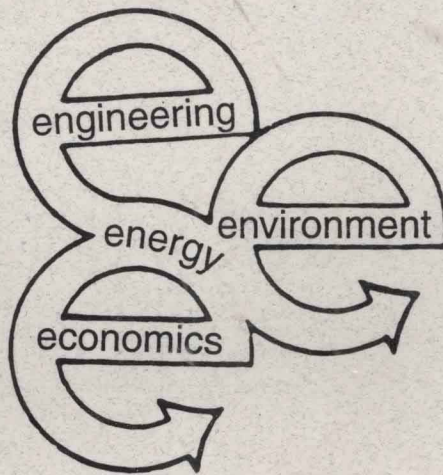


2000

33rd ANNUAL

FRONTIERS OF POWER CONFERENCE

PROCEEDINGS



Co-Sponsored by:

THE ENGINEERING ENERGY LABORATORY

and

THE SCHOOL OF ELECTRICAL AND COMPUTER ENGINEERING

October 30-31, 2000

**A University Extension Program
Oklahoma State University
Stillwater, Oklahoma 74078**

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Oklahoma State University
216 Engineering South
Stillwater, OK 74078-5034
(405) 744-5157 or
(405) 744-9912

PREFACE

2000 FRONTIERS OF POWER CONFERENCE

This Proceedings is a compilation of the papers presented at the Thirty-Third Annual Frontiers of Power Conference sponsored by the Engineering Energy Laboratory and the School of Electrical and Computer Engineering, Oklahoma State University, with the support of the electric utilities in this area.

This Conference is the outgrowth of the research on energy conversion and storage started in 1961, and actively sponsored starting in 1964, by six electric utilities in this area. These six utilities were:

- *Oklahoma Gas & Electric Company, Oklahoma City, Oklahoma
- *Public Service Company of Oklahoma, Tulsa, Oklahoma
- *Arkansas Power & Light Company, Little Rock, Arkansas
- *Kansas Gas & Electric Company, Wichita, Kansas
- *Empire District Electric Company, Joplin, Missouri
- *St. Joseph Light & Power Company, St. Joseph, Missouri

This original research resulted in the establishment of an Annual Conference starting in 1963, on Energy Conversion and Storage. This Conference was held annually through 1965, and essentially stressed direct energy conversion. At about 1965, the number of national Conferences dealing with direct energy conversion increased rapidly, so the OSU Conferences on Energy Conversion and Storage were not held in 1966 or 1967. The support by utilities continued throughout this time.

The School of Electrical and Computer Engineering felt there was continuing need for a forum whereby the electric utilities, electric power equipment manufacturers, the universities, and government agencies could discuss and examine the technology that was relevant to the needs of the electric power industry in solving the problems confronting them. Therefore, the Conference was reinstituted with a new name, a broadened scope and held in 1968, as the Frontiers of Power Technology Conference. With the continued support of the electric power industry and a slightly shortened name, this Conference has been successfully conducted over many years and is in its 33rd year.

A special acknowledgment is made to the authors and moderators for their contributions, as the Conference would not be possible without them.

Rama Ramakumar
Director, Engineering Energy Laboratory
School of Electrical and Computer Engineering
and
Conference Director
Stillwater, Oklahoma 74078-5034
October 2000

MEMBERS OF THE PROGRAM COMMITTEE FOR THIS YEAR'S CONFERENCE

Terry L. Henry, Director, Corporate Planning, OG&E Energy Corporation, Oklahoma City, Oklahoma

Steve Howell, Manager of Engineering Services, Oklahoma Municipal Power Authority, Edmond, Oklahoma

William C. Howell, Plant Manager, Stateline Combined Cycle Plant, The Empire District Electric Company, Joplin, Missouri

Dan Lingelbach, Professor Emeritus, School of Electrical and Computer Engineering, Oklahoma State University, Stillwater, Oklahoma

Robert B. Wallace, Manager, Region Support, Public Service Company of Oklahoma, Tulsa, Oklahoma

