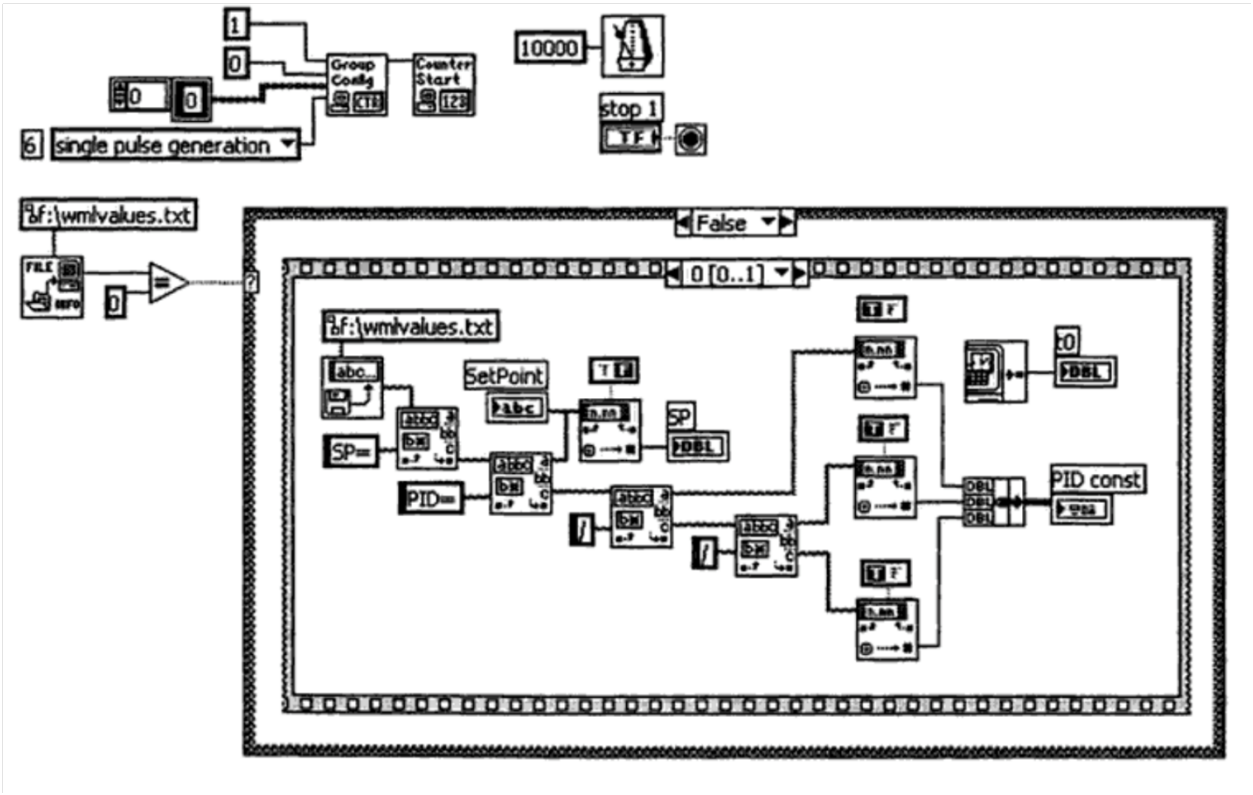

Figure 12 Implementation on a virtual instrument using LabView graphical programming environment (implementation of a new settings access to Laboratory Server)

The communication through Internet allows at a registred user to access using a name and corresponding password the Web pages with the DUT laboratories[32].

The main achievments resulted as cooperation of the remote accessed laboratories include: development of skills related Web, C and LabView programming of the remote accessible devices, innovations related tele-measurements using mobile devices, Tablet PC and mobile phones, and initiative to develop home appliances automation systems for improved energy management of tools and devices into the modern buildings. Understanding the functional interactions that are established between the different measuring devices and between them and the devices being tested. We, the designers of the system, were at the moment (1999) between the first implementators which were developed complex systems remotely controlled through Internet, emphasizing aspects related synchronization of whole sub-systems, preserving stages coherency, building-up measurements data bases able to be exploit after experiments off-line.

The first approach, dedicated for higher education tools was achieve by integration of a series of laboratories at multi-national level into a standard Learning Management System (LMS)

[32]Moraru S.A., Romanca M., **Borza P,** Distributed Software Architecture and Applications for Remote Laboratories, Heft Nr. 21 (2008), ISSN 1613-5652, ISBN 978-3-940793-17-1, pp 21-28, The 2nd International Workshop on e-learning and Virtual and Remote Laboratories 2008, February 14-15, 2008, Hasso-Plattner-Institute Potsdam, Germany, (Deutsche Nationalbibliothek/Katalogdatenbank ILTIS, http://dnb.b-nb.de)

with the help of European community in the frame of two successive Leonardo da Vinci projects[33, 34]. These projects permitted to the working groups to develop more sophisticated functionalities related to LMS, respectively assured the combination between the real remote accessed through Internet experiments and the virtual laboratories by merging the data acquired and stored on laboratory server attached to LMS. Thus, precedent measured and acquired data stored on server was used for registered users in case when their request was similar with other user that run in the past the same experiment with the same parameters. In this way, the potential bottle-neck related to the DUT was avoided. A scheduler dedicated for prioritized access to workshops was implemented. Many of the functions implemented were standardized at the level of European consortium.

In the field of Domotics (Home Appliance Automations), since 2003 and for more than a decade, we have developed a large series of intelligent sensors and actuators. Also, together with Portuguese and Greek collaborators we have published several papers and we have organized a first European Seminar about Domotics in Setubal Portugal in 2004[35]. The system initially designed was implemented by a second generation of system as embedded development endowed with different kind of wireless transceivers: Bluetooth, Wi-Fi, and RFM. On the other side, the client, respectively the laboratory server was transferred from the PC or laptop to embedded systems endowed with the wireless interface to Internet[36, 37].

From digital computers to quantum computers based on biological paradigms[38]

Together with prof L.F. Pau, as result of an extensive study, we have published a paper that intends to suggest the necessity to evolve the basic paradigm for digital processing systems, in the context of ever more apparent performance limitations and of some of the discoveries made in

[33]Leonardo da Vinci, proiect RO/02/B/F/PP 141053:VIRTUAL_ELECTRO_LAB, WBT World, Implementare platformă educaţională**, Borza P.N**., Responsible of the WP2, 2004-2006

[34]Leonardo Da Vinci Programme, VET-TREND, RO / 06 / B / F / NT175014, 2006-2008, Network Services, Responsabil WP II, din 2006, technical director **Borza P.N**.

[35]**P.N. Borza,** L. Gomes, Ghe. Scutaru (Eds.), e-learning and Virtual and Remote Laboratories, August 2004. INSTICC Press 2004, ISBN 972-8865-14-7 Proceedings of the 1st International Workshop on e-learning and Virtual and Remote Laboratories, VIRTUAL-LAB 2004, In conjunction with ICINCO 2004, Setúbal, Portugal

[36]Nedelcu, A. V., Sandu, F.,**Borza, P. N.,** Mobile data acquisition and tele-transmission by PDA, ANNALS OF DAAAM FOR 2008 & PROCEEDINGS OF THE 19TH INTERNATIONAL DAAAM SYMPOSIUM Book Series: Annals of DAAAM and Proceedings Pages: 957-958 Published: 2008

[37]Sandu F., Nedelcu A.V., Moraru S.A., Borza P.N., Aggregation of automated instrumentation via internet using remote VISA calls, Annals of DAAAM & Proceedings, Pages: 1217-1218, 2008

[38]**Borza P.N**., Pau L.F, From Digital Computers To Quantum Computers Based On Biological Paradigms And Progress In Particle Physics, https://arxiv.org › cs 2017

biology, nanotechnologies and fundamental physics. The prime thrust is to hinge upon progress in particle physics, tocapitalize on ways quantum processing allows to replicate biological processes with resulting computing performance benefits. Whereas a few authors have envisioned the potential for quantum physics in computing[39,40], they did not link it to progress in biology and only to a limited extent to recent discoveries in particle physics. As this scope is quite wide, the focus here will be to address some of the architectural elements, their realization, and to relate them to functional biological processes.

The paper covered the following aspects: i) an overview of the basic biological and physiological phenomena exploited in the suggested proposal; ii) survey advances in research on sub-particles with an emphasis on the implementation of new specific functionalities inspired by enumerated aspect; iii) describe the resulting architectural building blocks; iv) analyze some of the benefits to be expected; v) discuss open research and technological issues.

The conclusions summarize the main ideas in the paper, and also suggest a path towards a theoretical development of a generic architectural simulation model based on colored algebras.

Some details related this work will be presented below.

The paper proposes an architecture including three blocks: the input interfaces, a Signal Processing Block based on pathways propagation that is implemented on multiples layers and an output interface based on signals “sinks” that will be periodicaly sampled.

The principal hypothesis related the sub-elementary particles physics raised by paper are: the processing is done by *information* carrying by *quantum particles interacting along propagation pathways*; the *massless quantum energy carriers may coexist with energized sub-particles* able, based on their energy, to propagate along pathways; *deflection and collection elements*, specific to the carrier types, may be implemented *along the pathways*; the *dual particle types also enable different delays*. The transformation of the quantum particles is realized by functions which can *mimic biological or physiological processes*. The signalling amongst the pathways, or in sub-lattices, is relying on *magnetic-electrical interactions*, as recently discovered[41]. The spatio-temporal filtering of charge carriers exploits the Moiré processing, or structured resonators. Information *storage is realized by resonant quantum structures*, such as *quantum wells* or *quantum dots*, capable of producing single photons on demand at high rates[42.] The inputs/outputs are via *asynchronous quantum* charge generation at very high data rates,

[39]N. D. Mermin (2007), Quantum computer science: anintroduction, Cambridge University Press, UK

[40]M.A. Nielsen, I. L. Chuang (2010), Quantumcomputation and quantum information, Cambridge University Press,

[41]J. T. Heron et al. (2014), Deterministic switching offerromagnetism at room temperature using an electricfield, Nature, 516 (7531), p. 370

[42]T. Meany, Quantum dots for future opticalquantum technologies, Laser Focus World, October2015, p. 45-47

respectively synchronous read-out by conventional means at lower data rates. *The quantum pathways are changed by the functional blocks*. The control path gives the software driven sequence of functions and parameters to be executed. The *signalling path, separate from the control path,* activates/ deactivates the set of required functional blocks and pathways. The *quantum pathways carry the particles* (with charges and spin) by *ballistic conduction*, so one must identify the phenomena by which the flows are enabled and controlled.

Several fundamental progresses in sub-elementary particles are considered by the paper: *the anomalous quantum Hall effect*[43] *(QHE), the phase Berry effect (or Berrycones potentials) (PBP) and the proof of existence of the Majorama subparticles*[44] able to offer a like "zero" case for the coloured algebras basis proposed by the paper.

At the core of the proposed architecture, lie the functional blocks (see Figure 13). The properties there of in terms of quantum pathways transformations rely first on a geometrical structure, and next on the selection / injection of selected defect categories.

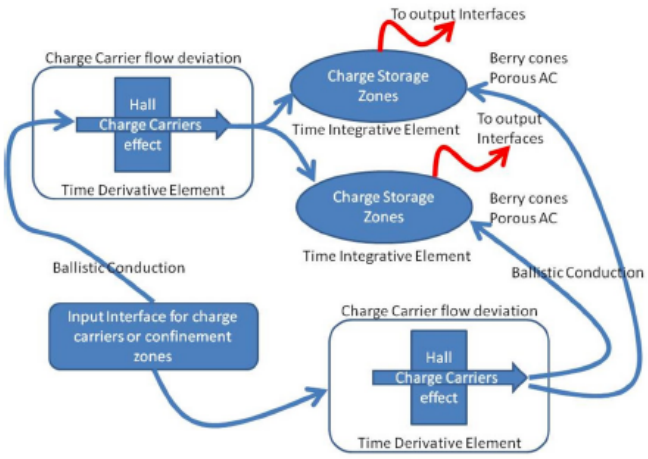

Figure 13. Main functional elements of the proposed computing structure (Quantum pathway path oriented asynchronous processing: interfaces and confinement zones; pathways based on ballistic conduction on 2D graphene; sensing and eventually threshold elements; charge carrier collector zones with or without sensing and eventually threshold elements. All these elements can be placed on a single or adjacent multiple graphene or other condensed matter layers)

A *fundamental change of the architectural view is related to the avoidance of switching phenomena* along the programmable pathways (dynamic reconfigurable) of the charge carriers. *This fact will overpass one of the important obstacles on the way of performance increasing of actual computers that is represented by the "thermal wall"*. This illustrate the limited capacitance of the structures created into the digital processing units to extract the heat produced inside them.

The phenomena taking place are effects such as: ballistic conduction, the confinement of the charge carriers (electrons and positrons or other pair of sub-elementary particles) in accordance with fermions composition rules. These phenomena are induced by structural defect inside the 1D, 2D and multi-D allotropic structures, and/or by group effects. These are the result of building up,

[43] K. Von Klitzing (1985), The quantized hall effect,(Section 3), Nobel lecture, Dec. 9, 1985;http://www.nobelprize.org/nobel_prizes/physics/laureates/1985/klitzing-lecture.pdf

[44] https://www.princeton.edu/news/2014/10/02/capping-decades-searching-princeton-scientists-observe-elusive-particle-its-own

at nanoscale of successive and different 2D layers; in this way can be designed new variants and also very complex processing structures. The 2D layers can be based on graphene, boronnitride, or other ferromagnetic nano-structured materials, which can be inserted inside regular structures (see Figure 14).

