

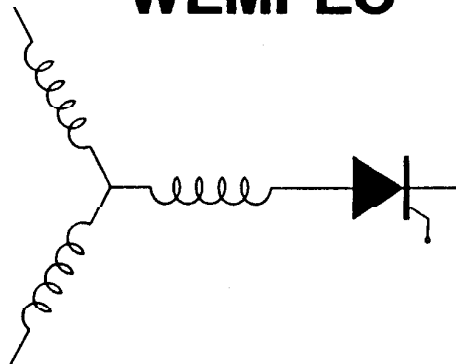
# Wisconsin Electric Machines and Power Electronics Consortium

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The Industrial Consortium  
A Format for University-Industry Interaction

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## WEMPEC



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**THE INDUSTRIAL CONSORTIUM  
A FORMAT FOR UNIVERSITY-INDUSTRY INTERACTION**

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**Abstract**

For the last 10 years the Wisconsin Electric Machines and Power Electronics Consortium (WEMPEC) has provided base support and a focus for educational and research activities in electric machines and power electronics at the University of Wisconsin-Madison. The consortium currently has over 40 industrial sponsors and involves five faculty members and more than 40 graduate students.

Based on a program plan developed jointly with several industrial participants WEMPEC has emphasized close interaction between faculty, students and industrial sponsors and a balanced program of educational and research activities. The paper describes the organizational structure and program activities of the consortium and the advantages to both the university and industrial partners. Some of the issues and problems associated with consortium development and operation, such as intellectual property rights, communication between faculty and sponsors, technology transfer methods and other related issues are discussed. Although focused on WEMPEC, the paper also describes some of the variations in structure used in other consortia to serve the needs of different programs and varying programmatic goals.

**Introduction**

The need to generate external support for university research activity creates an environment in which the ability to maintain a steady stream of grants and contracts is crucial to the success of a program. Generally, funding comes in relatively large increments compared to day to day needs and this can cause problems even when a program is well funded overall. For example, it is often necessary to defer decisions until a grant is approved. This is particularly awkward in the case of attracting quality graduate students since a delayed offer can often result in the student accepting an offer elsewhere.

The fundamental problem is the lack of base funds to provide flexibility in day to day operation and the ability to respond rapidly to research opportunities. In an effort to help solve this problem, the concept of an industrial support group which could provide base funding and a program focus has evolved and has come to be referred to, in university circles, as an industrial consortium. Although the primary initial motivation is often the issue of base financial support, the impact of such organizations on research productivity, educational improvement, industrial interaction, technology transfer and other such items has been very positive.

At the University of Wisconsin - Madison, a large number of consortia (over 20) have been initiated with varying degrees of success. The following discussion is primarily based on experience gained in the Wisconsin Electric Machines and Power Electronics Consortium (WEMPEC) but will attempt to deal with some of the organizational and operational issues in more general terms.

## The Consortium Concept

An industrial consortium is basically an organization of interested companies who agree to help support an expanded program in a well defined and limited program area. The goal of a consortium is usually stated as "An improved and expanded program of education, research and service in (the specific area of the consortium). For example, the goals of WEMPEC as stated in the original proposal developed in 1980 were:

"The sponsors and the faculty directors of the program will be dedicated to the development of the best possible education, research and service program in the area of electric machines and power electronics. Specifically the program goals will include:

- 1) A strong undergraduate elective program graduating 20-30 BS degree recipients per year.
- 2) A strong MS and PhD program involving 6-12 MS and 3-6 PhD students engaged in research in the fields of electric machines, power electronics and AC drives.
- 3) Improved instructional and research laboratory facilities.
- 4) A close and productive relationship between the program faculty and students and the sponsoring companies".

Note that these goals were stated as joint goals of the faculty and sponsors and dealt specifically with undergraduate teaching, graduate teaching and research, facilities and the desire for close interaction between the sponsors and university participants. This broad base of activity has been a major strength of WEMPEC and seems to be an important attribute of successful consortia.

## Organizational Characteristics

The structure and plans for a consortium are typically summarized in a document called the program plan which is the equivalent of a proposal to create the consortium as well as a plan for operation. Although there can be considerable variation in the details of a program plan, the following items form the core elements of the WEMPEC document and outline the major characteristics of consortia development and organizational structure.

