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Transformation of Electric Power System Engineering Education to Apply the Triple E-Factors

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***Abstract*—The power industry worldwide is undergoing a substantial transformation during the last two decades, where the economic optimization and friendly environmental development are the primary objectives. The deregulation of the energy markets, power trading and the upgraded and improved quality of services are the new challenges in the management and the operation of the power systems. The analysis of the electric power industry reveals that the driving forces behind its development follow the three E-factors, as designated by CIGRE, namely Engineering, Economics and Environment.**

This paper describes how the engineering education, the Albanian Power Sector and the respective Legislation are prepared to apply the triple E-factors (Engineering, Economics and Environment). Special attention is given to the graduates of the M-EPSE (Master degrees of Electric Power System Engineering) Program in order to adopt and apply the triple E-factors.

Keywords— Engineering; Economics; Environment; Education Engineering; Electric Power System; global competency.

I. INTRODUCTION

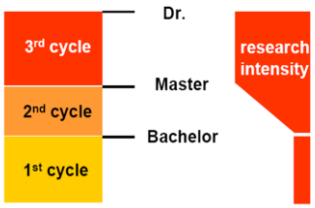
University education is shifting its focus from pure knowledge acquisition towards defining competence profiles through structuring principles of university curricula. It is not easy to define a body of knowledge that can be considered as a definitive one and as a complete foundation for the university graduate for decades to come.

Thus curricula and teaching policies are more and more focusing on the analytical, methodological, conceptual and communicational skills which will enable a university graduate to adapt to the changing requirements and be innovative throughout his or her life. Such changes of perspectives require new ways of organizing curricula and the teaching process itself.

The power industry worldwide is undergoing a substantial transformation during the last two decades, where the economic optimization and friendly environmental development are the primary objectives. The deregulation of the energy markets, power trading and the requirements for improving quality of services are the new challenges in the management and the operation of the power systems.

From Sorbonne declaration to the Meeting of London the European stakeholders have underlined the necessity of a deep reform across all European HEIs. On 2003 Minister of High Education and Science of Albania Sign the Bologna Declaration. Based on Bologna Process and its main documents new degree structure with three cycles of studies Bachelor-Master-Doctorate was established in Albania. Levels according to Bologna process and implementation time in Albania is describes in Fig.1 (a, b).

The shift of focus, which the Bologna reforms have emphasized already introduced in Albania, calls for a new educational approach and culture in undergraduate and post graduate education [1-3]. The new enrollment at the Bachelor Level in Public & Private Institution of higher education in Albania is shown in Fig.2.a.



(a)

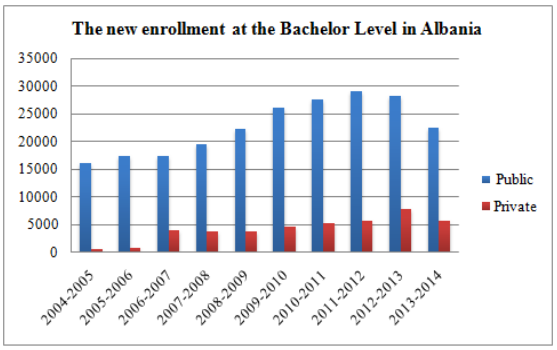
(b)

Fig. 1. *Level according to Bologna process (a) and implementation time in Albania (b).*

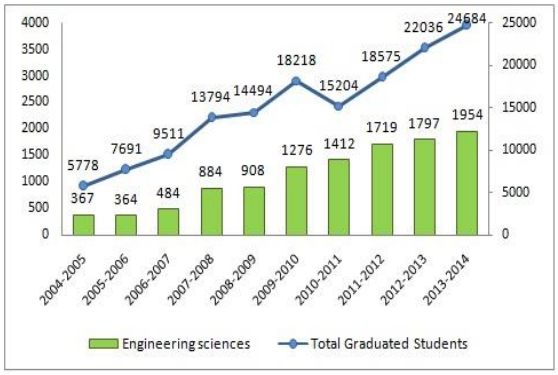
The distributions of students according to the administration of HEI are about 85.1% in Public Institution of higher education and 14.9% in Private ones. In the academic year 2013-2014, about 40.57% of total enrollments were female.