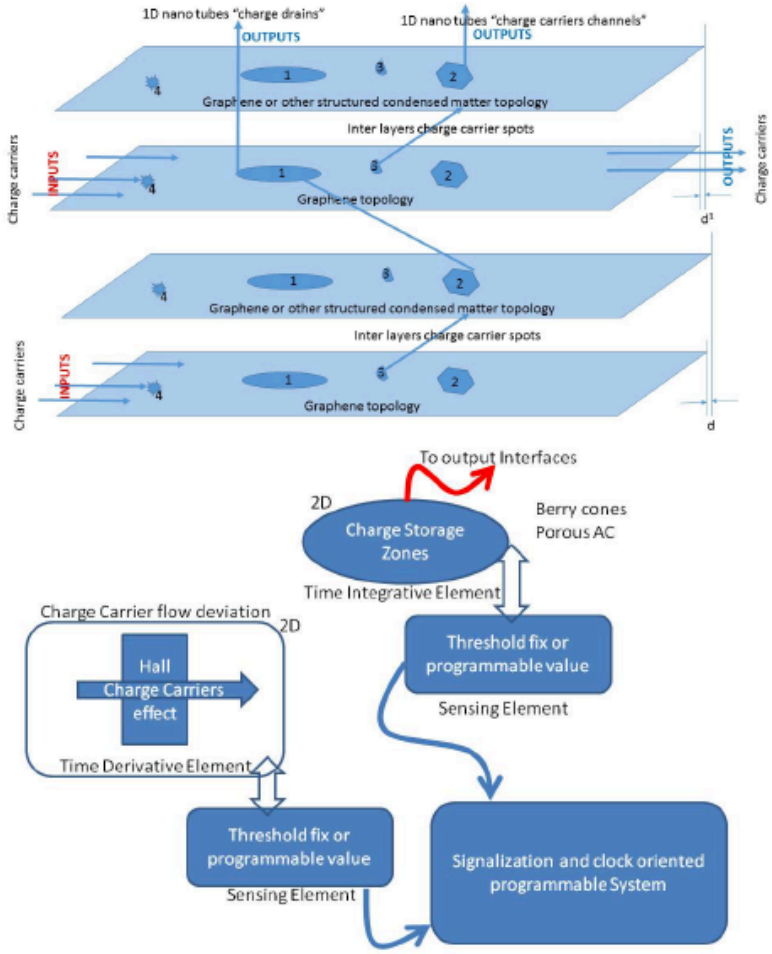

Figure 14. Quantum pathways synchronous processing: transition time based elements such as atomic FET's, and signalling by magnetic effects induced by electrical commands. Clock circuits, signalling logic and programmable control signals reside in the conventional processor of Figure 13; integrated with the quantum based processing, they carry out the synchronous extraction of charge/ processed pathways.

An interesting aspect described into the paper is related to the potential analogy between the existing instructions on rogrammable computers and the proposed computation structures. Thus, for all the fundamental functions, executable instructions, decision and repetitive functions the paper'authors indicate the corresponding functional block (From Digital Computers to Quantum Computers Based on Biological Paradigms and Progress in Particle Physics pp 8-9).

Another interesting aspect is related to the *exceptional scalability* of computational system from both point of view: *computation capacity and energetic capacity*.

The paper tries to offer a visionary perspective on the evolution of information processing systems, first by combining conventional Turing machines with a new quantum biological

architecture, and next by unifying the normally disjoint views of information and energy via the use of quantum processing. Thinking about the time perspective for an implementation of this vision, it can be observed that much of the underpinning research in particle physics, biology and material science has recently accelerated, creating a moderate optimism on realizations in a foreseeable future.

Chapter 3. Toward Energy Efficient Systems using Smart Hybrid Storage Elements

Introduction of smart grids and electric or hybrid storage system

The first part of the chapter is dedicated to reveal the crucial role played by smart grids and inside these, of electric or other energy storage systems.

The actual development of technologies related to the power networks and mobile applications emphasize with clarity the necessity to overpass the existing difficulties related the control and energy efficiency of the electric systems by using electric storage sub-systems.

In the book, Emerging Nanotechnologies in Rechargeable Energy Storage Systems, chapter 9, an exhaustive review of storage devices and their applications is done[45].

The need of electric storage systems, represents today a major technologic step forward, because the variety of power networks elements, is in train to explode on generator and consumers sides too. The insertion of the new power sources especially the Renewable Power Sources (RES) into the electrical power networks generate many integration and operation problems because of their dependency on generation natural conditions and their variableness in time. These disturbances must be solved by solutions that permanently assure the balance supply and demand in power generation. As have mentioned by Funch et all[46] "the key issues of the energy transition in the power sector are the interaction between strongly increasing amounts of variable renewable electricity generation and the mix of flexible resources to integrate them into the power system." As have mentioned by Katie Fehrenbacher[47], "a next-generation smart grid without energy storage is like a computer without a hard drive: severely limited." Starting from parallel analyses of informational and energetic systems, a clear analogy between these two systems can be identified. A similar role in informational and energetic networks is played by the cache memory and the storage facilities, respectively. Inserting storage facilities into the power networks will facilitate the power flow control in a similar way that cache memory performs in the case of informational systems. Based on this, smart grids can be designed, including energy storage facilities that will permit improved control of the electric grid parameters. Therefore, like the "cache memories" that

[45]Rodriguez-Martinez L, Omar N., Emerging Nanotechnologies in Rechargeable Energy Storage Systems, Elsevier, Radarweg 29, PO Box 211, 1000 AE Amsterdam, Netherlands, 2017, ISBN: 978-0-323-42977-1(**Borza PN** is author of chapter 9 of the book).

[46]G. Fuch, B. Lunz, M. Leuthold, D.U. Sauer, technology overview on electricity storage: overview on the potential and on the deployment perspectives of electricity storage technologies, on behalf of Smart Energy for Europe Platform GmbH (SEFEP), Institute for Power Electronics and Electrical Drives (ISEA), RWTH Aachen University, Germany, 2012.

[47]Facts and figures. Available from: http://energystorage.org/energy-storage/facts-figures

are inserted close to a computer CPU and peripherals elements, the storage facilities will be installed close to generators and also close to the location of consumers, smoothing the power and energy variation of power lines.

Electric Storage Systems – general aspects

Electric storage systems (ESS) represent a high degree of complexity and variety. The effect of many factors and phenomena, all characterizing the resulting storage system performance must be taken into account in order to adapt and use optimally the ESS.

One of the most important key issues is related to the nanotechnologies achievements in the last few years, when the batteries and supercapacitor technologies suffered important changes. This is the reason for that I decide to insert such essential information about principles, technologies and implementations of energy storage systems. It is well known that in parallel, the fuel cells technologies have benefit for a special attention and significant funds dedicated for development of new types of fuel cells (interfaces) and application with these.

Nanotechnologies the support of electric energy storage cells and systems

The ESS reflects a hierarchical organization. Starting from the cells, these are grouped to form a module, and the modules are grouped to form a storage system.

At the cell level, a complex structure is encountered formed on multiple interfaces oversimplified in the following lines:

- porous activated carbon zones form the armature of a capacitor having a huge area. On this are accumulated ions of the same sign. Because the activated carbon surfaces are very thin the distance that separating the charge carriers having opposite sign is extremely small. This is correlated with very large surface and will determine an extremely high electric capacitance. As result of the close interaction forces that appear between atoms of electrode and ions of electrolyte, the ions are very close arranged on porous activated carbon surface,
- the active zones formed by porous material are compacted using a “binding material” that ensures the mechanical integrity of the electrodes, improving in the same time the electrical conductivity, and
- the electrical connection between the active areas and the cell electrodes is implemented by graphene, graphite, carbon nanotubes, or other structured carbon materials or constituents.

The shape of the stationary phase and the electrode matter crystallization affect the properties of the interfaces. These interfaces are living entities because during cell functioning, or as a result of time passing, their properties and features are modified. This phenomenon is known

as aging of the ESS. Charge carrier mobility depends on the electrode–electrolyte interface as an expression of integrative interaction of the two phases that are adjacent to this level. The degree of consistency of the interfaces and the minimum distance ensured between the opposite charges carrier determine their electrical properties. The variety of chemical compounds and substances that can interact at this level is particularly high.

Supercapcitors versus batteries short overview

A supercapacitor is an electrochemical capacitor, characterized by small time constants and composed of load collector, porous electrodes, electrolyte and separator made from porous material with increased purity.

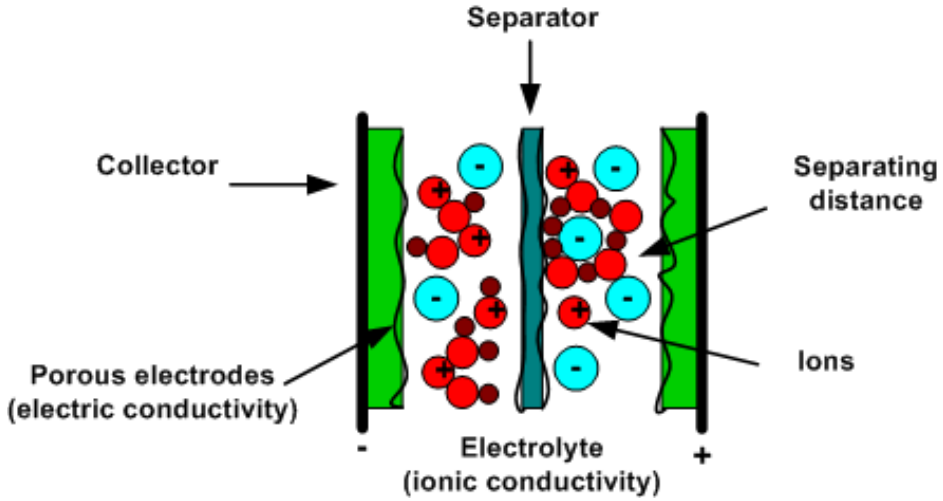

Figure 15. Microstructure of a supercapacitor[48]

For example, in the case of activated carbon-based interfaces, the electric double layer capacitor (EDLC)[49] is very thin, and therefore the distance that will separate the opposite sign charge is very short. The porous electrodes are made from material like activated carbon, metallic oxides (RuO_2, IrO_2), polymers etc. Depending on the electrolyte, supercapacitors can be grouped in two categories: organic and inorganic. The organic electrolyte (organic solvents - acetonitryl) ensures a good mobility of the ions, even at reduced temperatures[50]. Its disadvantages are related to the risk of explosion while working at extreme high temperatures (> 70°C). The disadvantage of the inorganic electrolyte (H_2SO_4 or KOH) is related to the nominal cell voltage level (0.7V ÷ 1.5V), which is more reduced than in the organic electrolyte case (2.5V ÷ 3.5V). The advantage

[48] S. Rael, B. Davat, and F. Belhachemi, "Supercondensateurs a couche double electrique, principe de fonctionnement et comportament electrique", Journees Electrotechniques du Club EEA, Cachan, pp. 57-67, March 2002.

[49] Helmholtz, H. (1853), "Ueber einige Gesetze der Vertheilung elektrischer Ströme in körperlichen Leitern mit Anwendung auf die thierisch-elektrischen Versuche", Annalen der Physik und Chemie (in German), 165 (6), pp. 211–233, doi:10.1002/andp.18531650603

[50] S.W. Novis, and L. McCloskey, "Non-aqueous electrolytes for electrical storage devices", Patent, Philadelphia, US, 2005.

of the inorganic electrolyte is related to extending the positive temperature range, thus reducing the risk of explosion[51]. Additionally, the inorganic electrolyte is characterized by increased value of the conductivity (0.8S/cm ÷ 1S/cm for H_2SO_4)[52]than in the case of the organic one (0.02S/cm ÷ 0.05S/cm).

Consequently, the intensity of the electrical field can reach very high values.

The separator is a porous membrane (paper, glass fiber, polymer) which delimitates the two electric layers of the supercapacitor, insulates the electrodes and ensures the ion transfer between the electrodes by using the electrolyte, which penetrates the pores of the separator. The separator is characterized by small electric series resistance (0.1 mΩ ÷ 100 mΩ), directly proportional with the thickness of the separator (10 ÷ 100μm) and reversely proportional with its contact surface[23]. Also, the conductivity value of the separator is directly proportional with its porosity. For supercapacitors, it can be delimited three main types of pores, depending on their size: micropores (< 2 nm), mezopores (2 nm ÷ 20 nm) and macropores (20 nm ÷ 50 μm)[53],[54]. The pore size influences the energy density, the power density and the capacitance which is increasing while reducing the pore size

The fundamental constraints applied to voltage and temperature in the case of EDLC are essential to preserve the integrity of the electrode–electrolyte interface. The energized charged particles or molecules (ions) can sometimes break the nanostructure of the interface, causing degradation of the cell electrical parameters, accelerating the aging process, and even fully damaging the storage cell.

The supercapacitors or ultra capacitors are based on non-faradic phenomena having high-power density and comparatively higher life cycles than batteries. There are a few main advantages of supercapacitors over other storage systems: (1) it has virtually unlimited life cycle (millions of times); (2) it has very low impedance; and (3) it supports a very high rate of charging and discharging, the limitation being the accepted device temperature domain.

