

**ANNUAL REPORT OF THE CENTER
FOR ENERGY AND COMBUSTION RESEARCH**

University of California, San Diego

July 1, 1997 – June 30, 1998

1. SUMMARY OF ACTIVITIES AND PLANS FOR THE COMING YEAR

The Center for Energy and Combustion Research focuses on basic problems in finding new sources of energy and on the social, environmental, economic, and political consequences of energy consumption, including combustion. Studies range from investigations into the fundamental nature of energy and combustion to practical applications in propulsion, energy conservation and production, as well as pollution control.

Current research includes flame theory, combustion in turbulent flows, asymptotic methods in combustion, fire research, reactions in boundary layers and other areas of combustion and energy. Three specific new grants are for "Reduced Chemistry and Modeling of Species Production in Combustion," from the Office of Naval Research, "Lean Partially Premixed Turbulent Combustion," from Solar Turbines, and a subcontract from BKM, Inc. on "Diesel Engine Combustion".

The Center for Energy and Combustion Research has brought together researchers from England, France, Germany, Japan, Korea, Norway and Spain for brief periods of study and of exchange of ideas during this period.

Plans for the 1998-99 academic year include further emphasis on the fluid dynamics of reacting flows relevant to propulsion and on chemical aspects of propulsion and energy problems. A Preproposal for a large MURI has been submitted to the Office of Naval Research to study Pulsed Detonation Phenomena for Propulsion, jointly with researchers at Stanford University and at the University of Florida. If this initiative is successful, then a large thrust will be mounted on fundamental research relevant to Pulsed Detonation Engines.

2. ACADEMIC AND PUBLIC SERVICE

A. Membership

It is necessary to distinguish between CECR "members" and "affiliates". "Members" are those who are involved in CECR on a day-to-day basis and who actively participate in CECR programs and research. These include: The Director and Associate Directors, Active Adjunct and Emeritus Professors, and Researchers who are employed full-time by CECR research grants. "Affiliates" are regular faculty members who participate in some CECR projects but who also have other activities and projects not part of CECR.

Faculty Members:

Forman A. Williams - Director
PhD, Engineering Science
Professor of Engineering Physics and Combustions

Robert J. Cattolica - Associate Director
PhD, Engineering Physics
Professor of Engineering Physics

K. Seshadri - Associate Director
PhD, Engineering Science
Professor of Chemical Engineering and Fluid Mechanics

Alvin S. Gordon
PhD, Chemistry
Adjunct Professor of Engineering Chemistry

Paul A. Libby
PhD, Aeronautical Engineering
Professor Emeritus of Fluid Mechanics

Stanford S. Penner
PhD, Physical Chemistry
Professor Emeritus of Engineering Physics

Norbert Peters
PhD, Mechanical Engineering
Adjunct Professor of Mechanical Engineering

M. Simnad
PhD, Materials Science
Adjunct Professor of of Materials Science and Engineering,
Nuclear Engineering and Energy Technologies

Affiliate Faculty Members:

D.J. Benson
PhD, Mechanical Engineering
Associate Professor

M. Krstic
PhD, Mechanical Engineering
Associate Professor

J.C. Lasheras
PhD, Mechanical and Aerospace Engineering
Associate Professor of Fluid Mechanics

D.R. Miller
PhD, Chemical Engineering
Professor of Chemical Engineering

M. Meyers
PhD, Physical Metallurgy
Professor of Materials Science

V.F. Nesterenko
PhD, Physics
Associate Professor of Materials Science

K. Nomura
PhD, Mechanical Engineering
Assistant Professor of Mechanical Engineering

S. Sarkar
PhD, Mechanical Engineering
Associate Professor

B. Researchers

Shui-Chi Li
PhD, Mechanical and Aerospace Engineering
Assistant Research Scientist

Kurt O. Lund
PhD, Engineering Science
Assistant Research Scientist

Dietmar Trees
PhD, Mechanical Engineering
Assistant Research Scientist

C. Visiting Researchers and Scholars

CECR participants interact extensively abroad on energy and combustion issues. There is continuing joint research with investigators at Cambridge University in England, RWTH Aachen in Germany, Université de Provence in Marseilles, France, The University of Tokyo and Ishikawajima-Harima Heavy Industries in Tokyo, Japan and elsewhere. Renowned scientists from throughout the United States and abroad, specializing in energy and combustion research, regularly visit UCSD and participate in CECR programs through formal lectures, research activities and informal discussions. Visitors from the last year include:

