

UNIVERSITA' DEGLI STUDI DI PADOVA  
NUCLEO DI VALUTAZIONE DI ATENEIO

FINAL EVALUATION REPORT

on

**Dip.to di Ingegneria Elettrica dell'Univ. degli Studi di Padova**

**V.Coccoresse, A.J.Davies, D.Lavers, J.Mizeraczyk:  
November 2006**

**1. Introduction**

This report is the result of an evaluation exercise undertaken in Padova over the period 6th - 8th November 2006. The evaluation was carried out by a team of experts having knowledge and expertise relevant to the programmes of research being undertaken in the Department of Electrical Engineering. The team, as appointed by the University, comprised Professors J. Douglas Lavers (University of Toronto, Canada), Anthony Davies (University of Wales Swansea, U.K.), Jerzy Mizeraczyk (Polish Academy of Sciences, Gdansk, Poland), Vincenzo Coccoresse (Università degli Studi di Napoli "Federico II", Napoli, Italy) and Francesco Profumo (Politecnico di Torino, Italy). The University made available to the evaluation team the self-evaluation report prepared by the department and a set of guidelines for the evaluation exercise.

The team agreed to meet in Padua from 6th to 8th November 2006 and this meeting was attended by V.Coccoresse, A.J.Davies, D.Lavers, J.Mizeraczyk. F. Profumo was, however, unable to attend. As indicated in the guidelines, the meeting was dedicated to the following activities: i) discussion of the preliminary individual expert reports in order to address possible amendments to them; ii) visits to the department and interviews with its members; iii) common discussion on the outcome of the visit in order to address the final common report, to be prepared after the meeting.

After initial discussions of the self-evaluation report, the panel agreed on a work plan and also agreed to designate Prof. Davies as coordinator of the panel. On 7th November the panel members visited all the laboratories associated with the 9 programmes mentioned in the self-evaluation report and, during these visits, the panel had extensive talks with most of the personnel contributing to the programmes. As far as programme 5 (Fusion) is concerned, a visit was made to the RFX experiment. On 8th November, after having interviewed the Director of the department, the panel discussed the outcome of the visit and agreed on the general contents of the common report. The four individual expert reports, modified on the basis of the outcome of the visit, are an integral part of the present report and are appended as Annexes A, B, C and D.

**2. Assessment of the 9 Programmes**

The programmes of all 9 research groups were assessed and are reported on in detail below.

**(a) Programmes in which the research is of a leading international standard**

***Electrical Drives***

The evaluation panel considered this research program to be of international quality and to compare very favourably with leading electric drives groups elsewhere. In reaching this conclusion, the panel considered the projects being undertaken, the number of students being educated, the interaction with both Italian industry as well as the broader international research community, and the dissemination of the research results in terms of conference and archival journal publications. The current projects within the group were found to be of significant research and economic interest, both with respect to local Italian industry and in terms of attracting students. As specific examples, the panel noted the projects relating to drives for automotive power steering applications, systems for direct drive applications and the high efficiency drive for an inner city electric scooter. In all instances, the projects incorporated the essential characteristics of theory, design and experimental validation. The level of activity in the program was found to be very high, the students were enthusiastic, and overall research direction had focus and coherence.

The panel was impressed with the level of research funding that has been available to the group, both from national competitions and from local industry. The panel noted, in particular, the success that has been achieved in reaching out to local industry for support. The funding has obviously resulted in the development of excellent research facilities for design and testing. The panel specifically noted the availability of several experimental test benches for motor parameter extraction and drive system testing.

The research output of the program, as measured by the quality and number of publications, was found to be excellent. The work is published regularly in strong archival journals and is presented regularly at leading international conferences. Additionally, there are strong contacts with most of the leading international electric drives groups. The panel was also impressed with the regular symposia that have been organized to present the research in the program to local industry. The panel is confident that the group will continue to attract strong funding and significant numbers of students.

### ***Electrical Power Systems***

This is a classical and mature field of research in Electrical Engineering and is of vital economic and technological importance to the Electrical Supply Industry both within Italy and on an international scale. The research topics are very current in terms of interest, particularly the projects on Distributed Generation, on Innovative Technologies, and on Energy Economics. There are a good number of staff and students in the group who are well known in the field and have attracted considerable funding from EU and institutional national sources as well as from research contracts. Furthermore the group has extensive links with other national and international research groups and participates fully in the activities of International Standards Committees.