Program Area Description - The need for expanded effort in the area and the special capabilities of the group proposing the consortia are important aspects of the narrative.

Program Goals - The goals for the program, as listed earlier for WEMPEC, form an important section of the plan. Specific statements as opposed to very broad, general outlines are important.

Program Faculty and Directors - The faculty members who will be directly involved are listed and the director or directors clearly identified. Other faculty members who may be involved in supporting roles can also be listed but it is important to clearly identify the major players.

Program Description - A concise but complete and specific description of the various proposed activities of the consortium is generally given. In the case of WEMPEC, this description included the following subdivisions:

### Education

- Undergraduate Course Development
- Graduate Course Development

Seminar Series  
Cooperative Programs  
Continuing Education

**Research**

Generic Research (now generally "pre-competitive" research)  
Grant and Contract Research

**Service**

Liaison With Sponsors  
Faculty Visits, Program Review Meetings  
Information Services  
Research Reports, Tutorial Reports, Software  
Consulting

Additional information and examples concerning various aspects of these program functions is given later in the paper.

Program Administration - The basic plan for administration of consortium funds and activities is clearly an important organizational issue. Some consortia utilize an advisory committee structure which involves representatives of the sponsoring companies. While this can be a successful approach, it has the disadvantages of requiring time commitments on the part of sponsors and, for large consortia, the problem of having a very large group or the development of an acceptable rotating committee membership plan.

In the case of WEMPEC, which was intended as an open ended program with a large and diverse group of sponsors, program administration was delegated entirely to the faculty directors. This decision was reached after consultation with a number of potential sponsors and was based on feedback which indicated that sponsors would be more comfortable with faculty control as opposed to the possibility that individual sponsors could exert a disproportionate influence on consortium operation. The paragraph in the WEMPEC Program Plan following the statement that the program administration will be the responsibility of the faculty directors is:

"It is the intent of the directors and associate directors to communicate our plans and seek the comments of the sponsors in determining major funding policies and in establishing the direction and content of the teaching and research programs. The primary mechanism (in addition to liaison visits) for sponsor input to program policy will be "program advisory questionnaires" which will be sent periodically to all sponsors to communicate program plans and seek comments. Final decisions on expenditures, overall program policies, course content, research project topics, and day to day operations must, of necessity, reside in the directors and associate directors".

There was also a listing of the primary purposes for which consortium funds would be used including graduate student stipends, laboratory and administrative staff salary support, research laboratory equipment and funds for visiting faculty, travel, publication costs, visits to sponsors and other miscellaneous costs.

Intellectual Property - Some provision to handle patents arising out of consortium activity is an obvious necessity. In the case of WEMPEC this was handled by arranging for the Wisconsin Alumni Research Foundation (WARF) to handle all WEMPEC patents. WARF is a non-profit corporation which has handled faculty patents from UW - Madison for many years. The original arrangement was for granting nonexclusive licenses to use WEMPEC patents with royalty credits to WEMPEC sponsors based on the length of time of

sponsorship prior to the date of the patent. This is being considered for modification to permit exclusive licenses in certain cases after a full notification to all sponsors and the passage of a specific period of time from such notification.

The treatment of patents and the subsequent funding of successful research ideas initiated with consortium funds are the most complicated issues arising in consortium management. It has been necessary to improvise solutions to these and other problems during the growth of WEMPEC. One innovation, the mini-consortium is described later in the paper.

**Sponsor Contributions** - The issue of the amount of the support provided by each sponsor must be spelled out. The range of possibilities is large, extending from fixed dollar amounts to variable contributions based on sales, number of employees, etc. The choice depends on the goals of the consortium. In the case of WEMPEC, a large, broad based group of sponsors was the desired goal and in order to include small companies the sponsor contribution was set at \$5000/unit with a maximum of three units from any one company. With this structure larger companies with several divisions could become multiple sponsors without smaller companies feeling the consortium was being dominated by a few large sponsors. The sponsorship contribution was increased to \$7500/year after five years of operation. At all times the fee was kept at a low value in order to encourage "grass roots" engineering level support rather than executive level support for the financial commitment.

#### **Consortium Activities**

During the entire 10 years of its existence WEMPEC has been the focal point for nearly all activity in electric machines and power electronics at UW-Madison. Although providing only 15-25% of the total external funding, the importance of the consortium funds and the program identity made possible by the organization cannot be overstated. While the importance of the funding and the funding flexibility is easily appreciated, the significance of the other aspects of consortia operation may be less clear and are therefore emphasized here.