MEMBERS OF THE EXECUTIVE COMMITTEE FOR THIS YEAR'S CONFERENCE

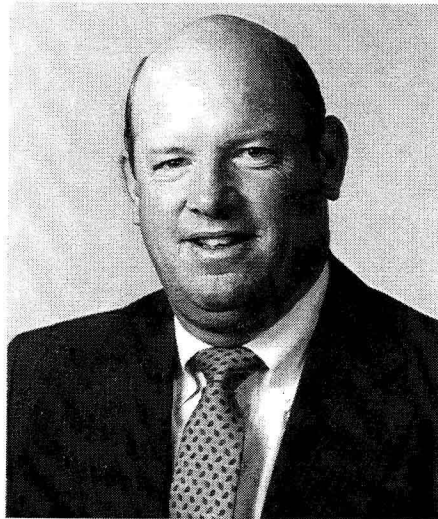
Jack Coffman, Vice President, Power Supply, OGE Energy Corp., Oklahoma City, Oklahoma

Harry Gordon, Director of Engineering Support, American Electric Power, Columbus, Ohio

R. Ramakumar, Director, Engineering Energy Laboratory and PSO/Albrecht Naeter
Professor of Electrical & Computer Engineering, Oklahoma State University,
Stillwater, Oklahoma

KEYNOTE SPEAKER

GLENN FILES SENIOR VICE-PRESIDENT-DISTRIBUTION AMERICAN ELECTRIC POWER



Glenn Files joined American Electric Power as Senior Vice-President of Distribution in June of 2000 at the close of the merger of Central and South West and AEP. Glenn's career with CSW spanned 29 years, beginning in 1971 at Public Service Company of Oklahoma where he held positions in Customer Service, Customer Accounting, Local Operations, Division Management and Corporate Planning. In 1989, he was promoted to the position of Vice-President of Marketing and Business Development for Central Power and Light Company in Corpus Christi. Glenn was named Executive Vice-President of West Texas Utilities in October of 1991 and was selected to be President and Chief Executive Officer of WTU in May of 1992. In February of 1996, Files was promoted to the position of Executive Vice-President of Central and South West Corporation. As EVP, Glenn was responsible for Transmission, Distribution, Power Generation, Information Technology, and the unregulated retail and telecommunications businesses.

Glenn holds a Bachelor of Science degree from Cameron University in Lawton, Oklahoma. He completed the Harvard University Program for Management Development, the Management Program at the Darden Graduate School of Business Administration at the University of Virginia, and the Advanced Management Program at Oklahoma State University. Glenn has served on and chaired numerous boards of directors including United Ways, Chambers of Commerce, and industry associations. He was a member of the Central and South West Corporation Board of Directors and currently serves on the Board of the Electric Power Research Institute.

Glenn and his wife, Linda, have been married for 29 years. They have six children ages 11 to 24 years old.

INVITED LECTURER

Roy Billinton
C. J. Mackenzie Professor of Engineering &
Acting Dean of Engineering
University of Saskatchewan
Saskatoon, Canada



Dr. Roy Billinton moved to Canada from England in 1952. He obtained the B.Sc. and M. Sc. Degrees from the University of Manitoba and Ph.D. and D.Sc. degrees from the University of Saskatchewan. He worked for Manitoba Hydro in the System Planning and Production Division. In 1964 he joined the University of Saskatchewan, formerly serving as Head of the Department of Electrical Engineering. He is presently C. J. Mackenzie Professor of Engineering and Acting Dean of the College of Engineering.

Dr. Billinton is author or co-author of eight books on reliability and over 650 papers on Power Systems Analysis, Stability, Economic System Operation, and Reliability. He is a Fellow of the IEEE, the Engineering Institute of Canada, the Royal Society of Canada, the Canadian Academy of Engineering, the U. K. Safety and Reliability Society, and a Professional Engineer in the Province of Saskatchewan.