A classical overall image (Figure 16) is illustrated by Ragone's plot. In the case of batteries, the faradic phenomena that occur as a result of the cyclical charging–discharging processes will

[51] V. Khomenko, E. Raymundo-Pinero, and F. Béguin, "Optimization of an asymmetric manganese oxide/activated carbon capacitor working at 2 V in aqueous medium", Carbon, vol. 153, pp. 183-190, 2006.

[52] F. Beguin, and E. Frackowiak, Carbons for electrochemical energy storage and conversion systems. Advanced Materials and technologies Series. CRC Press Taylor and Francisc Group: Philadelphia, USA, 2010, pp.8.

[53] J. Chmiola, G. Yushin, Y. Gogotsi, C. Portet, P. Simon, and P.L. Taberna, "Anomalous increase in carbon capacitance at pore sizes less than 1 nanometer", Science, vol. 313, nr. 5794, 2006, pp. 1760-1763.

[54] M. Toupin, D. Belanger, I.R. Hill, and D. Quinn, "Performance of experimental carbon blacks in aqueous supercapacitors", Journal of Power Sources, vol. 140, 2005, pp. 203-210.

have similar effects like in the case of supercapacitors, affecting the shape and size of the solid part of the cell interface. Therefore, the variation of molecular dimension of reactants at the interface level will affect the functional capacity of the battery cell over time, causing aging of the battery[55]. The "thickness of electrodes and separators" influence the performance of the ESS.

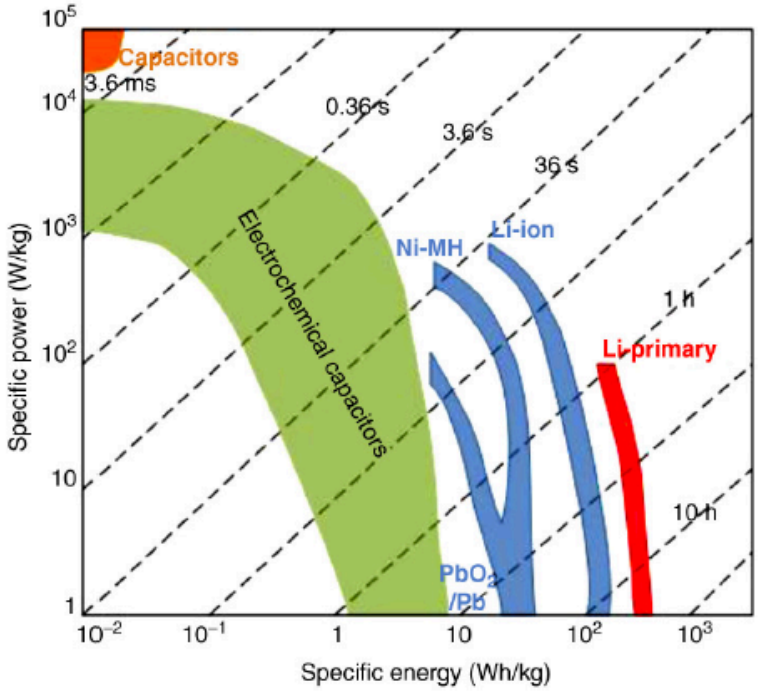

Figure 16. Specific energy versus Specific power for different storage elements

The phenomena that occur at the interface level are essential for the parameters and characteristics of the storage cells, power and energy densities, cell aging, time constants of their storage capacity, and the storage temperature range. The ESS implementation technologies must ensure a high reproducibility of the geometry of the interfaces and a constant degree of uniformity for the stationary phase layers. Another important factor related to performance is the adequate choice for the interface reactants (stationary versus mobile phases). The perfect adaptation occurs in the shape of the local near field configuration between the porosity corresponding to the shape of the stationary phase and the ions of electrolyte (mobile phase) that will be hosted by the interface.

In general, energy storage cells have a finite capacity and their electrical parameters fit only partially with the requirements of most applications. Batteries and supercapacitors present an integrative character. In the case of batteries, theoretical maximum capacity may be determined as the integral of all reactant molecular link energy, at the interface electrode–electrolyte, able to

[55] UK Survey, Recent trends in electrochemical science and technology, in: Yu. M. Volfkovich, A.A. Mikhailin, D.A. Bograchev, V.E. Sosenkin, V.S. Bagotsky (Eds.), Studies of Supercapacitor Carbon Electrodes with High Pseudocapacitance, InTech, 2012.

react in a finite time. The chemical reaction speed at microscopic level is illustrated at macroscopic level by the steady-state internal series resistance. In the case of supercapacitors, their capacity depends on the maximum area that can be used to host adsorption phenomena at the level of electrode–electrolyte interface.

It is not feasible to build customized cells for each type of application based on its requirements. The simplest strategy consists of grouping standard cells and building up the necessary capacity as a modular system adapted by link topology to create an appropriate storage facility in accordance with the application requirements. Therefore, these elements can be "grouped" as an assembly of cells connected in series, parallel, or series–parallel to implement the storage modules. The size of most elementary cells determines the "*granularity* of the achieved storage system. At a storage system level, the wires that link the system elements and the way they are linked denotes the topology of devices and storage systems. These properties play an important role in meeting the energy efficiency targets and in achieving the technical performance and system requirements (eco-footprint, shape, gauge, etc.).

The uniform distribution of matter at the interface level, and how to "package" the cells as a storage module and the storage modules as storage system are important design aspects. The uniformity of the thermal and electromagnetic fields obtained during the operation of the module and system in conjunction with the application are also key factors.

These factors are among the most important as they determine the reliability, availability, and lifespan of the whole storage system. All matters mentioned earlier are part of the structural design of the storage system and specifications determined by the deployed application.

Table 1. Comparison between Li-Ion batteries and Supercapacitor main parameters

Chemistry	Nominal Voltage(Volt)	Energy Density(Wh/Kg)	Power Density(kW/Kg)	Life Cycle (Numbers)
Li-Polymer Batteries	3.7	130-200	1-2.8	Up to 1000
Supercapacitor	2.5-2.7	5-10	4-10	0ver 1000000

The maximum performances obtained by the two main categories of storage devices, batteries and supecapacitors are illustrated in Table 1 and Table 2.

The actual evolution of nanotechnologies illustrates the development of hybrid storage cells that combine the faradic and non-faradic electrodes into a single device. The results are on interest because can be realized, for the moment in laboratory, cells merging the properties of the Li-Ion batteries and of the supercapacitors.

Table 2 Extremal values of the principal parameters of supercapacitors and batteries cells

Cell type	Supercapacitor[56]	Battery[57, 58]
Energy density	*Moderate* 10–20Wh/kg	*High* 80–300Wh/kgDependent ontechnology Peak value Li-O_2 3,500 Wh/kg
Power density	*High toveryhigh* 1–20kW/kg	*Moderatetohigh* 0.25–1.3kW/kg Dependent on technology
Domain of temperature	*Extended* –50°Cto+70°C	*Medium* 0°C to45–50°C Dependent on technology
Cyclability	*Very high* 500,000–1,000,000cycles	*Moderate* 200–5,000full cycles(DoD95%)
Voltage	1–2.7V Inorganic electrolyte1–1.2V Organic electrolyte2.7–3V Asymmetric electrodes4.5V	1.2–4.5V Leadacid1.2V Li-ion 3.7V $LiFePO_4$ 3V
Self-discharge	*High*	*Low*
Energy efficiency	90–98%	85–92%

The main problem that still remain is related to the aging characteristic that don't permit an ehough big numer of cycles for the combined cell.

A second problem is related to the missing of external controllability of the storage cell. Thus, these problems still remain open for the future research both in the fields of nanotechnologies, chemistry and in electrical engineering too.

These values are very perishable because technology advances require constant updating of these values. Taxonomy of the storage devices is shown in Figure 17.

A short description of the main storage elements is below presented.

From taxonomy of the energy storage system to hybrid storage systems

For the mechanical storage, the main phenomenon that forms the basis of conversion function is related to the inertia of different bodies. Transforming electricity into mechanical energy and vice versa is among the most common conversion processes. The stored electrical energy in batteries or supercapacitors is transformed into mechanical form by using an electromechanical converter like an induction machine or a complex system, which integrates the electrical machine with the power converter.

[56] U.K. Sur, Recent trends in electrochemical science and technology, in: Yu. M. Volfkovich, A.A. Mikhailin, D.A. Bograchev, V.E. Sosenkin, V.S. Bagotsky (Eds.), Studies of Supercapacitor Carbon Electrodes with High Pseudocapacitance, InTech, 2012.

[57] A. Burke, H. Zhao, Applications of Supercapacitors in Electric and Hybrid Vehicles, Research Report-ITS-RR-15-09, presented at EESCAP2015, Brasov, Romania, 2015.

[58]C. Andrea, Ferrari, et al. Science and technology roadmap for graphene, related two-dimensional crystals, and hybrid systems, Nanoscale 7 (11) (2015) 4587–5062.

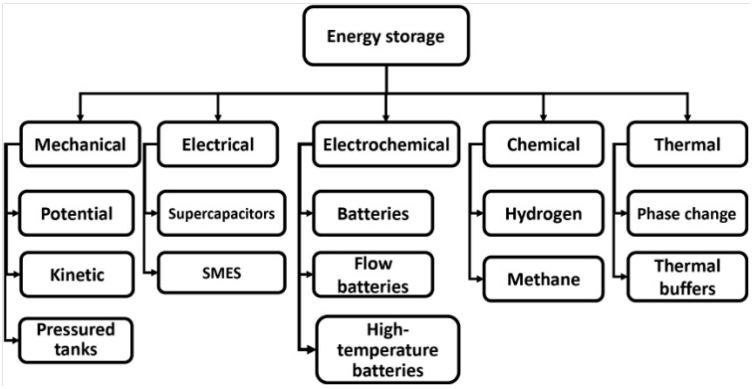

Figure 17. Electric storage devices

Before each case is analyzed, the corresponding physics transformation equations should be written.

The expression of kineticenergy is given by:

$$W_k = \frac{1}{2} \cdot mv^2 \text{or} \quad W_k = \frac{1}{2} \cdot J\omega^2$$

in case of a rotation of the body where the v is the linear or the rotational speed and J is the momentum of inertial for the body considered. The potential energy is given by: $W_p = m \cdot g \cdot \Delta h$ where m is the mass, g gravitational acceleration and Δh is the difference of elevaton between a reference level and the body level. In case of supercapacitors, the stored energy si gien by: $W_C = \frac{1}{2} CV^2$ where C is the capacitance and V este the voltage on the device.

In the case of batteries and flow batteries, the main phenomena consist of chemical reactions that take place between the electrodes and the electrolyte in a reversible reaction that depends on the type of reactants. The energy produced is given by reactants Gibbs free energy (thermodynamic potential at constant volume) and their mass involved in reversible reactions[59]. The Gibbs free energy[60](isothermal and isobaric free energy) is determined by equation:

$$G = H - T\,S$$

where H is enthalpy (measurement of energy in thermodynamic system), T is absolute temperature in Kelvin, and S is entropy (measure of energy divided by temperature).

Differentiating bellow equation results in:

$$dG = -S\,dT + V\,dp - W$$

where $\delta W'$ is other form of work except expansion work expressed by $p \cdot dV$.

In the case of closed systems, the simplified expression of Gibbs free energy is:

[59]E. Fermi, Thermodynamics, Prentice-Hall, Englewood-Cliffs, NJ, (1937).

[60]J. Wang, Modern Thermodynamics Based on the Extended Carnot Theorem, Springer, Berlin, (2012).

$$dG = -S\,dT + V\,dp$$

The Gibbs free energy in the case of processes preserving T and p constant G variation can illustrate the equilibrium of thermodynamic processes. So, if $\Delta G < 0$, the process is spontaneous; when $\Delta G = 0$, the process is in equilibrium; and when $\Delta G > 0$, the process is spontaneous but in the opposite direction.

To characterize the features and performance of storage cells, the standard test methodologies for interface characterization are voltammetry, galvanostatic, and electrical impedance spectroscopy methods[61]. The capability to supply energy by the batteries is given by their capacity depending on type of interface electrode–electrolyte and size of main elements and battery state of charge. "State of charge (*SOC*) is the percentage of the maximum possible charge that is present inside a rechargeable battery". The method used to determine *SOC* is based on the measurement of open circuit voltage (*OCV*) that was proposed by Christianson[62].

Knowing two points of SoC, an intermediate value will be calculated by linear interpolation, respectively, by Coulomb counting of charge transferred. The voltage of the battery terminals is:

$$\mathrm{OCV} = V_{Bat} + I \cdot \mathrm{R}$$

where V_{Bat} is the voltage at battery terminals, I represent the current measured in external circuit (positive in the case of discharge and negative in the case of battery charge), and R is the ESR.

In the case of flow batteries, the capacity of the generators is related to the volume or mass of reactant reservoir and the effective surface of ion exchange membrane that ensures the release of stored energy.

Another challenging aspect is related to finding out new combinations that can form efficient interfaces that enable storage of electrical charges. It is important to develop new technologies that represent new ways for the implementation of these interfaces to meet a higher level of energetic and functional efficiency.