In Fig.2.b are represented the graduated Students at the Public Higher Education Institutions (HEI) and

Engineering Sciences [4]. In the academic year 2013-2014, only 28.1% of total enrollments in Engineering Sciences were female.



(a)



(b)

Fig. 2. *The new enrollment at the Bachelor Level in Public & Private HEI (a), Graduated Students at the Public HEI and Engineering Sciences (b)*

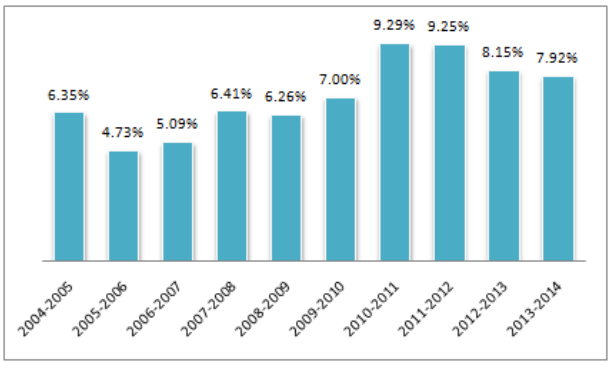
Students enrollment at the public and private Higher Education Institutions on the Engineering Sciences education fields for the academic year 2013-2014 are shown in Table I.

TABLE I. STUDENTS ON THE ENGINEERING SCIENCES EDUCATION FIELDS FOR THE ACADEMIC YEAR 2013-201TABLE

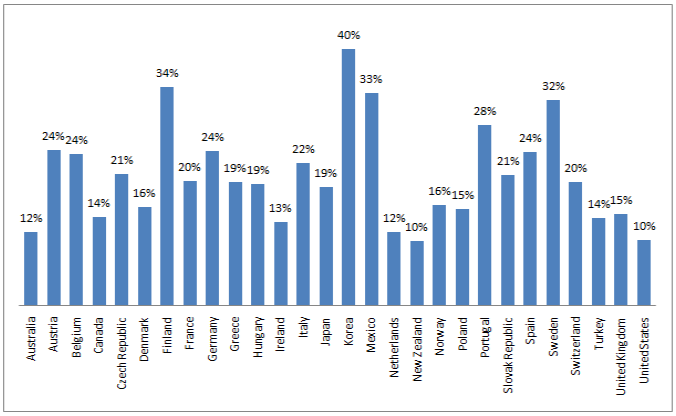
Engineering sciences		
Total	Total	18391
	Female	5984
Public	Total	16086
	Female	5430
Private	Total	2305
	Female	554

In Fig.3.a is represented the graduates in the Engineering Sciences education field in % of the total graduates students for Albania, while in Fig.3.b is the same indicator for OECD countries on year 2011 [5].

The mean value of this indicator for Albania is around 7.17% compare of 20.41% for OECD countries.



(a)



(b)

Fig. 3. *Graduated Students in the Engineering Sciences education field in % of the total graduates students for Albania (a) and for OECD on 2011.*

Actual structures for Electric Power System Education in Albania are:

A. Polytechnic University of Tirana (Public university)

Faculty of Electrical Engineering, Department of Electric Power System;

Faculty of Mechanical Engineering, Department of Energy;

B. University of Vlora (Public university)

Faculty of Technical Sciences;

C. Private Albanian University,

Faculty of Applied Sciences and Economics;

D. Private Metropolitan University of Tirana,

Faculty of Applied Sciences.

Polytechnic University of Tirana was founded in 1951 under the name of Polytechnic Institute. In 1957 the Polytechnic Institute was introduced in the structure of the State University of Tirana. In 1991 the PUT obtained the status of independent university, grouping in itself all the engineering faculties which until that period were part of to the University of Tirana. PUT is a public non profitable high technologic institution [6]. For the academic year 2013-2014 the total number of students at Polytechnic University of Tirana were 14218. They represented about 79% of total students enrolled at Engineering Sciences

education field in Albania. Only 5025 students out of the total or 26.1% were female.

II. Electric Power System Engineering Education

Power System Department is part of Faculty of Electrical Engineering (FEE) at Polytechnic University of Tirana (PUT) and is one of the oldest departments of the faculty. Our department is responsible for development and improvement of teaching curricula for Electrical Power System Studies with the symbiosis of education and research [7-9] as well as for optimal integration into the labor market.