VISITOR	AFFILIATION
William T. Ashurst	Sandia National Laboratories, Livermore, California
K.N.C. Bray	Cambridge University, Cambridge, England
Michel Champion	ENSMA, Poitiers, France
Misha Chertkow	Princeton University, Princeton, New Jersey
Paul Clavin	Universite Aix Marseilles, Marseilles, France
Jim Cole	California Institute for Energy Efficiency
Paul Dimotakis	California Institute of Technology, Pasadena, California
Farley Fisher	National Science Foundation, Washington, DC
Fernando Fachini Filho	Instituto Nacional de Pesquisas Espaciais - INPE, Brazil
Junichi Furukawa	Tokyo Metropolitan Technical College
Jong Soo Kim	Korea Institute of Science and Technology, Seoul, Korea
Amable Liñán	Ciudad Universitaria, Madrid, Spain
Bernie Matkowsky	Northwestern University, Evanston, Illinois
Keiichi Okai	The University of Tokyo, Tokyo, Japan
A.K. Oppenheim	University of California, Berkeley
Miltiadis V. Papalexandris	Jet Propulsion Laboratory, Pasadena, California
Heinz Pitsch	RWTH Aachen, Aachen, Germany
Paul Ronney	University of Southern California, Los Angeles
Daniel Rosner	Yale University, New Haven, Connecticut
Howard Ross	NASA Lewis Research Center, Cleveland, Ohio
Kozo Saito	University of Kentucky, Lexington, Kentucky
Antonio Luis Sánchez	Universidad Carlos III, Madrid, Spain
Reinhard Seizer	Technical University, Graz, Austria
Hans Thermann	RWTH Aachen, Aachen, Germany

D. Seminars

CECR sponsors a general series of seminars and public lectures in its areas of activities. A listing of these seminars is given in the following tables.

SEMINAR SPEAKER	DATE	TOPIC
Jong Soo Kim	August 11, 1997	“Diffusional-Thermal Instability of Diffusion Flames”
Amable Liñán	August 13, 1997	“Flame Spread Over Solid Fuels”
Paul Clavin	August 15, 1997	“Dynamics of Combustion Waves in Gases”
Paul Ronney	August 20, 1997	“Structure Of Flame Balls At Low Lewis-Number (SOFBALL): Results from the STS-83 and STS-94 Space Flight Experiments in the first Combustion Module (CM-1) Apparatus”
K.N.C. Bray	August 25, 1997	“Interaction Between Laminar Counterflow Flames and Water Mist”
Antonio Sanchez	August 26, 1997	“Chain-Branching Explosions in Mixing Layers”
Paul Dimotakis	August 26, 1997	“Mixing and Chemical Reactions in High-Speed Shear-Layer Flows”
Michel Champion	August 27, 1997	“Introduction of Dilution in the BML Model of Turbulent Combustion: Application to a Stagnating Flame”
James Cole	September 23, 1997	“California Institute for Energy Efficiency”
Daniel Rosner	December 2, 1997	“Morphological Evolution of Nano-Particles in Counterflow Diffusion Flames - Measurements and Modeling”
Misha Chertkov	December 2, 1997	“Propagation of a Huygens Front through Turbulent Medium”
Bernie J. Matkowsky	January 27, 1998	“Instabilities, Fingering and the Saffman-Taylor Problem in Filtration Combustion”
A.K. Oppenheim	January 28, 1998	“Life of Fuel in the Course of Combustion”
William T. Ashurst	March 20, 1998	“Darrieus-Landau Instability, Growing Cycloids and Expanding Flame Acceleration”
Howard D. Ross	May 12, 1998	“Combustion on Orbiting Spacecraft and Mars”

Miltiadis V. Papalexandris	May 15, 1998	“Unsplit Shock Algorithms and their Application to the Simulation of Unstable Detonations:
Heinz Pitsch	June 19, 1998	“A Flamelet Formulation for Non-Premixed Combustion Considering Differential Diffusion Effects”

CECR Special Seminar Series

CECR had special seminar series in the Spring of 1998 which focused on Turbulent Combustion. The lectures were given by Adjunct Professor Norbert Peters, a world expert in this field.