As result of the deep analysis of energy storage impementations it is clear that a single type of storage cell or device is unable to respond at the requirements of the applications. Only enumerating these parameters, like: energy and power density, nominal domains of temperature, cycling characteristics and the life span correlated with this, the mechanical dynamic characteristics, the ecologic impact or eco-footprint and, the cost of components, there are obvious

[61]V. Pop, H.D. Bergveld, D. Danilov, P.P.L. Regtien, P.H.L. Notten, Battery Management Systems, Accurate State of Charge Indication for Battery Powered Application, Philips Research, Springer, 2008.

[62]C.C. Christianson, R.F. Bourke, Battery state of charge gauge, US Patent 3,946,299, 1975.

that difficulties that stay in front of engineers in implementation of applications are huge. This is the reason for that I have proposed in 2005 to try to overpass partially these dificulties by adopting new hybrid storage solutions[63].

Thus, by hybrid electric storage systems (HESS) I have developed the concept of integration between fuels cells, batteries and supercapcitors using power electronic devices and specific electronic control systems integrated together. This were developed as a basic patent having as owner Siemens AG Austria.

Application and sizing of hybrid storage systems

In collaboration with IFSTAR Laboratories we have developed the testing procedures for inorganic and organic electrolyte supercapacitor in order to put in evidence not only the nominal parameters of those but also to measure the aging characteristics[64]. Also, we have developed a desiging methodology for sizing of the hybrid storage sub-system for electric vehicles. In Figure 18 this methodology is line-out.

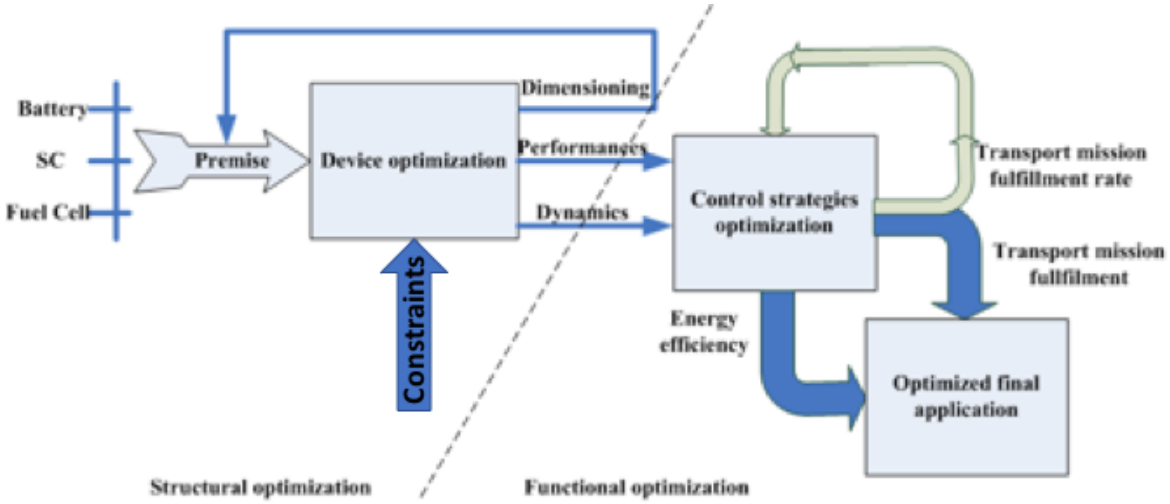

Figure 18. Methodology for designing of Electric Hybrid Storage Systems for Mobile Applications

The complexity of the problem consists in how can be interrelated two fundamental aspects: the structural development, sometime this includes the hardware architecture, with the functional development that assures the framing of application inside the constraints vectors. For a large set of applications, the functional development doesn't mean only to design and implement new complex functions, but also to streaming these as „strategies" that are triggered by specific

[63]EP1796199-A1,-European Patent 2007, **Borza P N** Electric power cell, Owner: SIEMENS OESTEREICH AG, Filed: 12.2005 (Free Patent - ISI Web of Knowledge)

[64]Musat A.M, Musta R., Carp M, **Borza P.N,** Coquery G., Characterization of the Organic and Inorganic Supercapacitors, Proceedings of IEEE Optim Conference, 2012, pp1545-1552, ISBN978-1-4673-1653-8/12

conditions appeared at system or components levels generate a succession of control functions which are successive activated. This image is very similar with the image provided by biological systems, where the programmability of their responses (one of them named stereotypes) represents that fundamental means in bio-systems reactivity. The main achievement related this research effort is related to the understanding of crucial role played by hybridization of the electric storage systems. Also, the orientation in research to the valorization of the living paradigms illustrated by the biologic systems feeding processes and growing too is fundamental for conceiving optimized technical systems.

Hybrid Electric Storage Systems Applications

A second relevant application that we have being developed and improved during several years consisted in implementation of a new starting system for the LDH1250HP diesel hydraulic locomotives. A patent[65], several papers[66,67,68], one research contract PNII[69] and, the most important thing, one prototype, are the proofs of deeply understanding of locomotive behavior and of the technological advances. The application was implemented for a heavy old fashion diesel hydraulic locomotive at the Brasov depot of locomotive replacing half of the initial batteries system by a group of aqueous stacked high voltage supercapacitors produced by ECOND Russia.

The system implemented assures the smooth starting of 1000kW internal combustion engine like a car in few seconds (less than 5sec.). The technical solution consisted in pre-loading locomotive supercapacitors (36F/110V) from the existing batteries on the locomotive and then suddenly discharging them with the engine's starting engine. In order to prolonged the starting process – as necessity of old fashion speed regulators existing on locomotive – the starting process

[65] Patent filed OSIM A/0011119/04.02.2009- " Sistem de Management Energetic si Metoda de Gestiune a Functionarii acestuia pe Vehicule Echipate cu Motoare cu Ardere Internă ", Authors:**Borza P.N**., Carp M.C., Traian S. C. Proprietar: Universitatea Transilvania din Braşov (in the legal depot frame)

[66]**Borza P.N,** Carp C., PuşcaşA.M, Szekely I., Nicolae G., Energy Management System based on supercapacitors used for starting of internal combustion engines of LDH1250 locomotives and charging their batteries pag. 227-232, Conference Proceedings ISSN 1843-5122, International Symposium for Design and Technology of Electronic Packages 14th Edition, Brasov, Romania 2008

[67]Carp M. C., Puscas, A. M., **Borza P. N**.,Energy Management System and Controlling Methods for a LDH1250HP Diesel Locomotive Based on Supercapacitors, 2nd IFIP WG 5.5/SOCOLNET Doctoral Conference on Computing, Electrical and Industrial TECHNOLOGICAL INNOVATION FOR SUSTAINABILITY Book Series: IFIP Advances in Information and Communication Technology Volume: 349 Pages: 429-436

[68]Carp M.C, Puscas A.M., Kertesz C., Romanca M.**Borza P.N.,** Monitoring system and intelligent control system used in the starting process of a LDH1250HP locomotive, Optimization of Electrical and Electronic Equipment (OPTIM), 2010 12th International Conference on Optimization of Electrical and Electronic Equipment, Pages: 551-556 Published: 2010

[69]Contract nr. D2-1-018/2007, PN2, **Borza PN** director, Program 4 "Parteneriate în domenii prioritare", Sisteme electrice optimizate energetic pentru transportul terestru utilizând baterii si super-condensatori, TRANS-SUPERCAP", 2007-2010, coordonator tehnic(1.990.000 RON)

where maintained applying for other three four seconds the battery voltage on the same starting motor.

An improved control system, based on computer and embedded systems assured the sequence necessary to be implemented by the power commutation electronics (SCRs at 1200V/1900A, and IGBTs at 1200V/1200A). The pulse power applied to the starting electrical motor were more than 130kW with around 1500A peak current, and the total amount of energy necessary for achieving the starting process were in any situations below 210kJ. That is remarkable is the fact that this prototype has starting in various environmental condition, all the time at the "first key", even when the batteries voltage goes significantly below 96V (86V damaged batteries) that were the nominal voltage of the electrical system.

The implemented prototype, during more than five years were improved permanently based on the more than 1000 starting cycles executed at Brasov depot of locomotives.

Some details related the hardware design and also several improvements of the system during the years of implementation and functioning of the locomotive are presented below.

The initial electric scheme of the starting system is shown in Figure 19.

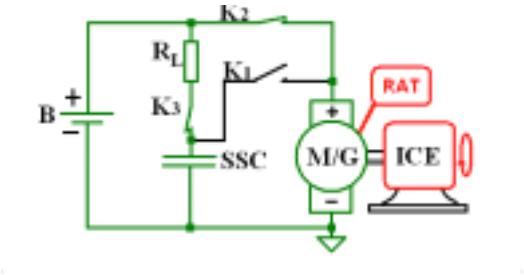

Figure 19. Schematics of starting system endowed with supercapacitor & battery for locomotive LDH1250HP

The batteries, R_L, K_3 and supercapacitor (SSC) form the charging circuit of the starting system. By switch on K_1 the SSC will be discharge on the starting motor. When K_2 will be switch on the continuity in supplying of motor will be assured till the Internal Combustion Engine (ICE) will start.

The implementation on the locomotive suffered during experimental works several improvements. In Figure 20 are presented several images of first implementation, where is placed the hybrid storage system, how look the control panel and implementation of Human Machine Interface (HMI) of the system.

The prototype was tested and afterward improved in case of the real working conditions during more than 7 years. One of PhD students that I co-supervized, Marius Carp was developed in cooperation with me a monitoring system accessed remotely by Internet. The monitoring system block diagram is shown in Figure 21. Mainly this was a data acquisition system and this has monitored the following signals: voltage and currents on supercapacitors, the locomotive' batteries and his starting-motor, temperature of batteries and of the supercapacitor packs and the rotation speed of the ICE. This last signal is used also as leading signal inside the electronics of the starting for controlling the end of starting process.

Figure 20. Pictures with some details of starting-system implementation on LDH1250HP shunting locomotive

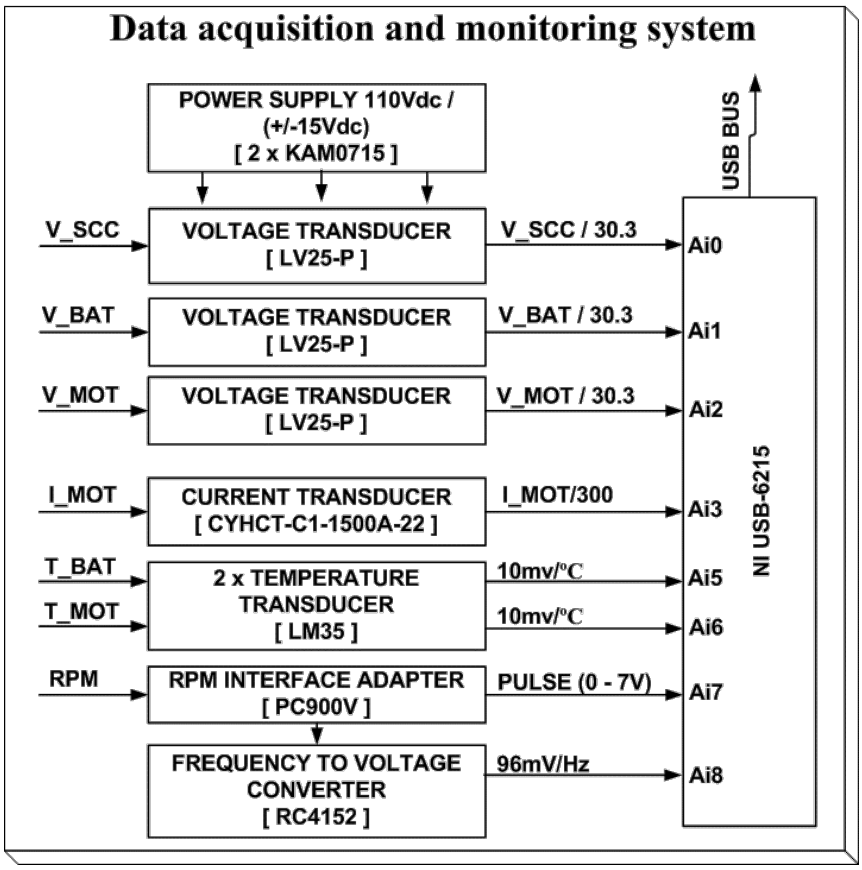

Figure 21. Monitoring system of LDH1250HP locomotive

The results of more than 1300 tests are shown in Figure 22. These illustrate a significant reduction of the maximum current provided by the locomotive' batteries pack that is more than five time low during starting process of locomotive. The consequences are a significant increase of life-span of batteries, a better reliability and better availability of storage system and a reduction

of the over temperature produced on batteries as result of the starting process. All these factors shown an important overall features improvement for the starting system.