Based on Bologna Process, new degree structure with three cycles of studies Bachelor-Master-Doctorate was implemented also for Electrical Power System Studies. In Fig.4 is represented the first approach that we have implemented. From Fig.4 we can see that at the beginning the new structure has had Bachelor of Science and Bachelor of Engineering as the first level of studies followed by Master of Science and Master of Engineering as the second level of studies.

The students faced difficulties to decide about the Bachelor studies and then spent more time for "bridging" to other ones. The first improvement was merging into a single Bachelor of Engineering as the first level of studies and then continuing with Master of Science and Master of Engineering as the second level of studies.

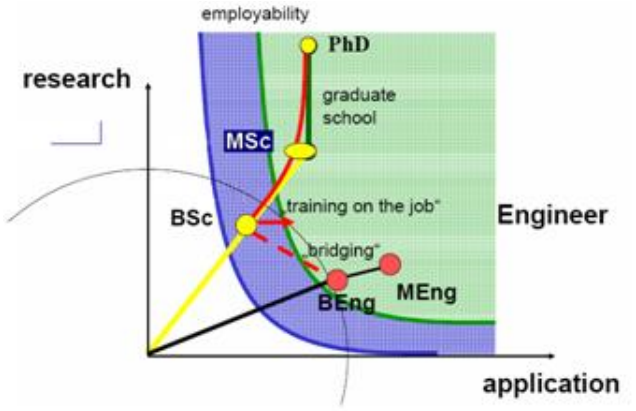


Fig. 4. *Electrical Power System Studies at PUT according Bologna Declaration*

Under framework of liberalization of Higher Education other challenges have to be faced such as financial pressure and increased of competition. The fact that institutional grants are mainly based on student numbers provides a rapid increased of master students as is shown in Fig.5.

A significant number of graduated students have been absorbed recently from the power sector labor market.

Power System Department at FEE used to perform a survey in power sector in respect of number of graduated students employed and the way how they face the challenges and responsibilities given according to the respective positions on different companies.

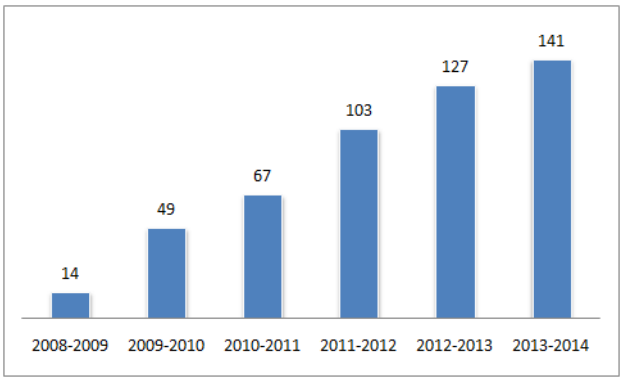


Fig. 5. *Master Students in the Electric Engineering Faculty.*

The result of the survey about the employment of the graduates of the Master degrees of Electric Power System Engineering of the period 2010-2016 is shown in the Fig.6. Referring to the survey it is evident the fact that 53% of the graduated students are employed at Distribution System Operator (DSO), 18% at Transmission System Operator(TSO) and 15% in KESH (Albanian Power Corporation).

The Survey helped a lot to identify as well the difficulties faced by the graduated students in the integration process in different positions inside the public or private companies.

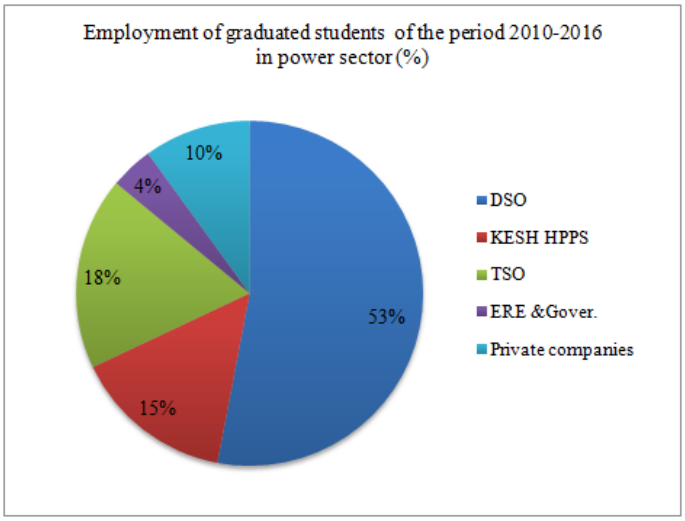


Fig. 6. *Master Students employments.*

It is worth to mention that one of the common problems that were reported by most of them was the lack of knowledge in respect of:

- Formulation and development of the engineering Projects;
- Project management and organization;
- Project implementation;

The above mentioned subject are not included in the curricula and the result of the survey in that respect

can be considered as a useful feed back in reviewing and adapting the curricula accordingly.