DATE	TOPIC
March 2, 1998	“Introduction to Turbulent Combustion”
March 4, 1998	“Premixed Turbulent Flame Propagation”
March 6, 1998	“Theory for Premixed Turbulent Flames”
March 9, 1998	“Turbulent Diffusion-Flame Fundamentals”
March 11, 1998	“Turbulent-Jet Diffusion Flames”
March 13, 1998	“Partially Premixed Turbulent Combustion”

Graduate or Undergraduate Teaching Programs

Participated in teaching the following courses:

Nuclear Energy Technologies (4)

Coal production, gasification, liquefaction. The energy storage systems. Techniques for direct energy conversion. Solar energy from windmills. Tidal and wave energy utilization. Hydroelectric power generation. Geothermal energy from hot rocks. Electrical power production, etc. Prerequisites: consent of instructor.

Nuclear Energy Technologies (4)

Energy demands and resources. Available nuclear energy, physical background and nuclear physics; fission and fusion processes, physics of fission reactors-safety and environmental effects, fusion, scaling laws, and start-up of magnetic confinement-equilibrium instability. Prerequisite: consent of instructor.

Fusion Science and Technologies (4)

Fusion processes, high-temperature plasma characteristics, and fusion power on the enabling technologies for practical fusion and related applications such as plasma-material interactions, plasma heating and wave-particle flux engineering, superconductivity, advanced materials, and nuclear fusion. Prerequisite: consent of instructor.

Energy and Thermodynamic Systems (4)

Energy processes and cycles and/or thermodynamic analysis of energy and non-renewable cycles, cogeneration and combined power cycles, and optimization analysis of thermodynamic systems. Prerequisite: AMES 110

Combustion (4)

Flow of reactive gases, with emphasis on processes of combustion, thermodynamics, chemical kinetics, fluid mechanics, and transport phenomena. Prerequisites: AMES 101A-B-C or AMES 103A-B-C, AMES 110, or consent of instructor.

Propulsion (4)

Gas dynamics, and combustion processes involved in propulsion of aircraft engines, and solid and liquid propellant rocket engines; characteristics of engine components; diffusers, compressors, combustors, turbines, pumps, etc. Prerequisites: AMES 101A-B, AMES 110, or consent of instructor.

Gas Dynamics (4)

Properties of gases for use in gasdynamics. Derivation of thermodynamic functions from statistical mechanics. Applications of classical and quantum statistical mechanics to chemical and physical properties of gases. Equilibrium and nonequilibrium radiation, chemical kinetics. Laser and reacting-flow applications. Prerequisite: consent of instructor.

Gas Dynamics (4)

Statistical mechanics, the Boltzmann equation, moment equations and the Navier-Stokes equations of molecular collisions. The Chapman-Enskog expansion and transport

coefficients: shear and bulk viscosity, heat conduction, molecular and thermal diffusion. Linearizations about equilibrium: applications to acoustics and supersonic flows with relaxation. Prerequisites: AMES 101A-B-C or AMES 103A-B-C, AMES 220A or consent of instructor.

Graduate Students

NAME	ADVISOR	DATES
Malissa Ackerman	F.A. Williams	1997 - present
Craig Eastwood	F.A. Williams	1997 - present
Tetsuo Hiraiwa	F.A. Williams	1997 - present
Alexander Telengator	F.A. Williams	1995 - present
Lenny Truett	K. Seshadri	1994 - present
Balachandar Varatharajan	F.A. Williams	1997 - present
Christopher Varga	F.A. Williams	1997 - present

Post-Graduate Researchers

PGR	ADVISOR	DATES
Bai-Li Zhang	F.A. Williams	1997 - 1998

G. University-Industry Activities

Faculty and staff members of the UCSD Center for Energy and Combustion Research continue to be associated with various university-industry activities. In particular, there have been significant interactions with Solar Turbines and with BKM Inc. Joint seminars with Solar Turbines were held both at their San Diego facility and at UCSD. Professors Libby and Williams worked with Solar Turbines to develop new turbulence models for computations of gas turbines. Many discussions of possible joint projects were pursued. CECR has strong ties with BKM Inc., a San Diego company specializing in Diesel engine research and development. At present there are two joint research projects with BKM: One is related to fuel injection and combustion for advanced military Diesel engines and the other one is related to development of Diesel-natural gas engines for high combustion efficiency and low emissions. The former is supported by the United States Army Tank-Automotive and Armaments Command and the latter is supported by South Coast Air Quality Management District. These two projects are both experimental and theoretical in character. For instance, our PDPA has been used to characterize the spray structure of high-performance Diesel fuel injectors for those research engines, and combustion calculations have been made with the newly upgraded KIVA code. These university-industry interactions are increasing.