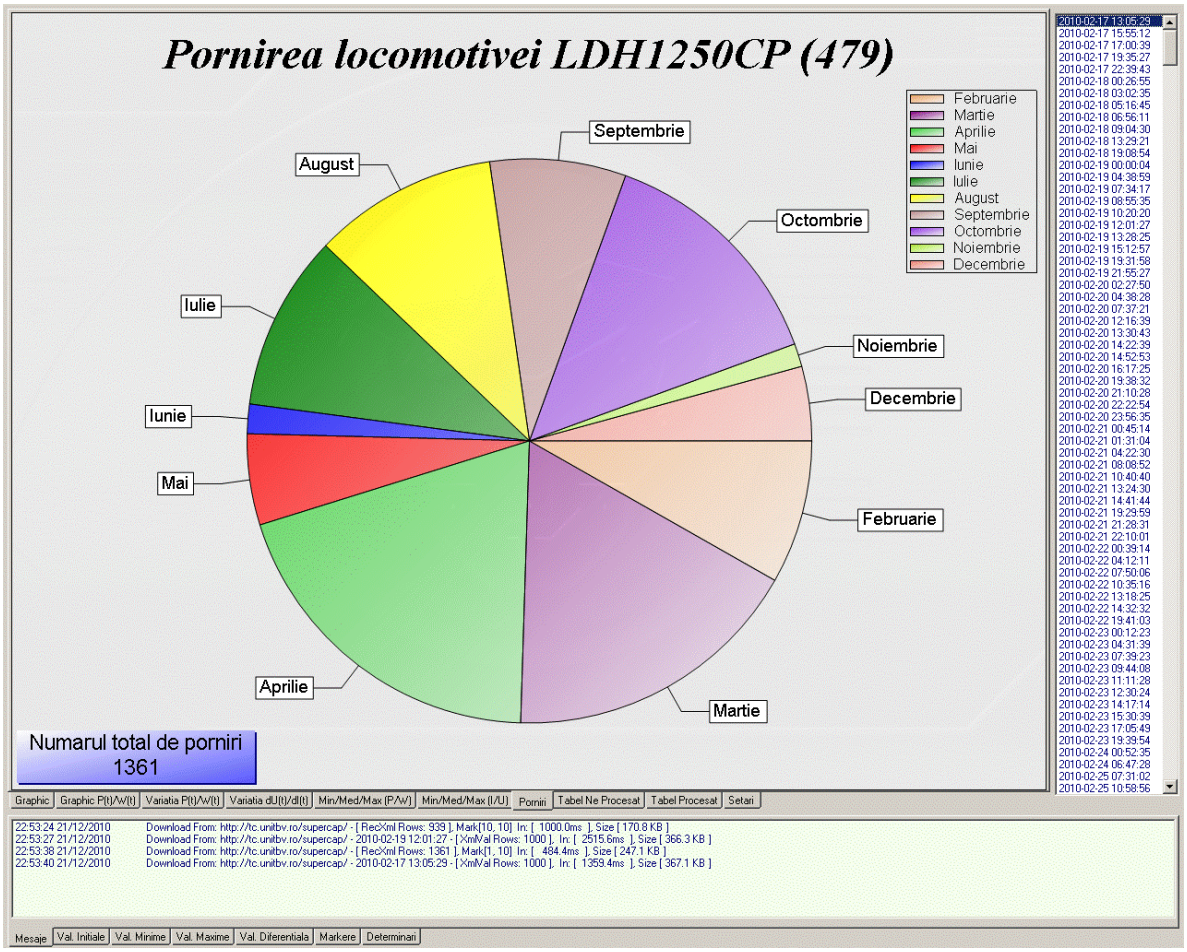

Figure 22. Number of starting cycles of LDH1250HP locomotive during one year (total number 1361 cycles) work provided by M Carp at Brasov locomotive depot.

During the tests, some interesting conclusions were arosed. Thus, the complementarity of ICE engine, in our case diesel engine and the characteristics of the staring system easier the starting process. In all the testing conditions that were relatively variate the energy consumed for the whole starting process were almost the same, respectively around 210 kJ. The *initial storage system capacitance* was reduced with *more than 50%* from 320 Ah/96V to 150 Ah/96V changing simultaneously the type of batteries from special, traction batteries to car batteries for the storage system pack. The life-span of batteries was increased with more than 70% and the temperature domain were significantly extended from 0÷45°C to -20°C to 55°C.

Interesting phenomena reflecting the compliance improvement of the storage system is illustrated in Figure 23 where are shown the diagrams of currents, voltage, on the different starting system elements. Thus, the supercapacitors as is shown in Figure 23 can, without significant loses, to recuperate the energy produced during starting process by the ICE and this energy is provided back the the starter storage system.

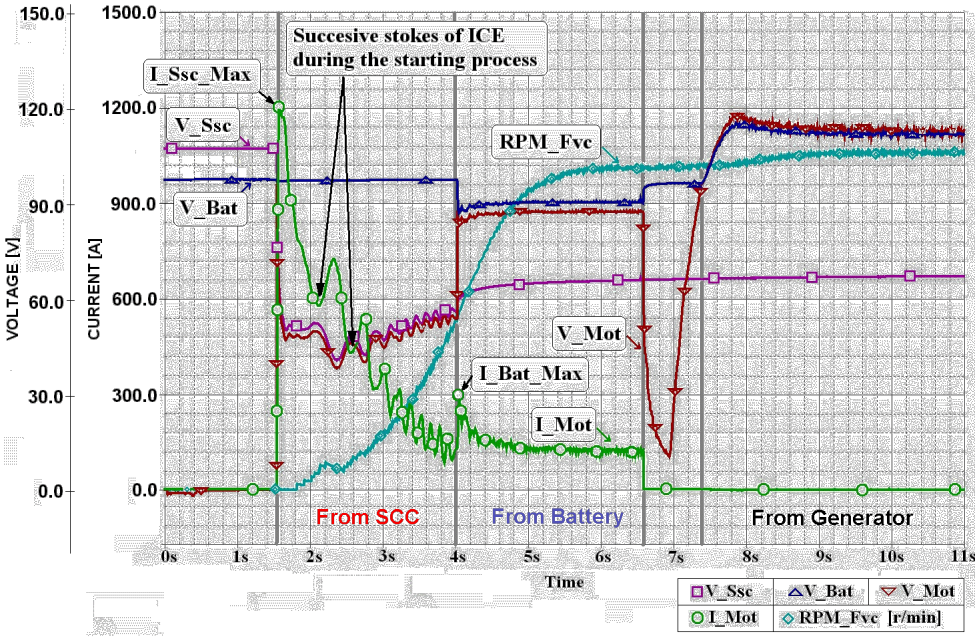

Figure 23. Records of the main LDH1250HP parameters during strating process. (measurements done by M Carp)

V_Bat is voltage variation on locomotive 'battery pack; V_Ssc is the voltage variation on stacked supercapacitor pack; I_{Ssc_Max} is the extreme value reached during starting process and supplied by supercapacitor pack; at second 4 the starting-system will commute from supercapacitor to battery, and I_{Bat_Max} is the maximum current supplied by the battery's pack; RPM_Fvc represents the rotation speed of the motor and V_Mot is the voltage on the starting motor. Should be mention that the starting motor is a special one, because this has two different excitation coils, one connected in series and the second one connected in parallel. Thus, during the starting of ICE, this permit a functioning regime as series excited DC motor, with a very important starting torque, and afterward on the same motor will activated the parallel excitation coil, and has being moved by ICE this electric machine become DC generator. The power of this electric machine is around 25kW.

A sigle detail is very interesting and in fact illustrated the performance obtained by the hybrid storage system, this is the ratio $_{Imax\_Ssc}$ and between $_{IMax\_Bat}$. In our case this valued durng more than 1000 tests was between 5 to 6 times, that means that all the "stress" of battery as result of current pulse was reduced significantly, increasing the batteries'pack life-span.

To conclude, the system implemented assured *a reduction between 15 and 25% of the daily consumption of fuels* in normal exploitation conditions that make possible the recuperation of investments in half of a year. The patent filed on management of energy system, as continuation of our works protect the original ideas consisting in improvement of the energy efficiency of the train's power networks applying the modified starting system.

The development of the same line of research was followed in the papers that reports investigation done in the field of reconfigurable electric storage energy systems[70,71] used on electric or hybrid vehicles. In the same sense, was developed the investigation on stationary applications related to the integration of PV generators to the power grids and also in domotics[72].

A first step toward optimized integration consisted in determination of the generation patern of solar power plants function of the place where these are installed. For this reson, we have developed a methodology for sizing of the storage facilities for small applications. Going deeply in this direction we have developed a test bench system dedicated for the photovoltaic facilities[73].

[70]Musat, A. M., Carp M. C.; **Borza P. N**.; Musat R.; Dalik S., ‚Hybrid storage systems and dynamic adapting topologies for vehicle applications, Pages: 1559-1566, PROCEEDINGS OF THE 13TH INTERNATIONAL CONFERENCE ON OPTIMIZATION OF ELECTRICAL AND ELECTRONIC EQUIPMENT, VOLS 1-5

[71]Puscas, A. M., Carp, M., **Borza P.N**, Szekely I., Embedded Intelligent Structures for Energy Management in Vehicles, 2nd IFIP WG 5.5/SOCOLNET Doctoral Conference on Computing, Electrical and Industrial TECHNOLOGICAL INNOVATION FOR SUSTAINABILITY Book Series: IFIP Advances in Information and Communication Technology Volume: 349 Pages: 421-431 2011

[72]Cotfas, D.T.Cotfas, P. A., **Borza, P.N** Ursutiu, D., Samoila, C., WIRELESS SYSTEM FOR MONITORING THE SOLAR RADIATION, ENVIRONMENTAL ENGINEERING AND MANAGEMENT JOURNAL, Volume: 10 Issue: 8 Pages: 1133-1137 Published: AUG 2011 ImpactFactor 1.008

[73]Borza, P.N.; Cotfas, P.A.; Cotfas, D.T.,PV Cells Test Bench System with Remote Access Trough Internet, Conference: 13th International Conference on Optimization of Electrical and Electronic Equipment Location: Brasov, ROMANIA May 2014

Chapter 4. Education, teaching, coaching and training activities

Educational activities

During my activity as professor I have participate at the education of more than 30 generation of students, in the frame of fine mechanics, mechatronics, electronics and computer engineering Departments of Transilvania University of Brasov and at other universities abroad Romania. Also, for the period 2002-2005 I have built-up a research team name E&I (Energy&Information), formed by around 35 researchers in the frame of Siemens PSE Romania. This group was dedicated for research, design and programming of the systems dedicated for power networks control, management of energy and new technologies in electrical traction in the frame of Siemens company. We have improved several components of the SINAUT Spectrum power network management program including power flow optimization modules. For a period of four years, I was member of Corporate Technology group Siemens AG where I have contributed at the technology management of Siemens AG in the domain of electric engineering, with a special accent put on storage of energy and management of the power transport and distribution. With this occasion, I was responsible for re-evaluation of storage technologies inside company.

At international level, I have managed as vice-chair two COST projects (Action 542 and MP1004) dedicated for electric storage technologies and respectively for development of hybrid electric storage systems. With this occasion, I have organized a series of "think-thank" meetings with the early stage researcher at Transilvania University of Brasov, Romania, at Herriot Watt University Glasgow, UK, at IRETS Satory, France coaching more than 100 researchers. Also, in the same frame I have organized four training schools in Romania, Spain, France and Norway where I have talked about the management of the power networks and the role of the electric hybrid storage systems and potential analogies between the bio-systems and the storage of energy and/or power networks.

In the frame of Master School organized on RES Systems at TEI of Western Greece, Patra, Greece, from 2004, each year I was invited to talk, to susitain cources and laboratories about Domotics and Management of energy in building and other related topics.

As result of a bilateral cooperation between my university and Armstrong Atlantic University Savannah, USA in 2016 I was invited to have a talk about the electric storage systems applied for RES integration into the power grids.

In Romania, at two international conferences I was invited as keynote speaker, the topical approached were the followings:

- "Non-Boolean Computing Perspective in The Light of Last Development in Condensed Matter" at International Conference on Theory and Applications in Mathematics and InformaticsICTAMI'2015, Alba Iulia, Romania
- Review of the actual technologies for Autonomous and for Perpetuity Smart Sensors at International Symposium for Design and Technology in Electronic Packaging, SIITME'2015, Brasov, Romania

Coaching, training and tutoring of the young generations

Also, I have hosted, in my laboratory, for coaching and training several foreign engineers in the last few years, as follow:

- PhD. Eng. Consuelo Gragera, from Extremadura University Badajoz that has developed research theme related HESS and their applications in dumping of noise and vibrations for hybrid and electric vehicle. Her thematic were about: "Integrating mathematical models, numerical techniques and experimental measurements NVH in EV drivelines" in which she has developed a model including HESS, the adjacent power electronics and a traction in wheel" brushless electric motor.
- MSc. Eng. Sofia Sanchez Mateo, from "Miguel Hernandez" University, Elche, Spain. She in collaboration with C. Gragera and me, we have developed partially a bio-inspired model about the HESS applied on electric vehicles. This work was finalized by publishing a chapter Numerical Approaches for the NVH study of Electric and Hybrid Electric Vehicle" chapter four of the book NVH Analysis Techniques for Design and Optimization of Hybrid and Electric Vehicles published by Shaker editor, Germany.
- MS. Eng. Mihailo Milanovic, from Technical University Belgrade, has collaborated with me taking the benefits of a COST grant for three months. During his stage in my laboratory he has developed an embedded system able to assure the management of analogue and digital signals dedicated for controlling of the acting system endowed with batteries. Now he is in train to finalize his PhD thesis and will used partially the developed skills for achieving his work
- MSc. Eng. Indrajeet Prasad, from India, he has developed research activities in the field of bio-inspired electric storage system, building up partially a supervising system for and an e-bike system. As result of his good work and skills developed during about two years of collaboration in the frame of my laboratory he has been since May 2017 admitted to cooperate with a group of CERN organization, located in Czech Republic.