Another interesting outcome from the survey was that around of 37 % of the employed graduated students have faced difficulties in planning, drafting strategies of developing the power system, dynamic programming method of optimization, with the aim to compare the costs of alternative system expansion plans etc.

The graduated students employed at Transmission System Operators (18% out of the total) reported difficulties in respect of:

- Congestion management;
- Electricity market mechanisms;
- Market (price) Coupling;
- Network access and tariff harmonization;
- Inter-TSO compensation (for cross-border transits);
- Balancing market;
- Cost-benefit analyses for generation and transmission projects;
- Detailed simulation of the power systems operation within market environment;
- Maximization of the net revenues while remaining within physical and institutional limitations of the power system;
- Simulation of the dispatch of electric generating units and the economic trade of energy among generation companies using a network representation of the power grid;
- Calculation of market prices for electricity sales/purchases in different regions.

Another difficulty reported from the survey was in respect of smart system devices. Such systems belong to new technologies and projects implemented recently on the distribution network in Albania. As a matter of fact all the topics above mentioned are related with the ongoing reforms process on power sector, a new market model adopted and steps towards the process of liberalization of energy market.

Again the result of the survey were very good indicators in the view of revising the curricula accordingly the driving forces of our economy such as privatization of generation facilities, environment aspects, liberalization of the energy market and adaptation of new legislation according the EU Directives for power sector.

University education is a very precious long-term investment that materialize in economic and social development of the country. Power System Department has felt and feels this responsibility and therefore throughout its life aimed at the creation of elite education with high quality preparation.

The main challenges are a symbiosis of education and research, integration into the labor market and the social responsibility. On the other hand the new technologies and new ways of communication push us to improve organizing curricula and the teaching process itself.

The graduates of the M-EPSE (Master degrees of Electric Power System Engineering) have to be prepared with the global competency skills needed to perform effectively in a globalised system [10]. Power System Department is already in the process of improvements in higher education engineering courses. Our department is responsible for development and improvement of present teaching curricula for Electrical Power System Engineers with the symbiosis of education and research [11-14] as well as for optimal integration into the labor market.

The present M-EPSE is more related to the power system analysis, power generation from fossil fuels and hydro power plants, power transmission and distribution networks, electricity market and is low attention to the renewable energy technologies, energy efficiency, district heating systems, new technologies in fossil power plants, environmental and social assessment in energy projects, sustainable development, waste treatment and disposals, economic and financing analysis, social and environmental issues.

Future technologies are expected to include more sustainable solutions for the power industry. The climate change largely discussed and environmental concerns have imposed higher requirements, both from the society and by the international conventions. Novel generation technologies, such as fuel cells together with high renewable energy penetrations are expected to grow in the distribution networks, leading to a radical change in the status of the traditional power systems. These distributed energy resources should be accompanied by proper technologies for monitoring and control as well as by proper communication infrastructures to allow the transition from the traditional distribution networks to smart grids and finally to the energy internet.

Establishment of an appropriate legal frame work, adoption of Union European Directives in respect of power market as well as the implementation of the reforms in the Albanian Power Sector accompanied with the changes in the organization and functions of existing electrical companies that operate in the power sector, have introduced new methodologies, models and market mechanisms. New technologies, liberalization of electricity markets, the success of the reforms and the power market efficiency functioning are closely linked with understanding and applying these mechanisms and methodologies [8, 9].

The objectives of the Albanian government's education strategies and private sector, need for professionals that can identify, plan, evaluate, and manage projects. Overall requirements are in improving overall energy sector performances thought constructing new generation capacities, focusing on renewable energy sources, increase of energy efficiency, application of new advanced concepts and technologies in the distribution networks, central district heating/cooling using, security of supply increasing and environmental protection.