3. ADMINISTRATION

A. Directors

Director:	Forman A. Willaims
Associate Director:	Robert Cattolica
Associate Director:	K. Seshadri

B. Advisory Committee

Dr. Harold Agnew
Former Chief Executive Officer
General Atomics

Dr. Alan C. Kolb
Chairman and Chief Executive Officer
Maxwell Laboratories, Inc.

Dr. R.A. Figueroa
Program Manager
Research, Development and Demonstration
SDG&E

Mr. Dave Esbeck
Vice President, Engineering
Solar Turbines Inc.

Dr. Charles Baker
ITER Program
UCSD

Dr. S.S. Penner
Director Emeritus
CECR

4. FACILITIES AND SPACE

Unlike most ORU's, CECR has not been assigned independent space or facilities. Instead, CECR space comes entirely from AMES, and CECR is dependent on AMES for adequacy of its space. In AMES, space is assigned to individual professors, according to their needs, as justified by the sizes of their programs and the number of associates working with them.

A. Laboratories

The CECR laboratory space thus is, in fact, the laboratory space assigned by AMES to the CECR director and the two CECR associate directors. This space comprises B12, B14, B16 and B17 in Engineering Building Unit II and consists, in total, of 6000 sq. ft. This space currently is adequate for the existing CECR laboratory research activities.

In 1997-1998, Professor Williams was awarded \$200,000 for equipment funds by ONR and with this funding, we have upgraded our PDPA from two components to three components and have purchased a Particle Image Velocimetry System (PIV). Both the three-component PDPA and PIV are powerful tools in characterizing two phase reacting flows which can be found in Diesel engines and gas turbine. The three-component PDPA measures not only droplet diameter but also its three velocity components while the PIV system is an optical imaging technique to measure fluid or particle velocity vectors at many (e.g. thousands) points in a flow field simultaneously. Currently, the PIV is employed in our research on two-phase turbulent reacting flows to study how turbulence affects combustion and how trajectories of fuel droplets are influenced by gas flow field and by temperature gradient. Meanwhile, the PDPA is used to characterize the spray structure of Diesel fuel injectors. These measurements will significantly improve our understanding of liquid fuel combustion and provide useful information in helping to increase combustion efficiency and reduce pollutant formation in practical combustors.

In Professor Seshadri's laboratory, a gas chromatograph and a coupled gas chromatograph-mass spectrometer are employed to analyze flame structures. These experiments help improve the chemical-kinetic mechanisms for the numerical combustion models. A fluidized bed particle delivery system in conjunction with a counterflow diffusion flame apparatus is used to study the effectiveness of alternative dry powders for fire inhibition applications. Autoignition of liquid hydrocarbon fuels is studied in a burner with preheater for the oxidizer gas stream, capable of heating up a gas stream to temperatures of 1500 Kelvin.

B. Offices and Conference Rooms

Professors who are members of CECR have their own offices (Engineering Building Unit II, rooms 256, 555, 556, 557, 558, 559 and 560) and offices for their graduate students, researchers and visitors (Engineering Building Unit II, rooms 468, 469, 470, 471, 554, 561, 562, 563 and 564), all provided by the AMES department. The AMES space allotment to the CECR director is made on the same basis as the allotment to other faculty, without any special consideration of CECR. In Engineering Building Unit II, the CECR administrative office 554, the CECR secretary office and mail, FAX, copy and utility room, 565, all are taken from the CECR director's allotment, reducing his space for students and researchers and leading him to house them in his laboratory. No conference rooms, libraries, meeting rooms or related spaces have been assigned to CECR. It would be helpful to the effectiveness of CECR to have some such space.