The total number of research products in the form of publications is extremely good. In addition to contributing regularly to International Conferences in the field there has been considerable output in the form of journal papers and chapters in books etc although the group should be encouraged to continue to expand its publication rate in archival journals. The evaluation panel was impressed by the effort the group has taken to disseminate information to interested bodies

The researches being carried out are very relevant to the Electrical Supply Industry and to all bodies interested in power generation and distribution so that the prospects of obtaining continued funding for the research are excellent. The evaluation panel are confident that the group will continue to operate at its present high level.

### ***Industrial Automation***

Despite being a relatively small group, Industrial Automation was found to have a very active research and development program that was of considerable topical interest and of international calibre. The panel particularly noted the projects relating to motion control, drive-by-wire systems and the new project on hybrid automotive drives. In aggregate, the research program has a strong self-consistency and coherence, together with substantial intrinsic and industrial relevance. The overall attractiveness of the program has resulted in the group attracting a significant number of doctoral students and international fellowship holders, as well as a good level of research funding. The laboratory associated with the group was found to be very well equipped and maintained.

The leader of the group has a high national and international profile, as evidenced by his participation in important committees and editorial boards in the field. The productivity of the group was found to be very good, with research results appearing in high ranked archival journals and important international conferences.

The panel was of the opinion that the Industrial Automation program is excellent by international standards and will continue to have excellent opportunities for growth, which would guarantee an active and productive future for the program. Although power electronics is now a relatively mature discipline, there remain significant growth opportunities in the development of active and reactive power controllers for power system compensation. Significantly more opportunity exists on the mechatronic side, which is still relatively young. In both areas, there are also major opportunities for the group to interact with other areas within DIE, most notably Electric Power Systems, Electric Drives, and potentially Electric Machines.

**(b) Programmes in which the research is of high quality though with potential for further development**

***Electrical Machines***

The evaluation panel found the Electric Machines program to be generally satisfactory, but with significant scope for improvement. The research activities within the group are centred on simulation, partly using commercial Finite Element code, and partly using code that has been developed in-house. Several of the projects within the group are intrinsically interesting, particularly the linear motor development for robotic applications, and the in-wheel drive motor for transportation. The group has actively participated in several national projects, but overall, the research funding was found to be on the low side, particularly with respect to the industrial component. The researchers within the group are of high calibre, but the lack of research funding appears to have had an impact on the ability of the group to attract doctoral students. The area of electric machines is a very mature subject, yet today, there are numerous small companies that are making innovative products for exciting applications. Those involved with the Electric Machines program are strongly encouraged to expand their efforts to link with industry, partly to secure funding, but also to identify projects that would excite and attract young doctoral students.

Generally, the productivity of the group was found to be rather low, although it was noted that 50% of the publications were either journal papers or chapters in books. On balance, however, the journals were generally not of the first rank. As such, group has not yet established an international presence. Nevertheless, much of the recent work that was presented to the panel was of very good quality that deserves to be placed in a high quality journal. Those involved are strongly encouraged to do so. The young researchers within the group are equally encouraged to participate actively in leading international conferences such as ICEM or the IEEE Industry Applications Conference.

Given the large industrial base in north Italy, the prospects for increased industrial collaboration, leading to growth in the Electric Machines program, should be good. However, those involved with the program will have to make a determined effort to increase the presence of the group within the industrial community. The group is also encouraged to explore possible synergies with other programs within DIE, most notably Electric Drives and Industrial Automation.

***Electroheat and Electromagnetic Biomedical Applications***

The Electroheat Program at Padua has a very long history of excellence. Research in this area falls within an interesting and very topical area, namely problems that involve coupled physical phenomena. Classical electroheat tended to focus on a limited set of problems related to induction heating and melting of metals. The area has expanded significantly since those days, and the program at Padua reflects this broader vision in a coherent fashion. Certain of the research projects reflect important extensions of classical electroheat (e.g. heating of thin strip; resistance heating of curvilinear work pieces), while others postulate imaginative solutions to classical problems (e.g. the use of dual frequencies for induction hardening of gears). A major recent thrust in this electroheat area has been to recognize that electromagnetic fields have a very important potential in novel material processing systems. This recent trend is reflected in several of the projects presently being undertaken (e.g. re-heating of tixco cast billets, where precise temperature control is required) or are at the early stages of investigation (e.g. processing of silicon for photovoltaic applications). Equally important, the vision of electroheat has been expanded to include new applications in the biomedical area.

The Electroheat Program at Padua is recognized as being one of the leading centres for such research world wide. With a professorial staff complement of two, the program has the resources to carry on a meaningful research program, and the quality of this program is evidenced in the departmental summary report. The individuals involved with the program have an international reputation within the area. The funding for the program is very good, considering both institutional (~25%) and industrial (~75%) sources. In aggregate, the funding of more than 80K Euro per year is considered to be excellent.