From Fig. 3 we can see that the number of graduates in engineering fields in Albania is lower than other countries. Knowing that a large number of employees of energy companies have not engineering education, and that such knowledge cannot be obtained through short courses, with the support of NORMAK project is implemented a Master's degree in the field of power system, which enables to develop competency in forecasting the relevance of shifting from conventional to green energy economy, national energy strategies, national and Energy Community policies for environmental protection as well as to acquire knowledge to analyze specific energy sector requirements and sustainable development.

III. PERSPECTIVES AND PROBLEMS

In order to provide an advanced technical basis for the electric power industry through modern and up-to-date Long Life Learning as an essential element of the European Higher Education area our department, in the framework of TEMPUS JEP-41154-2006 Project, has finalized an intensive training program with six modules specifically tailored to the professional requirements of utility and regulatory staff [16].

The course was designed to enhance the economic, technical, and policy skills required for implementing policies and managing sustainable regulatory systems for infrastructure sectors.

A survey was realized at the end of the training program. Such survey address a wide range of issues linked to the future role and profile of the institution, including the development of a coherent approach to the restructuring of curricula.

In Table II are presented the modules and the number of participants.

TABLE II. THE MODULE AND THE NUMBER OF PARTICIPANTS IN THE TRAINING PROGRAM

Nr.	*Module*	*Days*	*Number of Participants*
1.	Asset Management	2	20 / 23
2.	Power Systems platform for steady state and transient calculations	3	26 / 20 /20
3.	Power system operation in market environments	2	20 / 21
4.	Planning and Operational Training	2	22 / 21
5.	Business Models for Distributed Energy Generation	3	28 / 32 / 31
6.	Integration of distribution generation in interconnected systems	2	31 / 31

Some problems raised from the questionnaires are reported in the following:

- The value of the course (Fig.7);
- The necessity of dipper knowledge transfer according to the needs of the labor market;
- The necessity to include in the master program study (Fig.8);
- Sustainability.

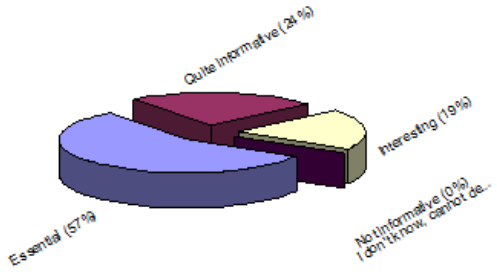


Fig. 7. *Results from the questionnaires for the value of course*

Based on identified intersection of needs, a new Master degree Curricula is launched in order to widely prepare the graduates student to the triple E-factors challenges. The new Master degree Curricula is focused in three pillars: Renewable Energy Resources and Policy, Energy management and Efficiency and Smart Grids, encompassed into Sustainable Energy as the common denominator.

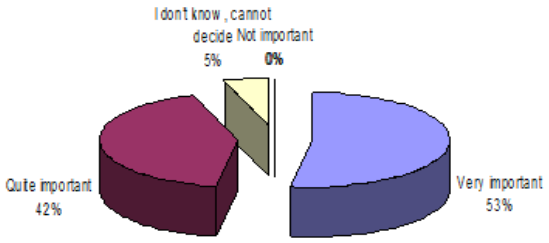


Fig. 8. *Results from the questionnaires for the Sustainability of course*

The new Master Studies is in accordance with energy sector requirements and main Energy Strategy objectives. It is based on energy sector analysis, the obligations to Energy Community as well as the energy sector requirements for professional staff in the fields of energy sector performances improvements, new generation capacities developments, National Renewable Energy Action Plans implementation, reducing greenhouse gas emissions, diversification and security of supply, distribution systems development with focus on smart grid, energy management, energy efficiency, energy market and meet environmental domestic, EC and international standards.

The new Master Studies contribute in increasing the professional and state administrations capacities with knowledge in sustainable energy fields and development.

The main objective it was to give the competences to recognize and strengthen individual skills and improve the capacity both in the energy sector and environment. Another objective was to give basic knowledge on economic in the field of energy and market as well as to understand EU and international initiatives for environmental protections and other climate issues, and to assess in the environmental and social issues in energy projects, using different software's in energy sector problem solving.

Students will acquire knowledge on sustainable resource management, sustainable development assessment, and technology and resource management. They will have the basic competences on energy demands, renewable energy solutions and their impacts on environment and mitigation measures, energy efficiency and energy storage for sustainable development as well as for Engineering Projects Development and management. Knowledge for information systems in smart grids are part of the new curricula.