CENTER FOR ENERGY AND COMBUSTION RESEARCH
 FUNDS AWARDED -- TYPE / AGENCY

FUNDING TYPE / AGENCY	FY 97/98
BUSINESS/INDUSTRY	
GIFTS	9,099
<i>TOTAL FOR BUSINESS/INDUSTRY:</i>	9,099
FEDERAL	
AFOSR	138,345
DOE	145,307
NASA	142,795
NOAA	
NSF	28,000
OTHER	
USA	20,000
USAF	
USN	95,000
<i>TOTAL FOR FEDERAL:</i>	570,447
FEDERAL FLOW-THRU	
DOE, DOD, NIH	
<i>TOTAL FOR FEDERAL FLOW-THRU:</i>	0
OTHER	
INCOME ACTIVITY	
<i>TOTAL FOR OTHER:</i>	0
PRIVATE	
CONTRACTS	97,175
ENDOWMENT	36,587
<i>TOTAL FOR PRIVATE:</i>	133,762
STATE	
APPROPRIATION	68,400
<i>TOTAL FOR STATE:</i>	68,400
<i>TOTAL FOR FUND TYPE / FISCAL</i>	781,708

RESEARCH
EDUCATIONS / EXPENSE

	FY 97/98	
	ALLOC	EXPENSE
		503
	5,999	-3,674
	2,500	2,305
ON 1195	600	1,004
	9,099	138
		24,070
	146,307	161,274
13		
	20,000	77,453
84		
		-1
84		
0380		8
051		
069		738
042		170,779
058	95,000	38,281
		105,097
0166		-30
0106	61,496	155,931
0098	76,849	91,910
089		30,093
	97,000	129,438
	45,795	52,451

CENTER FOR ENERGY & COMBUSTION RESEARCH
DEPT OF AMES - ALLOCATIONS / EXPENSE
FUND TYPE AND AGENCY

FUND	PI / AGENCY	FY 97/98	
		ALLOC	EXPENSE
32836A	Williams NASA LEWIS NAG3-2161	28,000	1,515
TOTAL FOR FEDERAL		570,447	1,039,007
FEDERAL FLOW-THRU			
78604A	Penner EG&G IDA HO INC.		
78605A	Penner EG&G IDAHO		
TOTAL FOR FEDERAL FLOW-THRU		0	
OTHER			
60826A	Williams CECR-MISC INCOME		8,882
66834A	Williams CONFERENCES/EXP		
66850A	Williams CONFERENCES/WMS		-6,088
TOTAL FOR OTHER		0	2,794
PRIVATE			
79576A	Li BKM INC. PO #17840	60,000	1,422
79695A	Li BKM INC. PO #17214		80,787
39426A	Williams UC PRESI DENTS OFFICE	36,587	27,565
79527A	Williams SOLAR TURB PO #HD9704839	37,175	37,070
TOTAL FOR PRIVATE		133,762	146,844
STATE			
07427A	Cattolica ACAD SEN RW146-G		1,501
19900A	Lund CALSPACE #CS-33-95		
19900A	Seshadri ACAD SEN RX143-GB	25,257	14,143
19900A	Williams CECR GENERAL FUNDS	43,143	44,040
TOTAL FOR STATE		68,400	59,684
TOTAL FOR GROUPS / FISCAL YEARS		781,708	1,248,467

CENTER FOR ENERGY & COMBUSTION RESEARCH
FUNDS AWARDED / EXPENDITURES BY GROUP

FUNDING TYPE / AGENCY	FY 97/98	
	ALLOC	EXPENSE
ENERGY AND COMBUSTION		
ACADEMIC SALARIES	61,844	41,707
GENERAL ASSISTANCE	241,307	199,525
BENEFITS	154,113	135,076
INCOME		8,882
SUPPLIES & EXPENSE	600	196,526
EQUIPMENT	233,849	353,446
TRAVEL	81,496	314,674
ASSESSMENT FEE	5,999	-3,674
MISCELLANEOUS FEES	2,500	2,305
<i>TOTAL FOR ALL GROUPS</i>	781,708	1,248,467
TOTAL FOR FUND TYPE / FISCAL YEARS	781,708	1,248,467

ENERGY AND COMBUSTION
Fiscal Year 1997 - 1998

EMPLOYEE	SALARY	TITLE NAME	GROUP
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FACULTY

SARKAR, SUTANU	7,655.56	ASO RES - 9-MOS 1/9 PYMT-B/E	RESEARCH
SESHADRI, KALYANASUNDARAM	25,933.32	RES - -9-MOS 1/9 PAYMT - B/E	RESEARCH
WILLIAMS, FORMAN A.	35,951.70	RES - -9-MOS 1/9 PAYMT - B/E	RESEARCH
	<u>69,540.58</u>		