- PhD. Eng. Victor Herrera, from Ecuador, he has been hosted in my laboratory for three months in order to develop partially his PhD Thesis. In June 2017, he was defended with full of success his thesis at Basque Country University, San Sebastian, Spain.
  I have participated as member of Jury at the defending of his thesis. His research work has resulted in the implementation of two systems: a bus and a tramway both with hybrid power supply and storage systems in the frame of Ikerlan IK4 company.
- MSc. Eng. Vasco Gomes, from New University of Lisbon, Portugal have participated for one year in my laboratory at the development of his thesis that he will defend till end of this year. I am co-supervisor of him, collaborating in the field of standard protocols like 61850 adapted for refiting of the heritage buildings.

At Transilvania University of Brasov, during the past years I have trained and co-supervised two PhD students:

- MSc. Eng. Ana-Maria Puscas that has developed the PhD. thesis with the title: "Energetic and Functional Optimization of Combined Energy Sources", in which she details the theoretic and experimental models for combined batteries and supercapacitors power sources and their specific power electronic control systems allowing the dynamic reconfiguration of cellular storage elements. With her and his colleague Marius Carp we have published more than 7 papers in the proceedings of international conferences (see List of publications).
- MSc. Eng. Marius Catalin Carp he has developed under my coordination the prototype of the starting system for the diesel hydraulic heavy shunting locomotive LDH1250HP. His doctoral thesis illustrated the deepest understanding of the problems related hybrid systems including ICE (diesel). The locomotive's battery pack was changed introducing a hybrid electric storage system. The huge work provided to make functional the prototype, the versatility and reliability proofed by the innovative starting-system have as result several papers and a patent that intent to protect several novative solutions that allow the control automatic in real-time of the starting process of the locomotive. In collaboration with him we have filed a patent about an original energy management system on a train.

(B-ii) The evolution and development plans for career development

Generalities

The future strategy that I intent to develop is oriented to efficient implementation of innovation in a critical but, in the same time, very important domain, of electrical engineering. It is the case of electric energy storage systems and their applications. The novelties are mainly related to the following factors: the *synergies* that can be build-up by trans-domains research activities; *analysis* and *development of innovation based on living world patterns*; more *deeper fusion between the information and energy*, or in other words, *encapsulated intelligence* implemented by the new control systems. As essential factor for the improvement of actual technologies is also the fundamental research which is nowadays, in the electrical engineering, related to the nanotechnologies and fundamental physics.

All strategies for future development of research activities should take into account also on factors like: the *existing and potential of the laboratories infrastructure*, and the *human factor* that strongly influence the speed of evolution in research. Not on the last place, as importance, is situated *the research funding strategies* that suppose to find and efficient use all the opportunities related cooperation in the multiple fram like: European, trans-national and national frames. It is also ojective to understand the necessity to reach a "*critical mass*" of researchers working together for clear targets.

The supervising of the doctoral studies represents only one tools from the multiple tools necessary to be used in synergic way and, all these, should follow a vision about the future of science and technologies translated in specific development and research plans.

Today is not possible to research alone or into a small group, it is necessary to find collaborators that have and want to develop together with us the complex research activities. In this sense, I have pave the way in the field of electric storage systems, by coagulating collaboration relationships with strong international groups: Prof. Andrew Burke from Davis Institute of Transportation USA, Assoc prof. Felix Hamza Lup from Georgia Southern University, USA, Eng. Gerard Coquery from IFSTTAR France, Dr. Mario Conte from ENEA, Rome Italy, Dr. Aitor Millo from IKERLAN Spain, Prof. Joao Martins from New University Lisbon, Portugal, Prof. Peter Hall from Sheffield University and Prof. Steve Tenisson from MAST/Gildfort University UK, Prof Socrates Kaplanis from TEI and Prof. Elefterios Kayafas from NTUA Greece, etc.

The collaboration with well-known companies, like Siemens, Alstom or Orona are other potential partnerships which the working group from Transilvania University collaborated and continue the collaboration into the future.

Scientific research and technological roadmaps

Thanking into account the field of interests specified by Prof. Borza, are considered several domains of electrical engineering and electronics that should be analyzed in order to reveal the trends and potential achievments during a seven years period of time. Thus, are illustrated some steps on those evolution lines that are for the moment probable to be reaching, in the fields of:

- Storage devices and systems: Electric Storage Systems (ESS), Hybrid Electric Storage Systems (HESS):
- Controllers for ESS or HESS;
- Applications that will integrate the ESS or HESS;
- Models and methodologies necessary to optimization of ESS or HESS inside systems and their corresponding applications

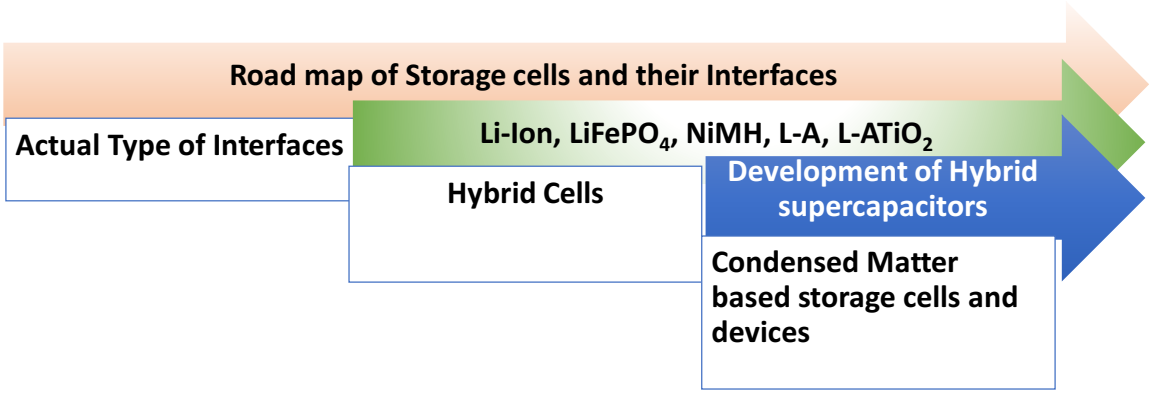

Figure 24. Scientific and technological road map for storage devices (3/5/7 years)

Figure 24 shown the preview evolution and trend related electric energy storage devices, in particular the batteries and supercapacitors.

Another cell and device not mentioned here is represented by the fuel cells (FC). For these kinds of devices in the last years a substantial research and financial effort has done. In case of fuels cells, the hydrogen or his chemical combinations researched in order to offer a significant improvement of the energetic capacitance for the storage system doesn't given semnificative results. Several factors determined the partial falling of the expectations: stability of the cell interface with the role to separate the charges for different polarities inside the device; the long start-up period of devices; the low energetic density of hydrogen; the sealing problems related the reservoirs for hydrogen; the complexity of hydride's –solid hydrogen chemical structures- able to provide hydrogen. Also, the FC functioning temperature is relatively high that make difficult to

use such devices for mobile applications. An advantage, but only for some types of cells is represented by the "reversibility" of cell, is the case of PEM – FC that function also at relatively low temperatures <60°C.

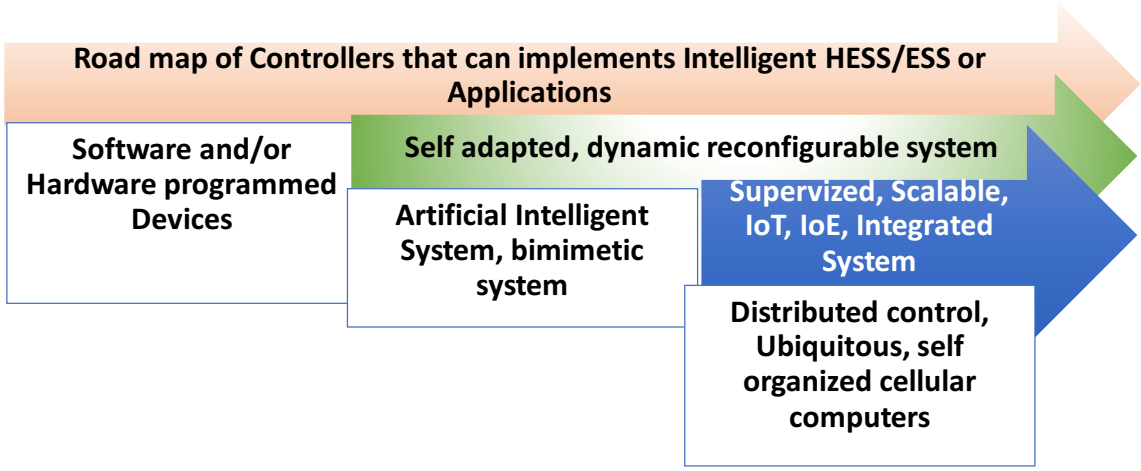

Figure 25. Road map of ESS/HESS systems for a 7 years time-horizon

Figure 25**,** shown the most probable evolution of the ICT and embedded systems necessary to implement the intelligent, scalable, versatile and award based control systems for Intelligent electric storage systems (ESS/HESS) both for themselves and, in conjunction with other systems with which they are hierarchically organized. The behavioral complexity of the electric storage system, made from them, one of the most complex technical systems today. Especialy the aspects related aging process of ESS/HESS, the strategies for control of the power/energy supplied are important issues that will be revelead by the future work. In this sense, several development phasescan represent the approach on the way to innovative solutions. Embedding of the basic functionalities inside the HESS/ESS, charging discharging controllers, the potential balancing systems able to prevent overcurrents or overvoltages on storage system cells. Also, the temperature monitoring of each cell is mandatory in order to avoid fast aging or degradation of ESS/HESS parameters. The solutions will be based on characteristic determination for each type of cell. It will be necessary to take into consideration the parameter dispersion for each type of storage cell and the modeling and potential new methodologies for maintaining into an acceptable parameter variation will be considered in the near future.

The spectrum of applications that will be approach in the future years is illustrated in Figure 26. These applications will cover from intelligent sensors till intelligent actuators all the systems'components able to offer flexibility, rebliavility, scalability and quality of actions.

The insulated systems or the systems, that are only periodically energized, are mainly represented by vehicles, from personal vehicle to heavy vehicles. For each of them specific solutions can be research and developed using ESS or HESS or combination between these and classical connected to the grid solutions.

The energy management into the building is a very important field of development in the new future, with huge economic and energetic potential. Starting from actual "prosumers" that are implemented at the buildings level to the complex integration of the functionalities inside buidings as "smart buildings solutions" or at the next level as smart power grids and/or cities represents many other research field where the optimization of efficient methodologies for energy management are crucial factors for evolution of society. To conclude, and repeat again, *the fusion between information&energy"is the patway for overall improvements in energy management*.

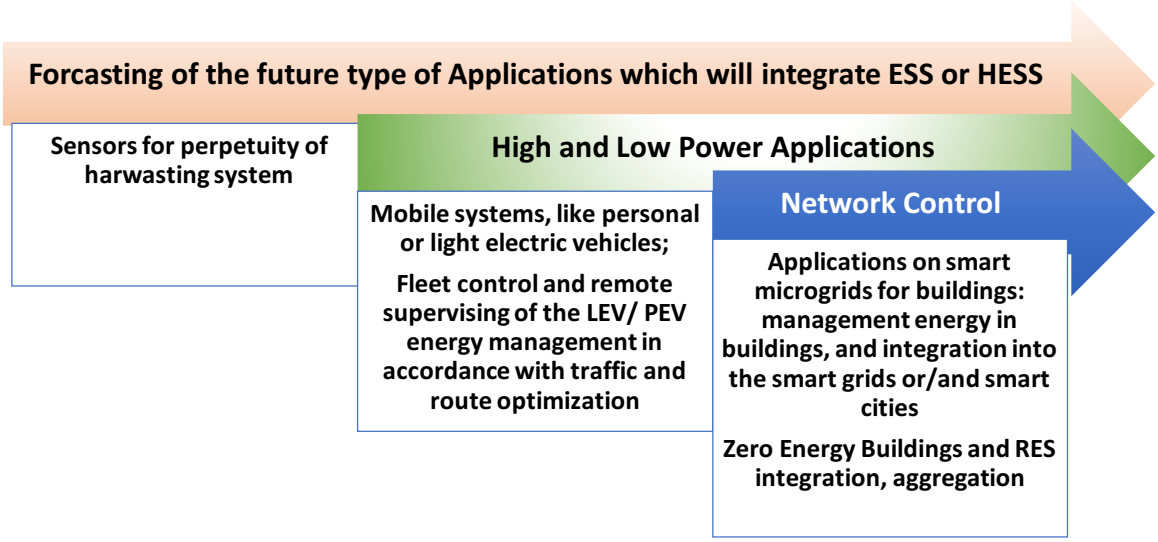

Figure 26. Forcasting of the potential applications that can be approached by Prof. Borza team in the future 3, 5 7 years

A last investigated domain, represents the models and methodologies related ESS/HESS implementation in different applications (Figure 27). Related this road map, the software and firmware evolution is essential in order to obtain optimized solutions. In this sense, as above was mentioned, the living systems will represent validated, optimized and perfect adequate solutions for technical application implementations. A significant issue is related to the deep understanding of all analogies that can be done between biological and technical systems. Several methodologies can be mentioned as potential future solutions for optimized implementation of applications. Those can be: neural network based algorithms for automatic classification of the ESS/HESS successive stages; genetic algorithms for identifing specific sequencess and strategies for the optimized

algorithms; superization of the information and rule based algorithms for flexible control of the ESS/HESS and their applications, etc.

