

## **Project “Through Application of Science to Innovations”**

KONČAR – Electrical Engineering Institute Inc. is a scientific organisation registered in the Register of Ministry of Science, Education and Sports in the area Engineering, and owned by the holding company KONČAR – Electrical Industry Inc., which leaves all the profit to the Institute.

The mission of the Institute is applied research and development of products, technologies and services for efficient electrical energy conversion and transmission based on corporate social responsibility. The Institute offers R&D services for: transformers, generators, circuit breakers, converters, wind turbines and rail vehicles. It also offers diagnostics, testing and certification of electrical products and equipment, and the following products: monitoring systems for electric power equipment, control systems and hybrid supply systems based on renewable sources.

### **Abstract**

Aware of the need for new knowledge and possibilities for its acquisition through applied scientific research, KONČAR – Electrical Engineering Institute Inc. has initiated collaboration with faculties in order to contribute by joint scientific research to the development of globally competitive innovative technical solutions. This partnership covers temporary employment on faculties of future Institute's employees, who thus become young industrial researchers whose scientific-research work performed at faculties is of interest for the Institute. The collaboration has support of faculties, because with temporary employment of Institute's young researchers they have secured financing and concrete scientific tasks. Young researchers have the opportunity to work on concrete technical problems whose solutions will be applied, and their future job is secure. By financing doctoral studies the Institute can choose the topics of such theses, and also the field of scientific research in which it would like to improve knowledge.

The purpose of the partnership is also to direct the academic community towards applied research of interest for the economy e.g. renewable sources, ICT, nano and hydrogen technologies, using government funds intended for scientific research. An important reason was also the efficient transfer of knowledge between faculties and the Institute. The first agreement was signed with the Faculty of Electrical Engineering and Computing (FER) defining the modes in which KONČAR's young researchers can acquire doctor's degrees and joint scientific-research projects. The successful model of collaboration with FER as the central faculty of the Institute and KONČAR Group was applied to the collaboration with the Faculty of Mechanical Engineering and Naval Architecture (FSB) and the Faculty of Chemical Engineering and Technology (FKIT).

This model has made the academic community aware that it can measure its scientific efficiency not only with the number of published papers, but also with innovations and protected intellectual property as final results of successful applied research.

The areas of the Institute's interest applied scientific research, innovations, involvement of - academic community in development of the economy, promotion of good practice and corporate social responsibility – are those promoted also by EU. Therefore the Institute was among the first that started promoting these values in Croatia, investing a part of its profit in the activities that maintain sustainable development of academic community. The model enables a harmonious and sustainable development of the Institute, and major benefits of that partnership are creation of new jobs through manufacture and sale of competitive products on the market.

### Brief description of the partnership

KONČAR - Electrical Engineering Institute and three engineering faculties of Zagreb University have established partnership in order to stimulate the development of original technical solutions and innovative products that will be competitive on the market. The collaboration covers the work on doctoral studies of KONČAR's young researchers with temporary employment on faculties who are conducting scientific research of interest for the Institute. By temporary employment of young researchers faculties have ensured both the financing of concrete scientific research and the possibility for inclusion in international scientific projects. By financing doctoral studies the Institute has the opportunity to choose topics of doctoral theses, what ensures solving specific technical problems as the basis of development of new products.

### Innovativeness

The partnership of KONČAR – Electrical Engineering Institute with three faculties is innovative in the mode of collaboration of the economy and academic community. The model of organized collaboration with FER based on mutual agreements has been gradually applied to two more faculties of engineering. The objective was to acquire new knowledge and skills in scientific research work through in-service training and applicable scientific research. That should facilitate the solving of complex engineering problems related to the development of new products, yet at reasonable costs using also other sources of financing.

Study-as-you-work scheme in doctoral studies is connected with the strain caused by everyday work that provides income, so that there is very little time for generation of new ideas and products. Young researchers with temporary jobs on faculties are focused on scientific research, they adopt the methodology of scientific work, and the end result is greater innovativeness. This study-as-you-work model of education motivates young researchers for innovative technical and technological solutions as a result of the expected scientific contribution realised in the process of working for the doctor's degree.

The collaboration is organised so that both sides have some additional benefits:

- Faculties have the opportunity to make scientific research of concrete problems with considerable assistance provided by the Institute in the form of model making, extensive measurements in its test laboratories, and active participation of young researchers. This combined work of young researchers, their tutors and other scientists results in valuable research published in CC journals and presented at conferences, what is very important for the advancement of all the involved.
- The Institute has the opportunity, through its young researchers at faculties, to become familiar with other scientific milieus and fields of their activities, and also to use their connections with other academic communities in the world. Transfer of knowledge from faculties to the Institute at very reasonable costs is also very important, because the Croatian Science Foundation and the Croatian Institute of Technology co-finance the collaboration on allied scientific research. Apart from that, the Institute gains new and innovative technical solutions or concrete products.