MODERATOR

Robert B. WALLACE

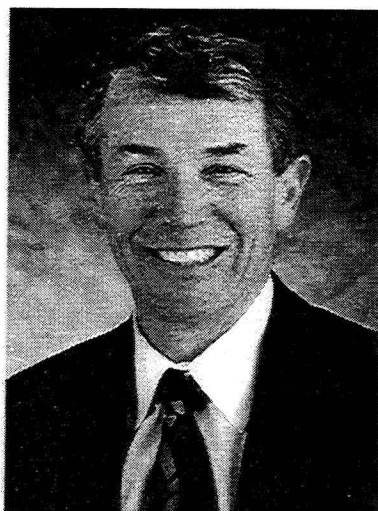


Bob Wallace is Manager of Region Support for Public Service Company of Oklahoma. Bob began his career with PSO in 1973 and has, since that time, served the company in various managerial and supervisory positions in the areas of construction, maintenance and engineering. Bob's experience as an engineer/technician has been primarily in distribution and substation work, focusing in the areas of standards, system protection and substation design.

Bob is a Registered Professional Engineer, is a senior member of the Institute of Electrical and Electronics Engineers and is a member of the Edison Electric Institute and the National Fire Protection Association. Bob received an M.B.A. from Oklahoma City University and a B.S.E.E.T. from Oklahoma State University.

MODERATOR

Jack T. Coffman



Jack T. Coffman, originally from Port Arthur, Texas, received his BS degree in Mechanical Engineering from Lamar University and his MBA, in 1986, from Oklahoma City University.

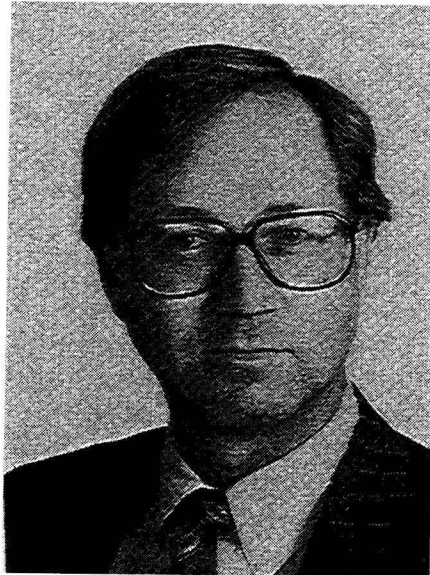
Mr. Coffman worked for Westinghouse Electric Company from 1966-1970. He then joined Oklahoma Gas & Electric Company as a Mechanical Engineer in the Generation Department. He was promoted to Senior Mechanical Engineer in 1975, Manager of Mechanical Services in 1982, Manager of Generation Services in 1984, and to Vice President, Power Supply in 1994. He currently serves OGE Energy Corp. as Senior Vice President, Power Supply.

Jack is a member of the American Society of Mechanical Engineers, serving as Chairman of Central Oklahoma Section in 1977-78 and in other positions within the section in other years. He is a member of the Edison Electric Institute, and has served in the positions of Chairman, Power Station Subcommittee and Vice Chairman, Prime Movers. He has also served as Chairman, Vice Chairman, and Secretary for Plant Design and Operating Committee. Mr. Coffman is a member of the Association of Edison Illuminating Companies, the oldest association in the United States for electric utilities and serves on the Executive Committee for the Power Generation Committee. He serves on the United Way Appropriations Committee and is a member of the Executive Committee of the Oklahoma State University Engineering Energy Laboratory.

Mr. Coffman has authored several technical papers and was the recipient of a patent award while with Westinghouse.

MODERATOR

TERRY L. HENRY



Terry Henry is Director, Corporate Planning for OGE Energy Corp. in Oklahoma City, Oklahoma. His responsibilities include preparation of planning analyses to guide the development of OG&E's long term strategies and business plans. He has previous experience in Resource Planning, System Studies, Marketing and Engineering.

He received his Bachelor of Science Degree from Oklahoma State University and his Master of Science Degree from the University of Oklahoma. He is a Registered Professional Engineer.

Mr. Henry's role in planning is directly related to the Frontiers of Power as we look to the future of the power industry. He is a member of the Program Committee of the Frontiers of Power Conference.