In all these models, and important theoretical advance will be represented by the integration necessary to be done between the *structural and functional optimization of the processes*.

Compared to other domains, in the case of ESS, *it is essential to benchmark functional models in relation to integral parameters*: energy, heating of the system's masses, and to optimize instantaneous (voltage, temperature, current, time), parameters too which at their turn, can affect the *reliability, availability and flexibility* of system solutions.

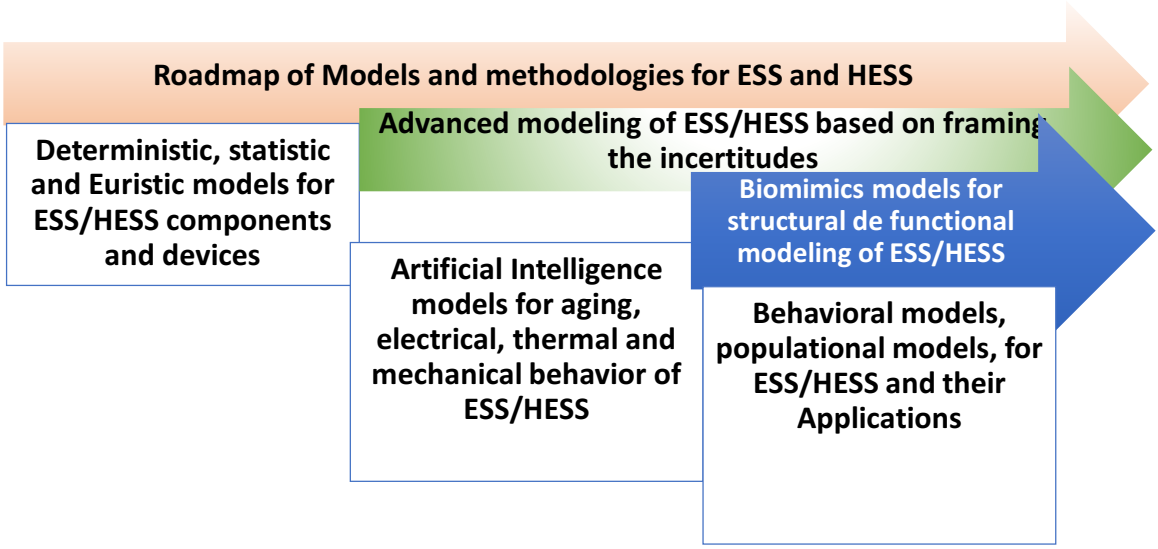

Figure 27. Modeling and methodologies for ESS/HESS system and their software implementations (3/5/7 years perpective)

Looking forward, the progress in the domains of nanotechnologies and physics will be transformed in technological turn on that will generate important changes at the level of power electronic devices, storage cells, more light and strong structures that will influence without doubts the future evolution of my targeted field. It is enough to mention the progress obtained by growing the graphene structures at the level of current collector of supercapacitors that already generate significant improvement of ESR and stability of the supercapacitor cell.

Concluding, the target domain is a complex, emergent, and essential for the improvement of all components of the electrical engineering domain, from special electric machine, other types of electromagnetic actuators, to power grids at all voltage levels, electric traction systems, elevators, home appliances, renewable energy sources, that all takes the benefits of ESS and HESS insertion.

For the RES domain, and also for the balancing of the smart grids, ancillary services like: primary response frequency, secondary frequency response, voltage support, islanding capacity black start capability, short-circuit power, oscillating dumping, ramp control, peak load management, Gen-Set optimization, etc., the insertion of the power compensators based on batteries or combination batteries and supercapacitors (see SWEMAG 5MW/5MWh)[74] can generate savings equivalent with the running of a classical power plant at 70MW capacity.

The nano, mini grids built-up inside building of near of them will be suffer great improvements in the near future, based on extended deployment of the electric energy storage systems. The ESS/HESS will play an essential role, will increase the quality of energy supplied, will permit an easier integration of the renewable energy sources, and also, the possible charging stations for electrical vehicles being connected with the building. The actual implementations are modular developed, integrating not only the electric and electronics parts but also the thermal, mechanical parts that are together dedicated for the ESS/HESS. Only a holistic image will assure in the future the achievement of the overall optimized features and parameters. The energetic capacity of these systems variate for a personal building between 2 to 3kWh. Inclusion of the ESS/HESS is interesting, because allows to build-up mixed building power networks that can be implemented, respectively, can functioning, together AC and DC nets that will bring a better energy efficiency and an easier way to integrate some home appliances into the networks.

To conclude, the roadmaps, the vision based on holistic analysis of the actual scientifical and technological progress, the development of the education and training activities, the coagulation of R&D cooperation by the multiples plans with well know groups at international level is the aim proposed for R&D activities in the future fel years. By the development of an actual, accurate and adequate vision about R&D followed by clear development plans will assures in the near future the achievement of the research group aims and goals.

[74]*** Yunicos – Stepen L., “Mapping the Future of Energy Storage in European Energy Markets, ESUE London Nov.2015 presentation

Personal career development plans

My self, I consider that the future activities will be oriented to four main activities:

1. To provide educational and training services for PhD and MSc students and also for peoples during their know-how updating along their life Life Long Learning, (LLL).
2. To provide research activities and coordinate the development of the electric energy storage systems and their applications
3. To provide consultance services for the authorities and private companies
4. To develop, by applications implemented, the technology transfer, disseminate and updated the know-how (outreach activities).

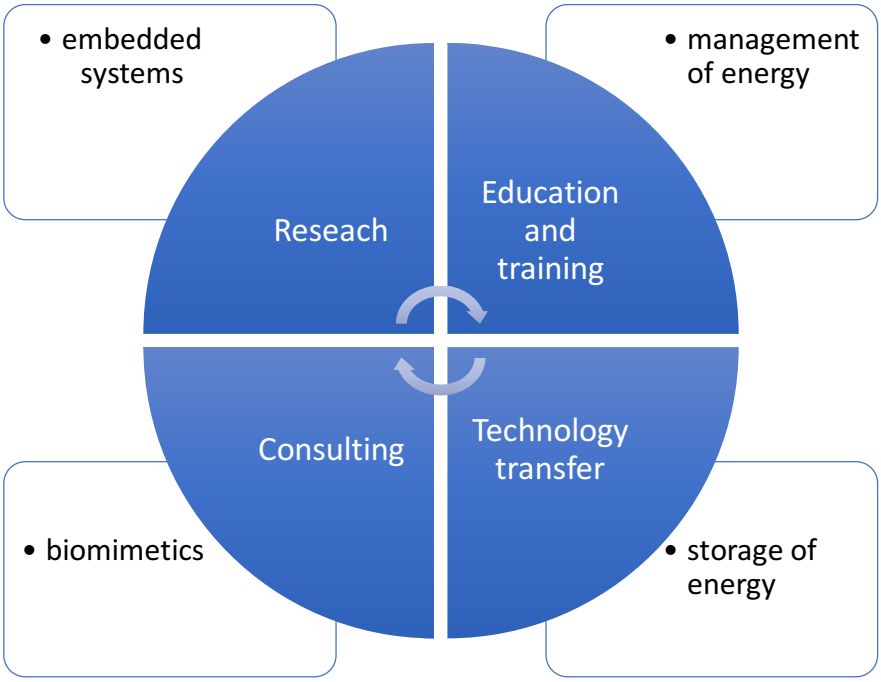

Figure 28. Prof. Borza Field of interest and related activities

For the development of my career I have proposed a "personal" research and technological “radar” (see Figure 24, Figure 25, Figure 26, Figure 27), including the work plans for a seven years period. This plan has as aim to orient research and find out innovative solutions for energy management having as source of inspiration the paradigms revealed by the living systems. Those applications are related to the home appliance applications and their improvement in order to assures the optimal information and power flows inside buildings (especially for Zero Energy Buildings ZEB types) and also for smart power grids. Thus, a new series of wireless sensors will work autonomously. These will include energy harvesting facilities; will be developing in order to increasing the signals matrix used into the control models and for taken the fundamental decisions in generation, conversion and consumption of the energy. These data will be processed in case of buildings and also in case of electric or

hybrid vehicles. Together with the enriched modeling of processes in close correspondence with the biological systems, the future proposals for PhD thesis subject will include a deeply analysis for implementation of storage facilities inside the networks, buildings, vehicles and other systems that can take the benefits of electric energy storage.

I will try, gradualy to reach the proposed goals (see Figure 29). Among the various sub-domains of electrical engineering, I considers that a large part of these themes and researchs will be focus on the development of *electrical energy storage systems* by *characterizing* them and *implementing dedicated control systems*, *energy management* for *stationary applications* such us buildings endowed with *smart hybrid electric storage*, *insulated generation systems* dedicated for fare a way working points, "***energy cubes***" dedicated for efficient integration of Renewable Energy Sources and *mobile applications* such as electric personal transportation systems, *hybrid buses*, *hybrid elevators* systems.

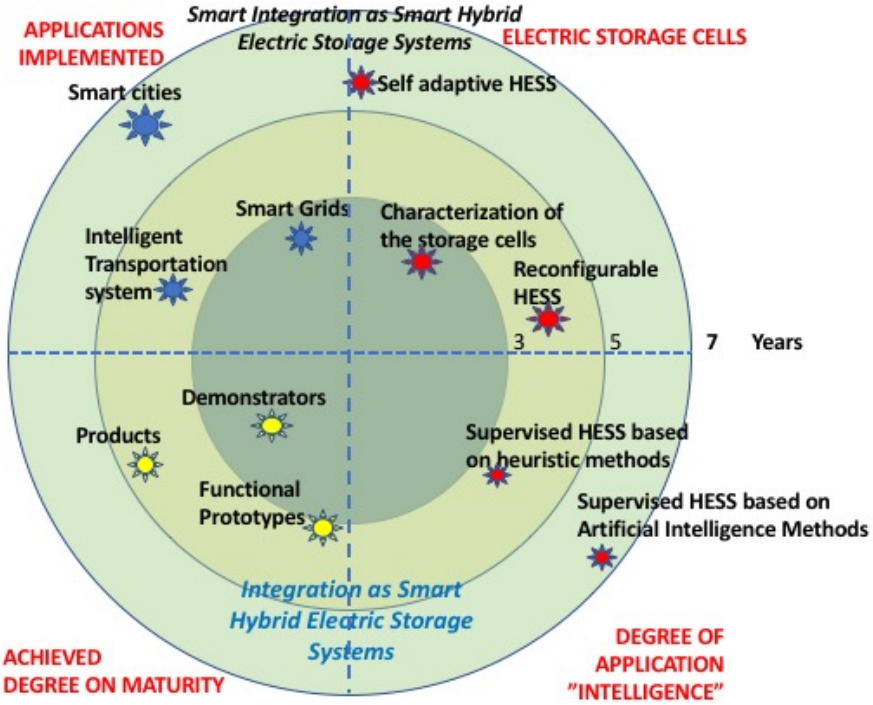

Figure 29. (Hybrid) Electric Energy Storage Systems - technology roadmap, Applications, Evolution

The development of career will tackle the classical stages in case of ESS or HESS: architectural design, sizing, reliability design and analysis, ESS/HESS modelling in correlation with system modelling, prediction of most frequent demands and possible system' stages. The functional research and design will be oriented to the development of control functions that are will keep inside the constraints all the instantaneous system 'parameters.

As is shown in Figure 29 the approach is gradual, starting from implementation of deterministic and/or statistic models the design (on the research pathway), at component and system levels. This will be followed by behavioral analysis where the living systems

methodologies will pay an important role in technical system'optimization (development based on mimicity).

The modularity, scalability, flexibility, reliability and availability, all of these features will be improved on the innovative researched solutions.

Applying these improvments from components, sub-systems till the whole system, the "organicity"obtained for the system will made this more resilient for the large variety of excitation signals.

Will be researched methods like: compensation, self healing, self reconfigurable methodologies, let say, self adaptive facilities for the targeted design. Also, the models for integration will use statistical and/or populational control of system'components, that are similar with the biocenosis occured in case of living systems.

The whole spectrum of methodologies, from deterministic modelling, to artifficial intelligence, or hierarchical supervized systems will be considered and researched.

The targets of the proposed researches illustrated by my personal career development plan cover: stationary applications, mobile applications, smart sensors and actuators closely related the the first two main application classes.

By attacking the research and technologies at inter-domains levels my research plan intent to stimulate the innovation on the pathway to development of the new solutions of energy management, in implementation of ESS/HESS and their applications. The original color will be printed out by the source of inspiration intented to be use, respectively the living systems.

Means to reach the proposed research and development objectives

As is illustrated in Figure 29, the future R&D objectives are ancored into actual research and technological trends. Regarding the management of research, I consider that these development into a wider circle both at national and international level, in synchronism with the vision of development will be beneffic for my research team. At the same time, it attaches great importance to the dissemination of research, the development of modern formative methodologies in higher education, as well as to the cultivation of new researchers and better adequate infrastructure for them, all of which will be fundamental objectives.