**Review Meetings** - From the beginning the WEMPEC Review Meetings have been the high point of yearly program activity. Initially a one day meeting attended by 20-30 representatives of sponsors, the meeting has now grown to two days with an attendance of over 100. Combining presentations on research projects, poster sessions, laboratory demonstrations and tutorials the meetings provide an opportunity to showcase consortia activity. They also, however, provide an important mechanism for informal feedback from sponsors and a means for creating important professional and social relationships between faculty, students and sponsor personnel. Preparing the Program Summary which records the yearly activity in all program areas is an important exercise in itself as is the once per year major housecleaning of the laboratory in preparation for the meeting demonstrations.

**WEMPEC Reports and Newsletter** - A major means of reporting consortium activity is the regular mailing of WEMPEC Reports to contact persons at each sponsor unit. Mailings take place whenever a group of 6-12 Reports have accumulated. There are three types of Reports; Research Reports which are typically technical papers, Thesis Summaries which summarize the results of student theses and Tutorial Reports which are usually course notes describing new or emerging areas which are being incorporated into our regular courses.

While the Reports constitute a major mechanism for keeping sponsors informed of WEMPEC activity, the problem of getting the material to the proper persons has been troublesome. Since cost and logistics prevent sending multiple copies of all Reports to

each sponsor, a quarterly Newsletter which summarizes all Reports is sent to as many individuals in each sponsor organization as are identified by the sponsor. This provides a means for reaching a broad spectrum of persons at each sponsor unit and keeping them informed of WEMPEC activities and plans.

Seminar Series - A weekly Research Seminar is held during the academic year. Approximately half of the speakers are from WEMPEC sponsors and the remainder are students presenting their thesis research results. Announcements of the seminar are supplied to all sponsors and it is common to have sponsor representatives attending seminars. Often sponsors visiting the campus to discuss research activity or interview students arrange their visits to allow seminar attendance.

Continuing Education - Seven different short courses are offered on a rotating schedule of two or three per year. All are well attended by WEMPEC sponsors and others.

Off Campus Graduate Courses - Five of our regular graduate level courses are offered in videotape format as "Outreach" courses and also through the National Technological University (NTU). These courses can be taken for credit or as non-credit courses and have been widely used by WEMPEC sponsors as well as others. Several sets of tapes have been purchased by companies for in-house instruction.

Liaison Visits - Faculty visits to sponsors and sponsor groups visiting the campus are common and highly encouraged. A special effort is made to visit all new sponsors and to have each new sponsor present a seminar on campus. In recent years the number of sponsor visits to the campus has increased substantially as a result of increased interest in some of the research activity and the transfer of the results to industrial applications.

#### Research Mini Consortium

The objective for WEMPEC sponsored research projects is to demonstrate proof of concept and to pursue pre-competitive base technology development. Consequently, there are typically a large number of projects funded by the consortium, and it is difficult to divert a significant portion of the resources towards a particular project. This problem becomes acute when a promising technology emerges and needs substantial funding to allow a demonstration of its potential. In at least one such case, interested WEMPEC sponsors were approached to form a 'mini consortium' to pursue rapid and focussed development in the area of resonant link power converters. Nine companies along with initial seed funding from the University provided \$180,000 over a period of 2 years to support the project. It is felt that such innovative approaches are necessary to allow limited consortia funds to fulfill the desired objectives.

#### Benefits to Consortium Partners

The consortia model outlined above has proven to be beneficial to both partners; university and industry. In summary form, the benefits include:

##### To Industry

- 1) Influence on research directions of university program
- 2) Expanded pre-competitive research base (highly leveraged)
- 3) Increased student pool in area of activity
- 4) Rapid access to research results
- 5) Increased access to tutorial materials
- 6) Route to other university resources
- 7) Access to faculty specialists for information and consulting

8) Information on international development in technology area  
To University

- 1) Flexible base financial support
- 2) Opportunity to leverage funding
- 3) Attractive program for prospective students
- 4) Supports industrial growth and development
- 5) Relevant research topics
- 6) Access to state of the art technical information
- 7) Feedback on educational needs
- 8) Student employment opportunities
- 9) Equipment gifts

