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PROCEEDINGS

Relative to the Southern New England Region:
Connecticut, Massachusetts, Rhode Island

A COLLOQUY AND WORKSHOPS: REGIONAL IMPLICATIONS OF THE ENGINEERING MANPOWER REQUIREMENTS OF THE NATIONAL ENERGY PROGRAM

March 1-2, 1979
Campus Center, University of Massachusetts
Amherst, Massachusetts 01003

COSPONSORS

School of Engineering, University of Massachusetts
Massachusetts Society of Professional Engineers

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Edited by Howard D. Segool

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COMTECH, School of Engineering
University of Massachusetts
Amherst, Massachusetts 01003

PREFACE

Only six-plus short years ago, on August 17, 1972 to be exact, the United States Senate debated and overwhelmingly voted the National Science Policy and Priorities Act (S.32). A principal driving force for its $1.025 Billion authorization was the finding that: "At this time of maximum need, much of the Nation's technical talent is being wasted or misapplied because of inadequate programs of civilian science and technology."

The NSPP Act was precipitated by vast cutbacks in Federal space and defense programs which left many tens of thousands of scientists and engineers unemployed nationally. Full passage by the Congress did not occur, however, and appropriation and implementation did not follow Senate authorization.

Here in Massachusetts we remember well the period 1971-73 when the collapse of space and defense contracts along Route 128 spun off many, many thousands of unemployed technical professionals into self-help groups which met in attempts to resolve their problems in church basements in towns the length of that famous thoroughfare. Despite the creation of special placement and counselling vehicles such as the Professional Service Center in Waltham and the Association of Technical Professionals, Inc., for a great many continued unemployment for very long periods, underemployment on a grand scale, and career, in some cases family, destruction were the consequence. The cost to society for the idleness and underemployment of such highly trained and capable people is incalculable.

Here at the University, as elsewhere, enrollment in the School of Engineering had plunged dramatically by the Fall of 1973. The market forces that instruct supply to meet demand (Note! not need, for there continued to exist the same important, even critical, civilian science and technology needs that inspired S.32) were at work.

In the severe economic recession which followed the birth of the energy crisis in October, 1973, the unfavorable situation among technical professionals continued and became the topic of many conversations between the cosponsors of this Colloquy, shaped generally along the lines of the NSPP Act, Title III -- Transition of Technical Manpower To Civilian Programs. With the activation of the U.S. Energy Research and Development Administration in 1975 a focus developed on the anticipated engineering manpower demands of the energy program.

Emphasizing that experience and maturity will be key ingredients to the creation of our future energy systems, that there may be available a storehouse of underutilized engineering experience and maturity needing only to be reconditioned to equip it for the specific energy task, a preproposal prospectus was submitted to ERDA on April 30, 1976. It was entitled "A Pilot Model Redevelopment Program for Engineering Professionals."

The potentially large investment proposed therein for the redevelopment of human resources for purposes which the Congress had not yet defined as National Goals not only invited validation but also incurred delay, while ERDA underwent reorganization into the U.S. Department of Energy and while the Congress labored over energy policy and legislation. On May 13, 1977 a validation proposal was made comprising this Colloquy and its Workshops, and was awarded on March 28, 1978, well before the Congress passed the five bills constituting the National Energy Act on October 15, 1978, for which this validation effectively had to wait.

In essence, the National Energy Act of 1978 recognizes that the era of abundant and inexpensive energy, as we have known it, is over and it is intended to create a policy framework for decreasing oil imports by:

- replacing oil and gas with abundant domestic fuels.
- reducing energy demand thru improved efficiency.
- increasing production of conventional sources of domestic energy through more rational pricing policies.
- building a base for the development of solar and renewable energy sources.

Replacing fuels, improving efficiencies, increasing production, developing alternative sources all imply massive transformations of the capital infrastructure whereby raw energy resources are extracted, transported, refined, converted into and utilized as BTU's. Whatever other commitments may be necessary to these tasks, such transformations are notably in the province of engineering, engineers and their support personnel.

With the U.S.D.O.E. in place, with the National Energy Act of 1978 on the books, presumably the stage is set for the Nation to implement the subsequent statement made by President Carter: "We have declared to ourselves and the world our intent to control our use of energy and thereby to control our own destiny as a nation."