MODERATOR

Cliff McKnight

Cliff McKnight received the B.S. in Electrical Engineering from Kansas State University in 1969. He has attended graduate classes at both the University of Tulsa and Oklahoma State University. From 1969 to 1970 he was employed by the U.S. Navy Ship Engineering Center, Washington, D.C. Since 1970 he has worked in a number of engineering positions with AEP Public Service Company of Oklahoma. These areas include distribution design, power generation, substation design, system protection and most recently as a senior staff engineer. His main interests are power system analysis, system protection, and system planning. He also teaches a series of in-house technical training classes at AEP PSO on these subjects. Cliff, his wife Susan and children Christopher and Melissa live in Tulsa, Oklahoma.

SCHOOL OF ELECTRICAL AND COMPUTER ENGINEERING

**MICHAEL A. SODERSTRAND
PROFESSOR and HEAD**



Michael A. Soderstrand received his A.A. degree in Engineering from Sacramento City College in 1966 and the B.S. and Ph.D. degrees in Electrical Engineering from the University of California, Davis in 1968, 1969 and 1972 respectively.

From 1963 to 1968 he worked as an engineer and announcer for radio and television stations in the Sacramento area. Upon graduation with his B.S. degree in 1968 he joined the technical staff of Sandia National Laboratories in Livermore, California where he developed DSP-based automatic testers for the acceptance equipment division, developed DSP-based telemetry systems and simulators for the electronic development division and was the project manager for the master control system for "Solar One", the first 10-megawatt commercial solar generating facility developed for Southern California Edison in Barstow, California.

In 1972, he was appointed to the faculty of the University of California Davis in Electrical and Computer Engineering where he served for 26 years as Professor and Director of the Digital Signal Processing and Communications Laboratory. In July of 1998, he became Professor Emeritus at University of California and accepted the position

as Professor and Head of Electrical and Computer Engineering at Oklahoma State University. Professor Soderstrand has published over 150 technical articles including two IEEE Press books and four textbooks. He was a pioneer in the late 1960's and early 1970's in the concepts of Active-R Filters and during the late 1970's and 1980's he pioneered the field of Residue Number Arithmetic Digital Signal Processing. His most recent research has included DSP hardware to implement new modulation schemes associated with wireless digital cellular communication systems and wireless computer networks. He was the first to develop pipelined hardware structures for recursive digital filters, pioneered the concept of adaptive sampling-rate and adaptive heterodyne filters, and is the developer of public-domain programs used to optimize DSP hardware.

Professor Soderstrand served two five-year terms as Chair of the Undergraduate Programs Committee for the Electrical and Computer Engineering Department at University of California, Davis. In this capacity he was responsible for the 1993 curriculum revision which was featured in IEEE Transactions on Education's special issue on innovative curriculum in Electrical Engineering. He has been a pioneer in the use of the Internet World-Wide-Web in education, the introduction of industry-coordinated project courses into the curriculum and the introduction of research experience into the undergraduate curriculum starting at the freshman level. Professor Soderstrand has been selected by the IEEE Student Chapter as the outstanding teacher of the year and was selected by the Tau Beta Pi student chapter as the outstanding teacher at large in the College of Engineering at University of California Davis.

Dr. Soderstrand has served as Vice President of the IEEE Circuits and Systems Society (international), first editor of IEEE Circuits and Systems Magazine (now IEEE Circuits and Devices Magazine), twice as Associate Editor of IEEE Transactions on Circuits and Systems, General Chair of the 1997 IEEE International Midwest Symposium on Circuits and Systems (MWSCAS) held in Sacramento, California, Technical Chair of the 1996 MWSCAS and Technical Chair for the 1995 IEEE Asilomar Conference on Signals, Systems and Computers. He also served as Vice President North and Vice President Central for the California Society of Professional Engineers. He was the MathCounts coordinator for the California State MathCounts contest held at University of California, Davis each year in March. Dr. Soderstrand is a registered professional engineer in electrical engineering. He is a Fellow of the IEEE.

Since July of 1998, Professor Soderstrand has been the Head of the School of Electrical and Computer Engineering at Oklahoma State University. Professor Soderstrand is working with the faculty, students and staff to make Electrical and Computer Engineering at Oklahoma State one of the top 50 schools in the country. In January of 1999, the School of Electrical and Computer Engineering led the way in opening a brand new program at Oklahoma State University in Tulsa offering Bachelor, Masters, and Ph.D. degrees in both Electrical Engineering and Computer Engineering. OSU Stillwater and OSU Tulsa are "one university with two locations" dedicated to outstanding teaching, research and service. In addition to his duties as Head of the School, Professor Soderstrand teaches the Senior Design class both at Stillwater and at Tulsa and carries out research in digital and analog signal processing for communications.