In this context, I consider permanent cooperation and cooperation as deep and possible with groups of researchers and laboratories from abroad, such as ENEA, IFSTTAR, IK4, Frauenhoffer, etc.

The practical goal targeted will be to reach a "critical mass" that which will be touch all the reserch specific points: human, technological and infrastructure necessary for providing competititve good quality research

(B-iii) Bibliography

[1]. Restian, Borza P., Daghie V., Nicolau N., Patent „Metodă şi aparat de solicitare informaţională a organismelor vii", Brevet RO93122 OSIM, 1987

[2]. A Restian, "Medicina Cibernetica", Editura Dacia Cluj, 1983

[3]. Borza P N, Demeter A, Instalatie pentru studiul stabilitatii punctului de ochire la tir, pg. 74-79, COMEFIN2 vol II Aparate Optice, Institutul Politehnic Bucuresti & ICSITMFS Bucuresti, 1986

[4]. Borza P N, Achim I, Bicicleta ergometrica cu compex de testare a capacitatii de efort la sportivi, pg-208-209, COMEFIN2 vol II Aparate Optice, Institutul Politehnic Bucuresti & ICSITMFS Bucuresti, 1986

[5]. Eric P. Widmaier, Hershel Raff, Kevin T. Strang "Human Physiology the Mechanism of Body Function ", 9th Edition

[6]. S.A.L.M. Kooijman, Dynamic Energy Budget theory for metabolic organisation, Cambridge University Press 2009, Third Edition, ISBN 0 521 45223 6

[7]. Brooks, G. A., Fahey, T. D., White, T. P., Exercise physiology: human bioenergetics and its applications, ISBN 1-55934-365-6 Myfield 1995

[8]. PN Borza, I. Prasad, S. Sanchez-Mateo, M. Kadar, A Biological Approach for Energy Management in Smart Grid and Hybrid Energy Storage Systems, pp 821-829, International Journal of Scientific & Engineering Research, Volume 7, Issue 3, March-2016, ISSN 2229-5518

[9]. D. Ragone, Review of Battery Systems for Electrically PoweredVehicles, Society of Automotive Engineers, (1968)

[10]. Bernard C., An Introduction to the Study of Experimental Medicine, Dower Pub. Inc, New York, 1957 –first published in 1857

[11]. Sterling, P. (2004). Principles of allostasis: optimal design, predictive regulation, pathophysiology, and rational therapeutics. Allostasis, 1– 36. doi: citeulike-article-id:2392029

[12]. Prasad I., Borza P.N., Herrera V.I., Milo A., Energy Management of Hybrid Energy Storage System for e-bike application, CISTEM 2016 –IEEE Conference, Marrakesh, Marocco.

[13]. Dumitriu A, Borza P, Marin I, Solutii pentru cuplarea spectrofotometrelor la calculatoare externe, pg88-91, COMEFIN2 vol II Aparate Optice, Institutul Politehnic Bucuresti & ICSITMFS Bucuresti, 1986.

[14]. Borza P N, Matlac I, Principii ale implementarii tehnicii de calcul in aparatura de laborator, pg.210-214, COMEFIN2 vol II Aparate Optice, Institutul Politehnic Bucuresti & ICSITMFS Bucuresti, 1986.

[15]. Borza PN, Director proiect cercetare - Cercetarea, proiectarea şi execuţia sistemului de urmărire a încărcării morii de făină şi integrarea acestuia în sistemul de supervizare a dozării materiilor prime pentru o linie de fabricaţie in industria cimentului (106-1994).

[16]. Borza P.N, director proiect - Proiectarea, realizarea, testarea unui sistem de dozare automată a materiilor prime utilizate la fabricarea pastei ceramice pentru izolatorii de joasă şi medie tensiune la EL-CO SA Tg. Secuiesc. Precizia de dozare 0,05%. Valoare 1.900.000 ROL, beneficiar EL-CO Tg Secuiesc.

[17]. M.C. Carp, Borza P. N., Puscas A.M., Smart Development Platform for Embedded Systems, pag 217-222, Conference Proceedings ISSN 1843-5122, International Symposium for Design and Technology of Electronic Packages 14th Edition, Brasov, Romania, 2008.

[18]. Stavăr, Borza P.N., Carp M.C., Puşcaş A.M., Pulse oximetry, a method of monitoring heart disease patients, pag. 232-237, Conference Proceedings ISSN 1843-5122, International Symposium for Design and Technology of Electronic Packages 14th Edition, Brasov, Romania, 2008.

[19]. M. Puscas, Borza P.N., Carp M, Pana Ghe. Energy Efficient ECG Signal Acquisition Channel for Ambulatory Patient's Monitoring, pag.212-217, Conference Proceedings ISSN 1843-5122, International Symposium for Design and Technology of Electronic Packages 14th Edition, Brasov, Romania, 2008.

[20]. Contract Hidroelectrica: Sistem de metering al serviciilor de sistem beneficiar Hidroelectrica Romania nr.490-11.2003 (aplicaţia S7-120R), responsabil de proiect din partea Siemens PSE –Borza P.N., in colaborare: Siemens PSE, Landis & Gyr Elvetia si ECRO Bucuresti.

[21]. Leonardo da Vinci, proiect Nr. RO/99/2/07267/PL/II.1.2b/FPI, TECH-REDIVIVA, **Borza P.N**. membru, (1999-2000).

[22]. Sandu F, W. Szabo, Borza P.N, Automated Measurement Laboratory Accesssed by Internet, Proceedings of the XVI IMEKO World Congress, 2000, Vienna, Austria.

[23]. Kayafas E., Sandu F., Patimiotakis I, Borza P.N., Approach to programming for Telemeasurements, Proceedings of the XVII IMEKO World Congress, 2001, Lisbon, Portugal.

[24]. Sandu F, D.N. Robu, Borza P.N., Szabo W., Twin-microcontroller GSM MODEM Development System, Proceedings of the 8th Internationala Conference of Optimization of Electric and Electronic Equipment OPTIM2012, Brasov, Romania.

[25]. Rodriguez-Martinez L, Omar N., Emerging Nanotechnologies in Rechargeable Energy Storage Systems, Elsevier, Radarweg 29, PO Box 211, 1000 AE Amsterdam, Netherlands, 2017, ISBN: 978-0-323-42977-1(Borza P.N. is author of chapter 9 of the book).

[26]. G. Fuch, B. Lunz, M. Leuthold, D.U. Sauer, technology overview on electricity storage: overview on the potential and on the deployment perspectives of electricity storage technologies, on behalf of Smart Energy for Europe Platform GmbH (SEFEP), Institute for Power Electronics and Electrical Drives (ISEA), RWTH Aachen University, Germany, 2012.

[27]. Facts and figures. Available from: http://energystorage.org/energy-storage/facts-figures

[28]. S. Rael, B. Davat, and F. Belhachemi, "Supercondensateurs a couche double electrique, principe de fonctionnement et comportamenelectrique", Journees Electrotechniques du Club EEA, Cachan, pp. 57-67, March 2002.

[29]. S.W. Novis, and L. McCloskey, "Non-aqueous electrolytes for electrical storage devices", Patent, Philadelphia, US, 2005.

[30]. V. Khomenko, E. Raymundo-Pinero, and F. Béguin, "Optimization of an asymmetric manganese oxide/activated carbon capacitor working at 2 V in aqueous medium", Carbon, vol. 153, pp. 183-190, 2006.

[31]. F. Beguin, and E. Frackowiak, Carbons for electrochemical energy storage and conversion systems. Advanced Materials and technologies, Series CRC Press Taylor and Francisc Group: Philadelphia, USA, 2010, pp.8.

[32]. J. Chmiola, G. Yushin, Y. Gogotsi, C. Portet, P. Simon, and P.L. Taberna, "Anomalous increase in carbon capacitance at pore sizes less than 1 nanometer", Science, vol. 313, nr. 5794, 2006, pp. 1760-1763.

[33]. M. Toupin, D. Belanger, I.R. Hill, and D. Quinn, "Performance of experimental carbon blacks in aqueous supercapacitors", Journal of Power Sources, vol. 140, 2005, pp. 203-210.

[34]. U.K. Sur, Recent trends in electrochemical science and technology, in: Yu. M. Volfkovich, A.A. Mikhailin, D.A. Bograchev, V.E. Sosenkin, V.S. Bagotsky (Eds.), Studies of Supercapacitor Carbon Electrodes with High Pseudocapacitance, InTech, 2012.

[35]. Burke, H. Zhao, Applications of Supercapacitors in Electric and Hybrid Vehicles, Research Report-ITS-RR-15-09, presented at EESCAP2015, Brasov, Romania, 2015.

[36]. Andrea, Ferrari, et al. Science and technology roadmap for graphene, related two-dimensional crystals, and hybrid systems, Nanoscale 7 (11) (2015) 4587–5062.

[37]. E. Fermi, Thermodynamics, Prentice-Hall, Englewood-Cliffs, NJ, (1937).

[38]. J. Wang, Modern Thermodynamics Based on the Extended Carnot Theorem, Springer, Berlin, (2012).

[39]. V. Pop, H.D. Bergveld, D. Danilov, P.P.L. Regtien, P.H.L. Notten, Battery Management Systems, Accurate State of Charge Indication for Battery Powered Application, Philips Research, Springer, 2008.

[40]. C.C. Christianson, R.F. Bourke, Battery state of charge gauge, US Patent 3,946,299, 1975.

[41]. EP1796199-A1-European Patent 2007, Borza P N Electric power cell, Owner: SIEMENS OESTEREICH AG, Filed: 12.2005 (Free Patent - ISI Web of Knowledge)

[42]. Musat A.M, Musta R., Carp M, Borza P.N, Coquery G., Characterization of the Organic and Inorganic Supercapacitors, Proceedings of IEEE Optim Conference, 2012, pp1545-1552, ISBN 978-1-4673-1653-8/12

[43]. Patent filed OSIM A/0011119/04.02.2009- " Sistem de Management Energetic si Metoda de Gestiune a Functionarii acestuia pe Vehicule Echipate cu Motoare cu Ardere Internă ", Authors: Borza P.N., Carp M.C., Traian S. C. Proprietar: Universitatea Transilvania din Brașov (in the legal depot frame)

[44]. Borza P.N, Carp C., PuşcaşA.M, Szekely I., Nicolae G., Energy Management System based on supercapacitors used for starting of internal combustion engines of LDH1250 locomotives and charging their batteries pag. 227-232, Conference Proceedings ISSN 1843-5122, International Symposium for Design and Technology of Electronic Packages 14th Edition, Brasov, Romania, 2008

[45]. Carp M. C., Puscas, A. M., Borza P. N., Energy Management System and Controlling Methods for a LDH1250HP Diesel Locomotive Based on Supercapacitors, 2nd IFIP WG 5.5/SOCOLNET Doctoral Conference on Computing, Electrical and Industrial Technological Innovation for Sustainability Book Series: IFIP Advances in Information and Communication Technology Volume: 349 Pages: 429-436

[46]. Carp M.C, Puscas A.M., Kertesz C., Romanca M., Borza P.N., Monitoring system and intelligent control system used in the starting process of a LDH1250HP locomotive, Optimization of Electrical and Electronic Equipment (OPTIM), 2010 12th International

Conference on Optimization of Electrical and Electronic Equipment, Pages: 551-556 Published: 2010

[47]. Contract nr. D2-1-018/2007, PN2, Borza PN director, Program 4 "Parteneriate în domenii prioritare", Sisteme electrice optimizate energetic pentru transportul terestru utilizând baterii si super-condensatori, TRANS-SUPERCAP", 2007-2010,

[48]. Musat, A. M., Carp M. C.; Borza P. N.; Musat R.; Dalik S., Hybrid storage systems and dynamic adapting topologies for vehicle applications, Pages: 1559-1566, Proceedings of the 13th International Conference on Optimization of Electrical And Electronic Equipment, Vols 1-5.

[49]. Puscas, A. M., Carp, M., Borza P.N, Szekely I., Embedded Intelligent Structures for Energy Management in Vehicles, 2nd IFIP WG 5.5/SOCOLNET Doctoral Conference on Computing, Electrical and Industrial Technological Innovation for Sustainability Book Series: IFIP Advances in Information and Communication Technology Volume: 349 Pages: 421-431, 2011.

[50]. Cotfas, D.T. Cotfas, P. A., Borza, P.N Ursutiu, D., Samoila, C., Wireless System for Monitoring the Solar Radiation, Environmental Engineering and Management Journal, Volume: 10 Issue: 8 Pages: 1133-1137 Published: AUG 2011 ImpactFactor 1.008.

[51]. Borza, P.N.; Cotfas, P.A.; Cotfas, D.T.,PV Cells Test Bench System with Remote Access Trough Internet, Conference: 13th International Conference on Optimization of Electrical and Electronic Equipment Location: Brasov, ROMANIA May 2014.

Acknowledgements

Prof. Borza wants to thanks for his professors, his collaborators and students with whom he has worked over the years. Also, he wants to thanks to the commission for empowerment, for the attention and the goodwill shown, during analysis of his habilitation thesis. Especially he addresses warm thanks to Prof. dr.ing. Elena Helerea for her great goodwill, attention, understanding, and constant encouragement in preparing this habilitation thesis. He addresses his warmest' thanks to her family for his wife's Clara and his son Paul Mircea, whom I sometimes lacked, but who understood to him supported and constantly encouraged