Our objective is to examine, on the microcosmic stage of Southern New England, four key issues relevant to the premise that dynamic new or improved vehicles are in order for the monitoring, maintenance and replenishment of an engineering manpower resource consonant with a vigorous regional role in the national energy program. Armed by a prelude of background information perceived to inform the engineering manpower demand/supply prospectus for our region, a concensus assessment is made by dialog among representatives of engineering manpower employers (industry), generators (educators) and related policy makers (government), and proposals for appropriate vehicles are sought.

Howard D. Segool
University of Massachusetts/Amherst

Nathan M. Becker
Massachusetts Society of
Professional Engineers, Inc.

March 19, 1979

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ACKNOWLEDGEMENTS

For their exceptional cooperation and committed efforts, we are indebted to the speakers and panelists who shared their expertise during the Colloquy. We are likewise greatly indebted to the Workshop chairmen for steering a myriad of complex discussions to a reportable concensus.

For their efforts in enabling us to extend appropriate hospitality to our guests we appreciate the help of Mr. Warren Johnson and Miss Bonnie Koocher who handled our special transportion and registration needs; and of Mr. Daniel Cerro, Jr. and his staff who provided faultless conference services.

The coherency we hope you will find in these Proceedings is largly due to the diligence of Mr. W. Norman Vercoe in securing, whenever possible, written text, as well as in recording all formal sessions. He, with the invaluable transcribing assistance of Ms. Jeanne Sullivan, delivered readable manuscript without which these Proceedings would not have happened.

We acknowledge with gratitude the professional help of Ms. Barbara L. Brown who designed the questionnaire, analyzed the data and composed the Evaluation Report covering this program.

Two further notes of appreciation are due. One goes to Mrs. Shelley Bailey whose efforts in preparing final camera-ready copy have contributed to this publication's accuracy and composition. Another goes to each other for the patience, perseverance and good humor we have enjoyed over the many, many, months when we might easily have turned our attentions to other endeavors.

Finally, our thanks go to Drs. James C. Kellett, Jr. and Lawrence Akers of the Office of Education, Business and Labor Affairs, U. S. Department of Energy, for remaining sensitive to and concerned about the fundamental importance of the engineering manpower resource, and for the financial support received from the U.S. Department of Energy.

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N.M.B.

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PROGRAM

Relative to the Southern New England Region: Connecticut, Massachusetts, Rhode Island

A COLLOQUY AND WORKSHOPS: REGIONAL IMPLICATIONS OF THE ENGINEERING MANPOWER REQUIREMENTS OF THE NATIONAL ENERGY PROGRAM

March 1-2, 1979
Campus Center, University of Masssachusetts
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THURSDAY, MARCH 1

12 Noon - 1 PM (9th FLOOR,LOBBY)	Registration; Workshop Assignments
1:00 PM (RM 917)	Opening Session - Presiding: Dr. Howard D. Segool, Co-Chairman School of Engineering, UMass
	Greetings Dean Russel C. Jones School of Engineering, UMass
	Mr. A. Paul LaRosa, President Massachusetts Society of Professional Engineers
1:15 PM	Keynote Address TWO CRUCIAL ITEMS ON THE ENERGY AGENDA: ENGINEERING MANPOWER AND CAPITAL REFORMATION
	Dr. Raymond L. Bisplinghoff Vice-President/Research and Development Tyco Laboratories, Inc.

COLLOQUY, PART I - WHAT WE THINK WE KNOW

1:50 PM	THE OBJECTIVES AND THE PROCESS OF THIS COLLOQUY Dr. Howard D. Segool
2:00 PM	INTERRELATIONSHIPS OF ENERGY POLICY AND THE NEW ENGLAND ECONOMY Mr. Edwin Zeitz, Principal Investigator New England Energy Policy Alternatives Study Director, Rates and Research Massachusetts Department of Public Utilities