OTHER FACULTY

LIBBY, PAUL A.	54,416.25	RESEARCH PROFESSOR-VERIP	RESEARCH
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GRADUATE STUDENTS - GSR

HIRAIWA, TETSUO	24,259.73	ASSISTANT IV	GRADUATE STUDENTS
VARATHARAJAN, BALACHANDAR	24,259.73	ASSISTANT IV	GRADUATE STUDENTS
VARGA, CHRISTOPHER M	23,566.10	ASSISTANT IV	GRADUATE STUDENTS
WILLEMSE, WERNER W.	3,601.26	ASSISTANT IV	GRADUATE STUDENTS
ACKERMAN, MALISSA D	12,614.51	GRAD STDNT RES- NO REMISSION	GRADUATE STUDENTS
EASTWOOD, CRAIG D	12,493.73	GRAD STDNT RES- NO REMISSION	GRADUATE STUDENTS
PANTANO-RUBINO, CARLOS ALE	15,725.08	GRAD STDNT RES- NO REMISSION	GRADUATE STUDENTS
PHAN, TUONG CHANH	719.57	GRAD STDNT RES- NO REMISSION	GRADUATE STUDENTS
PRESTRIDGE, KATHERINE P.	228.08	GRAD STDNT RES-TUIT & FEE RE	GRADUATE STUDENTS
TELENGATOR, ALEXANDER M	17,869.32	GRAD STDNT RES- NO REMISSION	GRADUATE STUDENTS
ZHANG, BAILI	2,920.85	GRAD STDNT RES- NO REMISSION	GRADUATE STUDENTS
	<u>138,257.96</u>		

RESEARCHERS - PGRS

SEISER, REINHARD	6,337.09	STAFF RESEARCH ASSOC I	RESEARCH
HIRAIWA, TETSUO	5,441.00	STAFF RESEARCH ASSOC II	RESEARCH
VARATHARAJAN, BALACHANDAR	5,441.00	STAFF RESEARCH ASSOC II	RESEARCH
VARGA, CHRISTOPHER M	7,949.97	STAFF RESEARCH ASSOC II	RESEARCH
LI, SHUI CHI	61,833.32	ASSOC RES ---- - 11-MOS	RESEARCH
TREES, DIETMAR	43,358.00	ASST RES ----- - 11-MOS	RESEARCH
HEWSON, JOHN C.	4,983.52	POSTGRAD RES ----- - 11-MOS	RESEARCH
LI, HUAIDONG	30,263.57	POSTGRAD RES ----- - 11-MOS	RESEARCH
RAYNAL, LUDOVIC	1,783.50	POSTGRAD RES ----- - 11-MOS	RESEARCH
ZHANG, BAILI	14,611.28	POSTGRAD RES ----- - 11-MOS	RESEARCH
LE RIBAUT, CATHERINE	5,675.80	VST ASSOC RES ---- - FISCAL YR	RESEARCH
SHAO, LIANG	5,675.80	VST ASSOC RES ---- - FISCAL YR	RESEARCH
	<u>193,353.85</u>		

ADMINISTRATIVE

BASTIAN, NANCY B	35,061.40	____ASSISTANT III	ADMINISTRATIVE
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TECHNICAL

WILLEMSE, WERNER W.	5,133.56	ENGINEERING AID	TECHNICAL
ZANG, RUI-XIAN	6,400.79	LABORATORY ASST I	TECHNICAL
	<u>11,534.35</u>		

TOTAL SALARY	502,164.39		
Reimbursement - Vacation Accruals	-14,756.39		
	487,408.00		

ENERGY AND COMBUSTION
Fiscal Year 1997 - 1998

	HEAD COUNT		FTE	RATIO /FAC
	FT	PT		
Administrative	0	0	0.00	////////
Faculty (tenure)	3	0	3.00	////////
Faculty (non-tenure)	0	0	0.00	////////
*Other Faculty	0	4	1.70	////////
Student Teaching Assistants/Readers	0	10	1.00	0.21
Student Research Assistants/Fellows	3	8	6.00	1.28
Technicians/Specialist	0	2	0.50	0.11
Office/Clerical Employees	1	0	1.00	0.21
Others (Research, PGRS)	3	6	5.00	1.06
Managerial Employees	0	0	0.00	0.00
Undergraduate Students	28	0	0.00	5.96
Graduate Students	4	0	0.00	0.85

E. Publications of CECR Researchers

1. Members Publications List

Shui-Chi Li

Li, S.C., "Spray Stagnation Flames," *Progress in Energy and Combustion Science*, Vol.23, pp. 303-347, 1997.