The aim is that through the professional expertise and through the identification of appropriate computer software's, to implement the modern technologies in power market in order to address all the issues and problems that face the process of liberalization, deregulation and creation of an open market also in a regional context. With our experts in Power System Department and partners in power sector we will be able to provide courses, lectures, and practices through which the interested specialist can gain valuable knowledge about implementation of the most modern methodologies in electricity market, thus enabling them to increase their knowledge and skills. These courses could be seen as a key development in higher education engineering and modernization of electrical power system in respect of:

A. Power System Development Planning including:

- Determination of the optimal pattern of system expansion to meet the electricity requirements over a given period;
- Dynamic programming method of optimization, to compare the costs of alternative system expansion plans;
- The year-by-year generating capacity additions needed to satisfy the projected system electricity demand with a satisfactory level of reliability with due regard to the characteristics of existing and new generating units.

B. Electricity Market Mechanisms and operation such as:

- Balancing market;
- Cross border trade mechanisms;
- Coordinated auctioning;
- Allocation of Transmission capacities;
- Congestion management;
- Cost-benefit analyses for generation and transmission projects.

During the last decade one of the week point identified in the power sector investment has been Project management. Almost all Projects formulated and implemented in power sector, such as Projects in construction of new generation facilities or rehabilitation of existing ones, investments done on Distribution or Transmission System have been impacted in terms of Project Implementation Efficiency.

A special attention will be given to the objective to transfer to the student's sufficient knowledge in respect of engineering project management. The expectation is that through the professional expertise to give basic knowledge and competences to the students to be able to monitor and evaluate a Project in terms of key indicators such as:

- Project management/organization;
- Effectiveness (achievement of objectives) and Relevance of project for the Country;
- Sustainability;
- Project implementation – Efficiency;
- Quality and adequacy of output with regard to
  a) *Technical aspects;*
  b) *Capacity development / Transfer of Know-how ;*
  c) *Sustainability .*
- Operation and maintenance (O&M) and management;
- Precautions;
- Risks and issues which may affect the project outcome and planned;
- Countermeasures;
- Conditions of Contracts Claims and dispute management;
- Environmental and social Impacts.

While the higher education system may be applauded for the enormous effort to increase higher education participation and universities have done a remarkable job of expanding their teaching provision and building up research activities at the same time, the quality of educational and research activities has suffered from missing of adequate infrastructure and insufficient financial coverage of that expansion. The fact that institutional grants are mainly based on student numbers provides further disincentives to differentiate among different target groups and qualification profiles.

There are possibilities for continuous improvement of teaching and research in EPSE departments. But at the same time difficulties coming from missing of adequate infrastructure, lack of direct funding and drastic increase of the number of students may negatively impact these possibilities. Definitive would be the implementation of the strategy for research and technological innovation, which is in its first steps.

IV. CONCLUSIONS

Implementation of new strategies would make possible the intensification of usage of up-to-date technologies and consolidation of knowledge for education of students. Actually the curricula used in Albanian Universities have slight differences with those applied in other countries. There are possibilities for continuous improvement of teaching and research in EPSE departments.

Continuous survey should be done in the future, in order to better monitor the necessity and the requirements of the industry in power sector public and private ones.

As lessons learned from our experience at university we can list some key issues which need to be addressed in a proper way in the future:

- Missing of adequate infrastructure;
- Lack of direct funding;
- Drastic increase of the number of students.

Development of e-content and video-conferencing technologies would improve collaboration with foreign universities, in order to better face challenges of the future.

Improvement of curricula following recommendations of CIGRE and strengthening the work for teaching of new technologies and subjects would open wider perspectives for new generations.

New technologies, liberalization of electricity markets, adaptation of EU Directives for the power sector, assessment of environment aspects, require a good understanding and application of new methodologies and market mechanisms.

Providing the appropriate curricula in that respect associated with adequate computer platforms will contribute in increasing the knowledge and skills of our students and of course to a direct contribution in the human resources of the power sector companies.

Strong and continuous collaboration with generation, transmission and distribution companies, independent power producers, regulatory body as well as with governmental organization responsible for power sector through common Projects internship of the students, is very import and fruitful for the future development of power sector in Albania.

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