The number of publications per member of staff is very good, although these have been mainly in the form of conference papers, a number of which are in leading conferences in the field. The staff is encouraged to publish more of the key research results in archival journals in order to gain a more widespread recognition for the work.

Given the ongoing interest from industry, which is very strong, there is no reason why continued funding for the area should not be obtained.

### ***Photometry and Light Engineering***

This relatively new programme was initiated in 2000 and, in the opinion of the evaluation panel, is an appropriate response by DIE to modern demands. The Programme on Photometry and Light Engineering, headed by Prof. Lorenzo Fellin, is highly relevant to industry (as demonstrated by the interest of North-East Italian companies) and society (in particular the road lightning project, the lightning of art works, and new light sources).

This young laboratory is relatively well equipped and the funding is also good. The group has already established several national collaborations and one international link (St. Petersburg). It seems that the group leaders are very active in disseminating their results (with the organization of several workshops) and in seeking possible funds. If one takes into account the fact that the publication activity of the group only actually started in 2003, the number of publications is very good in relation to the number of staff.

The needs of industry and society for the research and development delivered by this group are very high. The human resources available are, however, very much on the low side and need to be increased in order to undertake new projects effectively.

### **(c) Programmes in which the panel identified significant concerns that need to be addressed (not necessarily concerned with the quality of the research)**

#### ***HV Applications and Measurements***

The evaluation panel recognises that DIE has a long history in the field of High Voltage Applications and Measurements and was impressed by the laboratory facilities and equipment. There has however, at both national and international levels, been a slow decline in interest in the field in recent years. This trend, coupled with recent loss of distinguished researchers such as Prof Baldo and Prof Zingales, seems to have led to the High Voltage Programme losing its driving force.

The present members of staff have considerable expertise and are very well known in the field, participating fully in the Technical Committees of relevant professional institutes and organizations. Furthermore a considerable amount of testing and development activity is still carried out for industry but, due to the small size of most industrial concerns, it is difficult to obtain research funding in the form of contracts so that the amount of fundamental research work being conducted is very limited. These factors, coupled with the reduction in staff numbers and the lack of PhD students, has meant that the number of research products in the form of publications has been very low with only 12 conference papers and no journal papers over the last five years.

Although the facilities and expertise available in the group are of high quality and should be of interest to those working in the high voltage field, there is a pressing need to expand links with industry and to generate funds that will facilitate a more vivid research vision rather than simply testing and development. At a national level, Italian industry and universities working in this field should give serious consideration to developing a consortium on a national scale similar to the Power Academy in the U.K. which involves 6 U.K. universities, 15 industrial concerns plus two professional institutions. In addition, the proposed participation in the ITER project may help give a new momentum to the group. The evaluation panel hope that the University will continue to support the HV programme and give support and encouragement to Prof Giancarlo Pesavento in strengthening research in this field which might well be facilitated by incorporating the programme in a larger research grouping.

#### ***Industrial Magnetic Compatibility & Computational Electrical Science***

The evaluation panel had some difficulty in assessing this research programme since it seemed difficult to justify the linking together in a single programme of the computational research and the experimental work being carried out in the Electromagnetic Compatibility Laboratory. To the panel, the two research areas did not appear to be closely related and the department is recommended to review their position in the overall departmental research structure.

The computational research topics being pursued are of considerable topical interest and the work is of high quality. It is also highly relevant to other research programmes such as Electrical Power Systems and Fusion. The number of publications is approximately one per member of staff per year and it is noteworthy that these are mainly in high ranking journals. Increased participation in relevant conferences would help enhance the profile of the group.

The instrumentation and facilities in the Magnetic Compatibility Laboratory are a valuable facility but, to the panel, the personnel and resources available do not appear to be sufficient to justify existence as a separate research programme. In reviewing its research provision the department should consider the possibility of linking the work of this laboratory with other programmes so as to create a more viable unit.

#### **(d) The Fusion Research Programme**

The research activity in this programme, headed by Prof Giorgio Rostagni, is mostly dedicated to the Consorzio RFX project, which is recognized worldwide as being among the leading experiments in the field of fusion. The partners in Consorzio RFX are the University of Padova, CNR, ENEA and Acciaierie Venete S.p.A. Since this research programme is on a much larger scale than is customary in most universities, the evaluation panel decided that it was preferable to consider it separately.