### Summary

WEMPEC has been a key factor in developing and maintaining a strong educational and research program in electric machines and power electronics at the University of Wisconsin - Madison. Based on a model developed jointly with several industry participants, WEMPEC is an open-ended consortium structured to attract a large number of sponsors each supplying only a modest sponsorship contribution. Other key ingredients in the WEMPEC model include a strong educational focus on both resident instruction and continuing education, emphasis on generic or pre competitive research and a strong program of interaction with sponsors through reports, visits and an annual review meeting. Administration of the program is left entirely to the faculty directors but sponsor inputs are sought through visits and program advisory questionnaires. WEMPEC provides substantial benefits to both the university and industrial partners and as a result continues to provide an important mechanism for cooperation in education and research.

### Biographies

Donald W. Novotny received the B.S. and M.S. degrees in electrical engineering from the Illinois Institute of Technology, Chicago, in 1956 and 1957 and the Ph.D. degree from the University of Wisconsin-Madison in 1961. Since 1961 he has been a member of the faculty at the University of Wisconsin-Madison where he is currently Grainger Professor of Power Electronics and Co-director of the Wisconsin Electric Machines and Power Electronics Consortium (WEMPEC). His teaching and research interests include electric machines, variable frequency drive systems and power electronic control of industrial systems. Dr. Novotny is a Fellow of IEEE, and member of ASEE, Sigma Xi, Eta Kappa Nu and Tau Beta Pi and is a Registered Professional Engineer in Wisconsin.

Thomas A. Lipo received his B.E.E. and M.S.E.E. degrees from Marquette University, Milwaukee, WI in 1962 and 1964 and the Ph.D. degree in electrical engineering from the University of Wisconsin in 1968. He became Professor of Electrical Engineering at Purdue University in 1979 and in 1981 he joined the University of Wisconsin where he is currently Grainger Professor of Electric Machines and Power Electronics. He has received eleven patents and has eleven IEEE prize paper awards for his work including co-recipient of the Best Paper Award in the IEEE Industry Applications Society Transactions for the year 1984. In 1986 he received the Outstanding Achievement Award from the IEEE Industry Applications Society for his contributions to the field of ac drives and in 1990 he received the William E. Newell Award of the IEEE Power Electronics Society for contributions to field of power electronics. He is a Fellow of IEEE.

Deepakraj M. Divan received his B. Tech degree in Electrical Engineering from the Indian Institute of Technology, Kanpur, India in 1975. He also has a M.Sc degree and a Ph.D degree in Electrical Engineering from the University of Calgary, Calgary, Canada.

Since 1985, he has been with the Department of Electrical and Computer Engineering at the University of Wisconsin, Madison where he is presently an Associate Professor. He is also an Associate Director of the Wisconsin Electric Machines and Power Electronics Consortium (WEMPEC). His primary areas of interest are in power electronic converter circuits and control techniques. He has over 30 papers in the area as well as many patents.

Robert D. Lorenz received B.S.(1969), M.S.(1970), and Ph.D.(1984) degrees in mechanical engineering from the University of Wisconsin-Madison. In 1984 he joined the University of Wisconsin-Madison as an Associate Professor of mechanical engineering and Affiliate Associate Professor of electrical and computer engineering. He is Associate Director of the Wisconsin Electric Machines and Power Electronics Consortium and Co-Director of the Advanced Automation and Robotics Consortium. He was a member of the research staff at the Gleason Works, in Rochester, New York from 1972 to 1982. In 1969-70, he did his Master thesis research at the Technical University of Aachen, Germany. He is a member of the IEEE, the ASME, the ISA and the SPIE.

Robert H. Lasseter received his B.S. and M.S. degree in Physics from North Carolina State University in 1963 and 1967 and the Ph.D degree in Physics from the University of Pennsylvania in 1971. In 1973 he joined the General Electric Company in Philadelphia in the High Voltage Direct Current department. In 1980 he joined the department of Electrical and Computer Engineering at University of Wisconsin-Madison. He is currently a Full Professor with research interest in the application of power electronics to utility systems. This work includes harmonic interactions, simulation methods and converter controls. His work has resulted in two books and over 50 papers. He is an associate editor of IEEE Transactions on Power Electronics, a senior member of IEEE and an expert advisor to the US representative of CIGRE SC14.