It should be pointed out that the donations that the Institute has given in the last five years for the equipment and build-up of laboratories at faculties, publication of textbooks, organisation of conferences and awards for the best students have always been in accord with fields of its activities.

This model of partnership is fully applicable to all the business entities that wish to provide development by connecting with faculties. The partnership is based on manifold mutual benefits, and is economically acceptable, because it can be incorporated in the model encouraged and co-financed by the state.

With this approach it is achieved that the focus is not on the doctor's degree itself, but on the future doctor's scientific work, whose application results in innovations and concrete products. The adopted methodology of work and scientific contributions are the basis for obtaining the doctor's degree.

The establishment of the partnership of the Institute and the faculties required great mutual understanding, especially as regards intellectual property and business secret. Namely, the interests of academic community and the Institute to publish research results are not identical – the interest of one side is to publish them immediately, of the other as late as possible. Satisfying relations were established by compromises, and defined in agreements. Now it can be stated that both sides have learned how to work together in a new, well conceived and sustainable way.

Several years of partnership and the gained experience were the basis for the proposal of measures for strengthening innovative activity in the National Strategy for the Croatian innovation development 2013 – 2020 that is just being drafted. Incentives for mobility between the educational, science and industry sectors were proposed, as well as for synergy of innovations between two or more sectors.

### Leadership and purpose

Following the strategy of industrial development of EU and using the accessible scientific research and innovations, the Management of the Institute started ten years ago directing its business activities to the fields which are likely to have a big economic potential in the next twenty years: renewable sources, ICT, hydrogen and nanotechnology. These new fields are technically and technologically relevant for the current production programmes of companies in KONČAR Group, and through them the Institute will place at least a part of such products on the global market. Renewable sources were recognized as a new area, important not only for conservation of the environment, but also as having a great potential impact on the entire industrial and economic development. Specific new facilities and equipment for Croatian industry: wind, photovoltaic and cogeneration plants with hydrogen, were a real challenge for the management of the Institute to start our own applied research and development of new products and services that can be offered to companies of KONČAR Group and global market.

In the first ten years of work on market principles the Institute based its business activities on previously acquired knowledge and research and development infrastructure. It operated mainly on the domestic market, without much connection with academic community, whose activities even competed with the Institute's activities on the market. This state was impossible to sustain on a long term because it did not enable further development of the Institute.

To succeed in its intentions in the field of power engineering (renewable sources, smart grid, energy efficiency), the Institute had to initiate its own applied research, and at the same time to stimulate academic community to direct its investigations financed by the state to the fields of Institute's interest, and to instigate faculties to generate new knowledge and skills needed by emerging industries by introducing new courses of lectures and opening new laboratories.

Acquisition of knowledge only through the Institute's own research, and study-as-you-work scheme in doctoral studies were found insufficient. That is the reason why temporary jobs were found at faculties for five young researchers, future employees of the Institute, in order to enable them to work on scientific research, and earn their doctor's degrees on topics of special interest for the Institute. Stimulation of academic community to research and education relevant for the development of Institute's business activities was mutually beneficial both in economic and social terms, and enabled additional investments from national funds for science and technology.

Partnership relations were defined in agreements specifying all the terms and conditions, and each agreement was signed by both parties. On behalf of the Institute the signatory was the President of the Managing Board, and on behalf of faculties their respective deans, what was the guarantee that the partnership would be managed by top-level management on both sides. Responsible persons, mentors, tutors and advisors were also defined in the agreements in order to define unambiguously responsibilities, and check the performance.

### Management processes

First agreements of this kind FER and the Institute signed with Mate Jelavić and Marko Bago as young researchers of the Institute, who were obliged to take a job at the Institute after earning their doctor's degrees. Employment of these young researchers in the industry was an excellent example of collaboration, both before and after their doctorates, which provided both financial and nonfinancial benefits. The temporary employment of the third young researcher Tomislav Dragičević at FER began in 2009 in the field of smart micro grids. Similar positive experience the Institute had with Predrag Čanžar, who signed up for the doctoral study at FSB and won his doctor's degree in 2012. The topic of his thesis was fatigue behaviour of nodular cast iron, what is very important for quality control of casts in wind turbine manufacture. Investigations of nanotube applications, i.e. of nanotechnology for noise reduction, started with the employment of young researcher Tomislav Karažija at FKIT in 2008. Completion of his doctorate is expected in March 2013, and the first industrial application of preliminary results in 2014.