**DIRECTOR
ENGINEERING ENERGY LABORATORY
CONFERENCE DIRECTOR
&
PSO/ALBRECHT NAETER PROFESSOR
OF ELECTRICAL & COMPUTER ENGINEERING
RAMA RAMAKUMAR**



Rama Ramakumar received his Bachelors and Masters degrees in India and his Ph.D. degree from Cornell University, Ithaca, New York. He joined the faculty of Oklahoma State University in 1967 and was elevated to the rank of Professor in 1976. In 1987, he became the Director of the OSU Engineering Energy Laboratory in addition to being a Professor of Electrical and Computer Engineering. In October 1991, he was named the PSO/Albrecht Naeter Professor of Electrical and Computer Engineering. From January 1994 to August 1995 and from August 1996 to April 1997, he served as the Interim Head of the OSU School of Electrical and Computer Engineering. His research interests are in energy conversion, power engineering, energy storage, and alternate energy sources. In 1992, Dr. Ramakumar received the Halliburton Outstanding Faculty Award in the OSU College of Engineering, Architecture, and Technology. He received the university-wide Burlington Northern Foundation Faculty Achievement Award in 1993.

Dr. Ramakumar has published over 150 technical papers in various journals, transactions, and conference proceedings, co-authored 4 U.S. Patents, and contributed chapters in three books, and sections in six handbooks in the areas of energy and power. His textbook entitled *Engineering Reliability: Fundamentals and Applications* was published by Prentice Hall in 1993. During 1978-1979 he was a consultant to the Jet Propulsion Laboratory in Pasadena, California. His other consulting activities include working with the UNU in Tokyo, UNEP in Nairobi, National Science Foundation in Washington, D.C., Kuwait University, and the Florida Solar Energy Center. He was a member of the Wind Division Board of the American Section of International Solar Energy Society during 1976-1980.

At present, he serves as the Chairman of the Awards Committee for the IEEE Power Engineering Society's Technical Council, and Chairman of the Energy Development Subcommittee of the Energy Development and Power Generation Committee. Dr. Ramakumar is the Chairman and Organizer of the IEEE Working Group on Renewable Technologies and Energy Storage. He is also a Member of the Power Engineering Education Committee of the IEEE, Energy Development and Power Generation Main Committee, the Ad Com of ED&PGC, International Practices Subcommittee of ED&PGC, Task Force on Distributed Generation, and the Working Group on Advanced Energy Technologies. Dr. Ramakumar is a Fellow of the IEEE and his other professional affiliations include American Society for Engineering Education, American Solar Energy Society, International Solar Energy Society, and Oklahoma Society of Professional Engineers. He is a member of the honorary societies Sigma Xi and Eta Kappa Nu.

KEYNOTE ADDRESS

Glenn Files

**Senior Vice-President for Distribution
American Electric Power
Columbus, Ohio**

OKLAHOMA DEREGULATION -- THIS IS NO CALIFORNIA

It should be said at the outset that it is a privilege to participate in the long-running and prestigious Frontiers of Power Conference, and Public Service Company of Oklahoma, now proud to be AEP-Public Service Company of Oklahoma, is pleased to continue its sponsorship of the conference.

The buzzword of the beginning of the 21st century in the electric energy business is competition.

The given is that competitive electricity markets are developing, and the challenge is to get them right.

Recently a headline in the industry publication *The Energy Daily* suggested there is a “. . . Long, Muddled Road Ahead To Electricity Competition.”

The accompanying article said, “Efforts to restructure the nation’s electric utility industry have resulted in a muddled, disjointed transition that could take years to complete . . .” The conclusion was from a report done by Cambridge Energy Research Associates and the consultant Arthur Andersen.

Their prediction was that completing the complex and difficult electric industry restructuring effort across the U.S. could take up to another decade.