The department dedicates about 1/3 of its manpower to the Fusion programme and this indicates the importance that is attached to this area of research. The permanent DIE staff play a key role in the overall activities of RFX and their expertise will be particularly relevant in the International Thermonuclear Experimental Reactor (ITER) project which will consist of a large facility to be built in Padua under Consorzio RFX responsibility. The contribution of the department is channelled through the interdepartmental research centre CRF, due the multi disciplinary character of the competences needed. The programme gives extraordinary opportunities to young researchers to take part in a highly competitive international and multi disciplinary environment.

The Consorzio RFX programme is supported by the European Union at priority level and forms a vital part of the European fusion programme which has very important sociological implications with regard to future energy strategy. Apart from the continuation of the RFX experiment, the ITER project gives excellent future possibilities for this area of research which should hopefully attract even larger human resources to the department. It should be noted, however, that during discussion during the panel visit, some reservations were expressed about the rather small financial return that the department received in return for a considerable investment in terms of staff salaries.

In contrast to the considerable funding that has been obtained for this area of research, the productivity, if measured in terms of conference and journal papers, is on the low side when compared with some of the other programmes. However it has to be noted that it is a common experience for researchers working in large scale experiments to have relatively few journal papers each with a large number of authors. Therefore, in the particular case of this programme, the productivity should be measured in terms of the high prestige that the Fusion Group brings to the University and to the department due to the excellent and fundamental contribution that is being made to the European Fusion Programme.

### **3. General Issues to be Addressed**

#### ***Numbers of PhD students and Post-Doctoral Research Fellows***

The evaluation panel noted that the average number of research-active staff over the last five years had been approximately 35 while the number of PhD students had averaged only about 22 (much less than 1 per member of staff) and that there have been hardly any Post-doctoral Research Fellows. It further noted that concern had been expressed in the SWOT analysis and elsewhere about the high teaching and administrative loads. The panel were of the opinion that the amount of teaching and administration allocated to staff was very comparable with other European countries and the USA but that the small number of PhD students and Post Docs per member of staff placed a great onus on staff members themselves to carry out the research. It therefore believes that a concerted effort is needed in all research programmes to generate financial resources to support more PhD students and Post-doctoral Fellows thus increasing the critical mass of the research groups and allowing staff to concentrate on directing, developing and facilitating the research rather than actually carrying out the work themselves.

#### ***Overall Research Structure***

It was noticeable from the Self-Evaluation Report that, relative to the number of staff in the department, the numbers of research programmes (9) and individual projects (60), although giving an indication of the very positive research ethos, were large. It is accepted that some of the present groupings are inherited from traditional lines of research or are dictated by national demands, but the panel feels that there would be

considerable merit in some degree of rationalisation especially in view of the perceived need for increased academic and technical staffing. In particular, the department is recommended to give special consideration to (a) seeking ways of supporting the activities of the HV Applications and Measurements Programme and (b) to revising the structure of the Programme on Industrial Electromagnetic Compatibility and Computational Electrical Science.

#### 4. **Conclusions and Recommendations**

##### ***Conclusions***

The evaluation panel wishes to express its thanks to Professor Sergio Lupi, Professor Silverio Bolognani and their colleagues for the open and constructive manner in which they approached the evaluation exercise. The panel very much appreciated the excellent arrangements that had been made and the full and informative documentation that was made available to them.

From the evaluation exercise it is clear that the Department of Electrical Engineering has a very positive attitude towards its research activities. There are excellent research facilities with well-equipped laboratories and, in general, the research work being carried out is of a high standard. The great majority of the staff are of high research calibre, are respected in their fields and have excellent links with industry.

The department is accomplishing a significant amount of research without the levels of funding and numbers of PhD students and Post Doctoral Fellows that would be typical of other European countries and North America. The overall research programme does, however, appear to be somewhat fragmented with a large number of projects relative to staff and students numbers so that a degree of re-structuring into a reduced number of larger-size groups appears desirable. There is an urgent need to increase external funding in order to increase the number of graduate students and Post Doctoral Fellows.

The number of research products in the form of publications is very good but the research profile of the department would be enhanced by an increased publication rate in high-ranking archival journals.

##### ***Recommendations***

In the light of the above observations, the evaluation panel makes the following recommendations:

- The department should be encouraged to initiate an early review of its research structure with a view to increasing efficiency and ensuring the coherence of its research activities.
- Immediate efforts should be made to explore sources of funding for new junior manpower, including PhD students, Post Doctoral Fellows and researchers.
- That staff be encouraged to enhance research output in the form of publications in high impact, peer reviewed, international journals.

DIE has a distinguished history and an international reputation in research. The evaluation panel wishes the department well for the future and hopes that its recommendations and observations will help the department maintain its high reputation.