Young researchers of the Institute with temporary jobs at faculties are obliged by contracts to complete their doctoral studies in five years, and after that to work in the Institute for the period of time equal to the period of time of their doctoral studies. When they are at the faculty, 30% of their time they spend at lectures, and 70% of time they are engaged in applied scientific research of a particular problem related to the development of an Institute's new product, what is also a part of their doctor's thesis. Scientific-research work is supervised by an experienced scientist from the faculty. Usually other young researchers and scientists from the faculty work on such a project, whose topic is agreed between the supervisor and the Institute, which co-finances some 30 to 50% of total costs, depending on the other co-financier.

KONČAR's young researchers must regularly report on the progress of their investigations in the presence of the management of the Institute, the supervisor from the faculty, and others interested in the research and application of its results.

In the previous period, thanks to results of such employment and research, two scientific-research projects were defined, and their co-financing by the Croatian Science Foundation (HRZZ) was agreed based on the review of foreign reviewers and committee of experts of the Foundation. The implementation of these projects is supervised by HRZZ (time schedule, costs, and results), and their success is measured with the number of published papers, patents and inclusion of young researchers.

### Resources

The collaboration with faculties was initiated also with a view to providing impetus for academic community to deal with scientific-research topics that will be useful for the industry. The Institute brought in it knowledge and skills necessary for transformation of scientific research into products for the world market.

The impetus is in the form of young researchers from the industry, whose work at faculties is financed by KONČAR – Electrical Engineering Institute. They work on doctor's theses dealing with problems of

interest for the Institute, and on joint scientific-research projects managed by scientists from faculties. Of course, all the activities have a deadline, costs and objectives, whose result must not always be usable.

Since the beginning of the collaboration, the Institute paid for young researchers with temporary jobs on faculties the sum of HRK 4.5 million, and in the observed period the sum of HRK 3.77 million. The costs of projects related to applied scientific research of KONČAR's young researchers were:

- scientific project: Multi-criteria Wind Turbine Control, for the Institute HRK 0.75 million, for the Croatian Science Foundation HRK 1.4 million
- scientific project: Nanostructured and Functional Polymer Materials/NanFun, for the Institute HRK 0.48 million, for the Croatian Science Foundation HRK 0.96 million
- technological project: Fatigue Analysis Method for Increasing Wind Turbine Reliability, HRK 0.99 million for the Croatian Institute of Technology, of which HRK 0.23 million for the Institute.

KONČAR – Institute provided HRK 1.25 million for the first two projects, and in the case of the third one it received HRK 0.23 million. That means that the Institute paid the total of HRK 1.02 million. The projects were financed from the science and technology funds (the total was HRK 3.35 million, of which the faculties received HRK 3.1 million). Apart from that, KONČAR – Institute made donations to the faculties in the sum of HRK 0.25 million, which were for laboratory equipment, conferences and awards for the best students.

Balance of partnership of the Institute and three faculties of Zagreb University in the period 2008 – 2012:

- KONČAR - Institute financed the collaboration with the sum of HRK 3.77 million or annual average of HRK 0.75 million
- Funds of the Croatian Science Foundation and Croatian Institute of Technology financed the collaboration with the sum of HRK 3.35 million.

### Communication and dialogue

Most employees of the Institute come as graduates from three engineering faculties of Zagreb University. Partnership with faculties is based on agreements on:

- young researchers of the Institute with temporary jobs at faculties,
- joint scientific-research projects,
- donations for construction of laboratories, awards for best students, organisation of conferences and the like.

Mate Jelavić, PhD, winner of Vera Johanides Award for the best young scientists in 2011, said for the newsletter *Končarevac* about his status of young researcher and innovation-related work: *„In my opinion, the combination of scientific work and concrete application of research in the economy is the only correct way. Our opportunity on the market is research-based products with high value added. The road to such a product begins with investigation of the existing and similar solutions and their limits, and of physical phenomena in processes, what will eventually show us possibilities for improvements.“*

During their career in the Institute, the employees improve and acquire new knowledge through specialist and doctoral studies at the mentioned faculties, and therefore the Institute deems them partners in its long-term sustainable development. This comprehensive collaboration of an industrial institute and academic community had several results:

- 9 papers published in relevant journals, 42 papers presented at international conferences, and 10 papers at scientific meetings
- 2 new products recognized in the world:
  - wind turbine control system, awarded at the Zagreb international innovation exhibition

- Hybrid Box awarded at the international innovation exhibitions in Zagreb and Brussels, and with 2 world awards in the green product category (*Global Telecoms Business Award* and *World Communication Award*).