2:50 PM	PERCEPTIONS OF THE REGIONAL ROLE IN THE NATIONAL ENERGY PROGRAM Panelists: Sister Claire Markham Immediate Past Under Secretary for Energy Connecticut Office of Policy and Management Mr. Edward Brodzinsky, Assistant Director Massachusetts Office of Energy Resources (Rhode Island unable to be represented) Mr. W. Robert Keating Director, Energy Program New England Regional Commission
3:40 PM	Break
4:00 PM	THE COMMERCIALIZATION OF SOLAR ENERGY TECHNOLOGY Mr. Claude W. Brenner, Vice-President/Operations Northeast Solar Energy Center
4:50 PM.	FEDERAL INITIATIVES FOR THE COMMERCIALIZATION OF EMERGING ENERGY TECHNOLOGIES Mr. Jackson S. Gouraud, Deputy Under Secretary Energy Technology Commercialization U. S. Department of Energy (Paper read by Mr. Frank N. McElroy, Senior Program Analyst, ETC/USDOE, with comments)
5:40 PM..	Adjournment
6:00 PM. (RM 1003)	Social/Cash Bar
6:30 PM (RM 1001-02)	Buffet Dinner
7:45 PM (RM 917)	THE DEMAND/SUPPLY PROSPECTUS FOR ENERGY-RELATED ENGINEERING MANPOWER Mr. Norman Seltzer, Chief/Manpower Assessment Office of Education, Business and Labor Affairs U. S. Department of Energy
8:35 PM	HISTORY REPEATING ITSELF? TRENDS IN U.S. ENGINEERING DOCTORAL PRODUCTION Dr. Kenneth G. Picha, Director Office to Coordinate Energy Research and Education University of Massachusetts (paper read by Associate Dean Joseph S. Marcus, School of Engineering, UMass, with comments)

9:00 PM — REGIONAL DEMAND/SUPPLY PERCEPTIONS OF ENERGY-RELATED ENGINEERING MANPOWER

Panelists:

Dr. Armand Zottola, Chairman
Department of Economics
Central Connecticut State College

Ms. Christine LeCam, Economist
Massachusetts Department of Manpower Development

(Rhode Island unable to be represented)

9:30 PM — SUMMARY PROSPECTUS FOR THE REGIONAL DEMAND/SUPPLY DELTA IN ENERGY-RELATED ENGINEERING MANPOWER
Dr. Ronald H. Frederickson, Director
Counselling and Mental Health Administration Program
School of Education, UMass

10:00 PM — Adjournment

FRIDAY, MARCH 2

7:15 AM (RM 1001-02) — Buffet Breakfast

COLLOQUY, PART II - IMPORTANT WORKSHOP CONSIDERATIONS

8:30 AM (RM 917) — Presiding
Mr. Nathan M. Becker, Co-Chairman; Vice-President
Massachusetts Society of Professional Engineers

A MARKET MODEL OF ENGINEERING MANPOWER DEMAND AND SUPPLY
Dr. Marvin A. Sirbu, Jr., Research Associate
Center for Policy Alternatives
Massachusetts Institute of Technology

9:15 AM — RECOMMENDED CHARACTERISTICS OF AN ENGINEERING DEMAND/SUPPLY INTELLIGENCE SYSTEM
Dr. Walter H. Hibbard, Jr.
Distinguished Professor of Engineering
Virginia Polytechnic Institute and State University

10:00 AM — Charge to the Workshops
Mr. Nathan M. Becker

10:10 AM — Break

10:30 AM — ISSUES WORKSHOPS

	Workshop	Issues	Chairperson
RMS 901	I	A,C	Mr. Austin Gillis United Technologies Corporation
902	II	A,C	Mr. Leo L. Simms Avco Everett Research Laboratory, Inc.
911	III	B,D	Mr. Thomas F. Widmer Thermo Electron Corporation
915	IV	B,D	Dr. Paul Doigan General Electric Company

Definition of need; perceptions of responsibility, appropriate sponsorship, initial and continuation funding; and proposal outlines for:

A. A dynamic demand/supply intelligence system that will be interactive with educational, industrial and governmental bodies concerned with the maintenance of a regional energy-related engineering manpower resource of high quality.

B. Joint industry/university/government educational and retraining programs for the redirection of mid-career, under- and un-employed engineers into energy-related endeavors.

C. Joint industry/university/government educational and retraining programs for enabling the interoccupational mobility of technicians and non-engineering personnel into energy-related engineering support endeavors.

D. Improvements for incorporation in energy-related engineering degree curricula.

12:30 PM (RM 1101-02) — Buffet Lunch (ad hoc Workshop discussions)

1:45 PM — Workshops Reconvene
- draft issue responses

COLLOQUY, PART III - WHAT WE NEED TO DO

3:00 PM (RM 917) — Presiding:
Mr. Nathan M. Becker

Workshop Reports/Floor Discussion

Panel: Chairmen, Workshops I - IV

4:15 PM — Summation
WHAT WE HAVE HEARD YOU SAY
Professor Israel Katz
College of Engineering
Northeastern University

4:30 PM — Adjournment

Dr. Lawrence L. Ambs, Associate Professor
Department of Mechanical Engineering
School of Engineering
University of Massachusetts
Amherst, MA 01003

WORKSHOP IV

Dr. Ambs is an alumnus of the University of Minnesota, B.S. '60, M.S.'62, Ph.D. '67. He is very active in the Alternative Energy Systems research group in the School in areas related to automotive systems, exhaust emissions, energy conservation, heat pumps, turbomachinery. Special power turbine design techniques applicable in ocean thermal gradient energy conversion systems and energy conservation systems for large public buildings are among his most current interests. He has recently led workshops on energy alternatives for community college faculty development.