Li, S.C. and Williams, F.A., "NO_x Reduction in Diesel-Fuel Flames by Additions of Water and CO₂," 1997 Diesel Engine Emissions Reduction Workshop, Sponsored by DOE Office of Transportation Technologies, San Diego, July 28-31, 1997.

Li, S.C. and Williams, F.A., "Experimental and Numerical Studies of NO_x Formation in Two-Stage Methane-Air Flames," ASME paper 98-GT-73, presentation at The 43rd ASME Gas Turbine and Aeroengine Congress, Exposition and Users Symposium, June 2-5, 1998, Stockholm, Sweden.

Li, S.C. and Williams, F.A., "Formation of NO_x, CH₄ and C₂ Species in Laminar Methanol Flames," Twenty-Seventh Symposium (International) on Combustion, The Combustion Institute, Pittsburgh, PA, 1998.

Li, S.C. and Gebert, K., "Spray Characterization of High Pressure Gasoline Fuel Injectors with Swirl and Non-Swirl Nozzles," SAE Paper 981935, 1998.

Paul A. Libby

K.N.C. Bray, M. Champion and P.A. Libby, "Premixed Flames in Stagnating Turbulence. Part II - The Mean Velocities and Pressure and the Damkohler Number", *Combustion and Flame* 112, 635-654. (1998)

P.A. Libby, "Premixed Laminar Flames in Impinging Flows", *Combustion Science and Technology* 131, 345 (1998).

Kurt O. Lund

Lund, K.O., Lord, S.M., and C. Thompson, "Microcontact Effects on Conduction in Packed Beds for Large Solid/Fluid Conductivity Ratios," Fluidization and Fluid-Particle Systems, AIChE Annual Meeting Los Angeles, Nov. 17-21, 1997.

Norbert Peters

N. Peters, "The Kinetic Foundation of Thermal Flame Theory," *Advances in Combustion Science: In Honor of Ya.B. Zel'dovich* (W.A. Sirignano, A.G. Merzhanov and de Luca, Eds.), *Progr. Aeronautics and Aeronautics* 173, 1997, 73-91.

U.C. Müller, M. Bollig, N. Peters, "Approximations for Burning Velocities and Markstein Numbers for Lean Hydrocarbon and Methanol Flames," *Combustion and Flame*, 108, 1997, 349-356.

K. Seshadri, M. Bollig, N. Peters, "Numerical and Asymptotic Studies of the Structure of Stoichiometric and Lean Premixed Heptane Flames," *Combustion and Flame* 108, 1997, 518-536

Y.P. Wan, H. Pitsch, N. Peters, "Simulation of Autoignition Delay and Location of Fuel Sprays Under Diesel-Engine Relevant Conditions," SAE paper 971590, 1997.

H. Pitsch, H. Barths, N. Peters, "Modellierung der Schadstoffbildung bei der dieselmotorischen Verbrennung," BEV, Schriftenreihe Heft 97/1, 1997, 193-163.

A. Birtigh, A. Gutsch, B. Binninger, M. Chen, N. Peters, "Numerische Simulation einer teilweise vorgemischten Wasserstofflamme," GVC-Jahrestagung 1997, 24.-26. September 1997

Y.P. Wan, N. Peters, "Application of the Cross-Sectional Average Method to Calculations of the Dense Spray Region in Diesel Engine," SAE paper 972917, 1997.

C. Antoni, N. Peters, "Cycle Resolved Spectroscopy for IC Engines," SAE paper 972917, 1997.

H. Pitsch, N. Peters, "A Consistent Flamelet Formulation for Non-Premixed Combustion Considering Differential Diffusion Effects," Combustion and Flame 114, 1998, 26-41.

K. Seshadri, X.S. Bai, H. Pitsch, N. Peters, "Asymptotic Analysis of the Structure of Moderately Rich Methane-Air Flames," Combustion and Flame 113, 589-602 (1998).

K. Seshadri

Trees, D., and Seshadri, K., "Experimental Studies of Flame Extinction by Sodium Bicarbonate (NaHCO_3) Powder," Combustion Science and Technology: 122 (1-6), 1997, pp 215-230.

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