The scientific research by Predrag Čanžar, supported by KONČAR – Institute, was published in the prestigious journal *Materials Science & Engineering*. For contribution to science and for the support of the investigation, the Institute received expressions of gratitude from researchers and scientists.

The community is informed about achievements of the Institute in several ways:

- in annual Corporate Social Responsibility reports,
- in web site of the Institute: names of PhD candidates, topics of their theses, and place where the thesis will be defended,
- published papers are presented on the intranet, and entered in CROSB I - the national database of scientific and professional papers
- in the newsletter *Končarevac*, which is delivered to all government institutions, short information are published about new PhDs and all the awards (for young researchers, innovations, long service in KONČAR etc.).

This easily recognizable example of collaboration in education through doctoral studies immediately applied to scientific research with a view of developing new products is reported and discussed at various meetings on collaboration of academic community and economy, high-school education, funds for advancement of science, and also in drafting strategies in the fields of innovation and industrial development.

President of the Managing Board of KONČAR – Institute has had a number of presentations at high schools, conferences, round tables and symposiums on connecting science and the economy:

- Creativity and Innovativeness – preconditions for economic and social development, round table, MIPRO, Opatija, 2009
- Thorough Innovations to Competitiveness, round table „Innovation management – experiences of Croatian innovators“, Zagreb, 2010
- Renewable Sources, Smart Grids and Energy Efficiency, round table, FER, 2011.

### Social benefits

Collaboration with faculties was initiated to stimulate academic community to deal with scientific-research topics that might be useful for the industry, and also to show the industry that academic community can contribute to the development of society not only through education also through applied research whose aim is innovation.

Parties in this collaboration have manifold benefits:

- Faculties have the opportunity for active research financed by KONČAR - Institute, Croatian funds, and in the case of projects by EU funds
- KONČAR – Institute has entered new fields of activity at an acceptable rate (renewable sources, ICT, and hydrogen technology) and gained social status of a desirable employer with successful business and attractive fields of business activity
- the community has got the opportunity for new jobs based on application of the results of development in KONČAR - Institute (manufacture of wind turbines, hybrid renewable sources and trains)
- they have realised additional financing of education and scientific-research activities in the sum of HRK 7.12 million (the Institute would pay about HRK 0.3 million for the doctoral studies of five candidates).

New and innovative products are more than ever important for the competitiveness on the global market. To develop such products, engineers must be highly trained in the narrow fields of engineering in which they are working. Therefore KONČAR - Institute provides and stimulates study-as-you work scheme in doctoral and specialist studies. In the last five years there were nine new doctors and masters of science, three of them with temporary jobs on faculties. Study-as-you-work scheme in doctoral studies is connected with the strain caused by everyday work that provides income, so that there is very little time for generation of new ideas and products. Applying both schemes of doctoral studies, the conventional in-service study and the study-as-you-work one with temporary job at the faculty, it was found that the new model of scientific research and acquisition of doctor's degree through temporary employment of young researchers at faculties has some additional social benefits:

- young people get the highest education, and are specialised for jobs they will certainly do, because they are paid and directed by their future employer
- national funds for science are used in the most efficient, concrete way to create competent specialists and technical and technological innovations
- through the Institute the economy functionally invests in science and education
- in a special way partnership relations are established that fulfil all the EU criteria for sustainable development (research-oriented university, lifelong education, innovations, intellectual property, competitive economy)
- academic community becomes aware of concrete economic problems what makes it an active participant in the economic development
- interdisciplinary approach is promoted through collaboration of three faculties.

In their research scientists often only describe problems and propose theoretical solutions. This does not bring any great benefits for the community, because the taxpayers' money is spent on research whose objective is the advancement of individual scientists, and not their application in the economy. Work on investigations oriented towards concrete problems and practical solutions results in original solutions applicable in practice, and their aim is an innovative product competitive on the world market.

Prof. Ante Jukić, PhD, one of the mentors of KONČAR's young researchers and manager of a project supported by the Croatian Science Foundation, said in his interview for Business.hr about the relationship between the academic community and the economy: *„Croatia allocates very little funds for scientific research, and consequently, among other things, we are very poorly equipped with expensive scientific equipment. Partly the reason for that is that the majority of research is not oriented towards the economy, not even those in engineering and natural sciences, so that even if the money invested in research would be increased for several times there would be no effect on the development of the economy. Scientists should not be excluded from the responsibility for the development of the economy and the community, and, if wished, that can be easily achieved through the conditions for advancement and tenders for scientific-research projects“.*

Great social benefit in this short period from 2008 to 2012 is about 300 new jobs and preserving the existing ones both in KONČAR Group and at its subcontractors. These jobs are in the production and sale of products resulting from the partnership of the Institute and academic society in scientific research (wind turbines, trains, and Hybrid Box).