Mr. Nathan M. Becker, Vice-President
Massachusetts Society of Professional Engineers
28 Emerson Gardens
Lexington, MA 02173

WORKSHOPS I, II, III, IV

Mr. Becker is an alumnus of New York University, B.S. (Electrical Engineering), M.S. (Industrial Engineering). His career has emphasized manufacturing engineering and project management in complex manufacturing organizations. He is employed currently as Senior Program Engineer with the Raytheon Service Company, having been associated with the Raytheon Company for about 18 years. There he has worked in test equipment and production machinery design and has served as Chairman of the Raytheon Advanced Manufacturing Engineering Council and the Research Committee of the Industrial Engineering Council. He has served as manufacturing manager for special equipment associated with the Apollo, B58 and Polaris programs, among others.

Dr. Raymond L. Bisplinghoff
Vice-President/Research and Development
Tyco Laboratories, Inc.
Tyco Park
Exeter, New Hampshire 03833

Dr. Bisplinghoff is an alumnus of the University of Cincinnati, A.E. '40, M.Sc. '42, Sc.D. '63, and of the Swiss Federal Institute of Technology, Sc.D. '57 and holds an honorary degree from Case Institute of Technology, D. Eng. '65. Following an early period of employment in the aircraft industry and at the Bureau of Aeronautics, U. S. Department of the Navy, and interspersed with important Federal engineering and administrative appointments in advanced research and development, notably with NASA, he rose thru the faculty ranks at M.I.T during the period 1946-1970 to become professor and Head, Department of Aerospace and Astronautics, and Dean of the College of Engineering. He served as Deputy Director, National Science Foundation, 1970-74, and subsequently as Chancellor, University of Missouri (Rolla). He has been a corporate director of numerous major companies which have pioneered high-technology aerospace and energy endeavors; his distinguishd lectureships, awards and citations from prestigious national and international bodies and institutions are beyond listing in this brief. His career comprehends the most distinguished qualities of a scientist and professional engineer, an educator, a creative leader and administrator of complex undertakings.

Dr. Ray E. Bolz, Vice-President
Dean of Faculty
Worcester Polytechnic Institute
Worcester, MA 01609

WORKSHOP III

Dr. Bolz is an alumnus of Case Institute of Technology, B.S.M.E. '40 and of Yale University, M.S.M.E. '42, D. Eng. '49. He was associated with the Langley and the Lewis Laboratories, 1942-46, becoming Head, Jet Engine Combustion Section at Lewis in 1945. He has taught at Rensselaer Polytechnic Institute and Case Institute, at the latter becoming successively Head, Department of Mechanical Engineering; Leonard Case Professor and Head of the Engineering Division; and finally Dean of the School of Engineering at the merged Case-Western Reserve University. He has been involved extensively in ASME and ASEE activities related to undergraduate and graduate engineering education. He has been an advisor to the National Science Foundation, a member of the Education and Accreditation Committee of the Engineers Council for Professional Development, an industrial consultant and a Fellow of ASME. Over the years he has published in technical and educational journals.

Mr. Claude W. Brenner, Vice President/Operations
Northeast Solar Energy Center
70 Memorial Drive
Cambridge, MA 02142

WORKSHOP I

Mr. Brenner is an alumnus of the Massachusetts Institute of Technology and has spent his career in managing business enterprises which bring new technologies to marketplace. Formerly Vice-President and General Manager of Laser Graphics Systems Corporation, he has also served as General Manager of two divisions of EG & G, Inc. Before joining NESEC he served as a member of the New York State Energy Research and Development Authority Task Force and was Associate Director of New England's National Proposal for the Solar Energy Research Institute. AT NESEC, Mr. Brenner manages all internal operations directed toward the accelerated commercialization of solar technologies in the Northeast. These include the industrial development, communications, planning and assessment, and research and development divisions.

Mr. Edward Brodzinsky, Assistant Director
Massachusetts Office of Energy Resources
Room 800
73 Tremont Street
Boston, MA 02108

WORKSHOP II

Mr. Brodzinsky is an alumnus of the Pratt Institute School of Architecture, B. Arch. '66. He is a registered architect, AIA, and prior to his present position has worked in private practice in architectural design and research.

Dr. Kenneth D. Cashin, Associate Dean
School of Engineering
University of Massachusetts
Amherst, MA 01003

WORKSHOP III

Dr. Cashin is Associate Dean for Student Affairs and Chairman of the Curriculum Committee of the School of Engineering. He is a Professor of Chemical Engineering and the founding faculty member of the Departments of Chemical Engineering at both UMass (1948) and the University of Petroleum and Minerals, Dahran, Saudi Arabia (1968). His career as an educator has been distinguished and includes principal research interests in combustion engineering.

Dr. Paul Doigan
Manager, Technical Recruiting
General Electric Company
One River Road
Schenectady, NY 12345

WORKSHOP IV

Dr. Doigan is an alumnus of the University of Connecticut, B.S. (Chemistry) '41; New York University, B.S. (Meteorology) '43, Ph.D. '50; University of Massachusetts, M.S. '46. He is a fellow of the American Institute of Chemists and a member of the American Chemical Society, the IEEE, the ASEE, Sigma Xi. He is currently serving as Chairman of the Engineering Manpower Commission of the Engineers Joint Council. He has been employed by the General Electric Company since 1951. In his present position he has overall responsibility for corporate entry level technical recruiting and coordinates B.S./M.S. college recruiting with all schools in the Northeast and doctoral recruiting with all schools nationally.

Mr. Charles J. Faulstich, Director
Energy Management Services
Northeast Utilities
P. O. Box 270
Hartford, CT 06101

WORKSHOP II

Mr. Faulstich is an alumnus of Yale University, B.S. (Engineering) '54. His career has been entirely within the Northeast Utilities system. He rose thru marketing functions to become Industrial Sales Manager of the Connecticut Light and Power Company in 1967. In 1973 he transferred to the Northeast Utilities Service Company as Manager of Planning and Methods-Energy Consulting Services and subsequently to his present corporate function on January 1, 1978. He has served also as a Corporate Review Consultant in the company's Corporate Development Department.

Dr. Ronald H. Frederickson
Professor of Education
Director, Counselling and Mental Health Administration Program
School of Education
University of Massachusetts
Amherst, MA 01003

WORKSHOP IV

Dr. Frederickson is an alumnus of the University of Wisconsin, Ph.D. '63. His special interests are in career assessment, vocational adjustment and behavioral counselling methods. His publications are numerous, including articles, monographs, reports and one book on career development. He is a consultant to many bodies concerned with the human resource, notably the U.S. Department of Labor, Social Security Administration, U.S. Navy, the Massachusetts Department of Education and numerous schools and community agencies.

Mr. Austin P. Gillis, Manager
Professional Placement and College Relations
United Technologies Corporation
United Technologies Building
Hartford, CT 06101

WORKSHOP I

Mr. Gillis is an alumnus of Providence College, B.S. (Chemistry) '63 and the University of Notre Dame, M.S. (Physical Chemistry) '66. He spent the first ten years of his industrial career in various engineering and administrative capacities on fuel cell powerplant programs, including Apollo and the Space Shuttle, at the Pratt and Whitney Aircraft Division of UTC. He became Supervisor of Professional Placement at PWA in 1976 and in 1977 joined the UTC corporate office in his present function.

Dr. Gary L. Haller, Associate Professor
Department of Engineering and Applied Science
Mason Laboratory, Yale University
9 Hillhouse Avenue
New Haven, CT 06520

WORKSHOP IV

Dr. Haller is an alumnus of Kearney State College (Nebraska) B.S. '62 and of Northwestern University, Ph.D. '66. Following a post-doctoral year at Oxford University he has been on the faculty at Yale since 1967. His academic career at Yale has been laced with many visiting, advisory, consulting associations with industry, government and academic institutions and bodies both at home and abroad. He has some 30 technical publications or manuscripts to his credit, primarily concerned with catalysis or colloid and surface chemistry and bearing on energy-and-environmental-related processing systems.