### **Business benefits**

With such financing of doctoral studies of young industrial researchers with temporary jobs at faculties the Institute establishes permanent connections with faculties, which grow into partnerships with better

mutual understanding and respect. All this is especially important for building new relations between academic community and the economy.

With this methodology of work on doctoral studies the Institute realizes the following business benefits:

- knowledge and skills are acquired, which lead to original solutions of complex technical problems using the scientific approach
- competent external collaborators (the mentor and other researchers on a project) are used indirectly in investigations leading to innovations
- government funds are also used to cover the costs of such complex investigations, what lowers the costs of the research
- there is the transfer of the existing knowledge of scientists and new knowledge acquired by research done by the Institute and the faculties
- examples of good practice in collaboration of academic community and the economy
- academic community becomes aware of the need to design the education and research in accordance with the needs of the economy.

Results of research made during doctoral studies of young researchers were applied to the wind turbine control system developed by Dr. Mate Jelavić and train bus communication developed by Dr. Marko Bago. Their postgraduate studies were very successful because both sides realised some additional benefits with which it was not counted in the beginning. FER has got within the frame programme FP7 an international scientific project, whose value is EUR 208,000, and a scientific project financed by the Croatian Science Foundation and KONČAR – Institute, whose value was HRK 2 million.

Research and projects managed by Dr. Jelavić had as a result new highly innovative products with high value added. He recently said for Končarevac about his study at FER: *„In my doctor's thesis I described physics of wind turbines and outlined control algorithms. We have combined this knowledge in the Institute with previous knowledge about tramway, locomotive and excitation system controls. All this together resulted in a new product – wind turbine control system.“*

Employment of young industrial researchers has improved FER's competences and created international contacts, which have been decisive for approval of the present and future scientific projects. It was an excellent example of collaboration, which resulted in 2009 in temporary employment at FER of Tomislav Dragičević, the third young researcher. Tomislav Dragičević worked at FER on smart microgrids. His doctoral study and doctor's thesis have already yielded some additional benefits.

Namely, during the studies Tomislav Dragičević was granted an 8-months free specialisation at Aalborg University. The result of the specialisation was the doctor's thesis in English, and a 12-months postdoctoral specialisation. This young researcher made for the Institute very useful investigations, which were in the meantime used in the development of an autonomous power supply from renewable sources and fuel cells, the Institute's new product with registered trade mark Hybrid Box. This gave FER an exceptional opportunity for attractive investigations which have been recognized also by the Danish university.

The Institute had also very positive experiences with young researcher Predrag Čanžar, who enrolled the postgraduate doctoral study programme at FSB, and got his doctor's degree in 2012. The topic of his doctor's thesis was fatigue behaviour of nodular cast iron, what was very important for quality control of casts in wind turbine fabrication. During the work on PhD thesis his mentor has initiated a technological project together with KONČAR – Institute. The project was co-financed by the Croatian Institute of Technology and KONČAR – Electrical Engineering Institute, and completed at the end of 2012. With this project the faculty has received additional funds for the necessary equipment and scientific-research work, and the Institute has acquired new knowledge.

It must be emphasized that this collaboration of FER and FSB with the Institute was the basis for approval of IPA IIIc project in 2013. The project "Centre of excellence for integrity of constructions" is financed by EU in the sum of EUR 0.56 million, and it is jointly implemented by FSB, FER and the Faculty of Civil Engineering in Rijeka.

With the employment of young researcher Tomislav Karažija at FKIT in 2008 began the investigation of nanotube applications, i.e. of nanotechnology for noise reduction. He won his PhD degree in 2013, and first industrial application of the results is expected in 2014. A scientific project has been launched also in this field. It is co-financed by the Croatian Science Foundation and KONČAR - Institute, whose funds were used for the entire scientific-research work and additional laboratory equipment.

In the period 2008 – 2012 KONČAR - Institute has earned by sales of products resulting from the above mentioned scientific research:

- wind turbine control system – HRK 11 million
- Hybrid Box – HRK 2.7 million
- train bus communication – HRK 0.2 million.

A total of HRK 13.9 million was earned by sales of Institute's newly developed products, which are installed in 16 wind turbines whose value is HRK 147 million, two low-floor trains (HRK 70 million) and three Hybrid Boxes, as products of KONČAR Group and its subcontractors. This production and the sales have ensured about 300 new jobs and preservation of the existing ones as the greatest community benefit.

President of the Managing Board

Prof. Stjepan Car, PhD