Dr. Walter R. Hibbard, Jr.
Distinguished Professor of Engineering
College of Engineering
Virginia Polytechnic Institute
and State University
Blacksburg, VA 24061

WORKSHOPS I, II

Dr. Hibbard is an alumnus of Wesleyan University, A.B. (Chemistry) '39 and Yale University, D. Eng. '42. His distinguished career has embraced academia (professor of metallurgy at Yale, R.P.I.); industry (manager of metallurigical, ceramic and alloy research at General Electric Co.; vice-president, technical services at Owens Corning Fiberglass Corp; Board of Directors, Norton Co.); and government (Director, U.S. Bureau of Mines; Deputy Director, Energy Research and Development, Federal Energy Office). He is a member of the National Academy of Engineering and at various times has chaired or served on important committees of the National Research Council, the National Science Foundation, and the National Academy of Sciences. He is a Past-President, American Institute of Mining, Metallurgical and Petroleum Engineers, and recipient of its James Douglas Gold Medal and the Rossiter W. Raymond Award. He has received the Yale Engineering Association award, has served on the visiting committee to Stanford University, and holds honorary doctorates from Michigan Technological University and the Montana College of Mineral Science and Technology. In addition to membership in the principal professional societies related to his interests, he is a registered professional engineer in Connecticut, Ohio and Virginia.

At VPI, Dr. Hibbard is Director of the Virginia Center for Coal and Energy Research.

Mr. John R. Hickey, Senior Physicist
The Eppley Laboratory, Inc.
12 Sheffield Avenue
Newport, RI 02840

WORKSHOP IV

Mr. Hickey is an alumnus of Providence College, B.S. (Physics) '57 and of the University of Rhode Island, M.S. (Physics) '62. He has been employed since 1961 by The Eppley Laboratory, Inc. and has been involved in the development of radiometric instrumentation for extraterrestrial, terrestrial and simulated solar radiation. Principal Investigator and/or Project Manager for satellite, rocket, aircraft and shipboard measurements of solar radiation, including NIMBUS, Solar Constant Rocket Flights, GATE, BOMEX. He is the co-inventor of the H-F Cavity Pyrheliometer. He has authored or co-authored numerous papers on solar radiation instrumentation and Volume 14, Advances in Geophysics Series entitled "Precision Radiometry." He is the Governor's appointee to the Board of Trustees of the Northeast Solar Energy Center and is a member of the International Solar Energy Society, the American Meteorological Society, the Institute of Aeronautics and the Society of Photopotical Instrumentation Engineers.

Dr. Russel C. Jones, Dean
School of Engineering
University of Massachusetts
Amherst, MA. 01003

WORKSHOP III

Dean Jones is an alumnus of Carnegie Institute of Technology where he earned both his undergraduate and graduate degrees. His previous academic assignments have been as Assistant and Associate Professor of Civil Engineering at M.I.T. (1963-71) and as Professor and Chairman of the Department of Civil Engineering at the Ohio State University (1971-76). His special areas of interest are in construction engineering systems, structural and composite materials, engineering ethics and professionalism and in engineering education and the accreditation process. He undertook his present position in January, 1977 where he is making a major imprint on resource development and management and in relations with industry.

Mr. Harold D. Kastle
Manager, Industrial Relations
Equipment Division (AAI5)
Raytheon Company
Boston Post Road
Wayland, MA 01778

WORKSHOP IV

Mr. Kastle is an alumnus of City College of New York, B.S. (Psychology) and of Teachers College, Columbia University, M.S. (Educational Psychology). His career has been with the human resource.

Starting as a Training Assistant with the Raytheon Company in 1958, he has variously served as Personnel Administrator and Manager of Personnel Services at several divisional and at corporate headquarters; and as Industrial Relations Manager at other plant and divisional locations. He is a member of the faculty of University College of Northeastern University where he teaches the course in Human Relations.

Professor Israel Katz
Room 219 HA
Northeastern University
360 Huntington Avenue
Boston, MA 02115

WORKSHOPS I, II, III, IV

Professor Katz teaches engineering thermodynamics and engineering management at Northeastern University and is a consultant to the National Academy of Sciences, the National Science Foundation and the Department of Health, Education and Welfare. He was a civilian senior staff member at the U.S. Navy Diesel Engineering Laboratory at Cornell University during WW-II and served there for many years as Professor of Thermal Engineering and director of the Cornell Aircraft Powerplants Laboratory. Another large segment of his career was as an engineer and engineering manager at the General Electric Advanced Electronics Center. He is known nationally for his years as Dean of Continuing Education at Northeastern University and for the "State-of-the-Art" programs for working professional engineers.

Mr. W. Robert Keating
Director, Energy Program
New England Regional Commission
55 State Street
Boston, MA 02109

WORKSHOP III

Mr. Keating is an alumnus of the Universities of Massachusetts (B.S.C.E.), '66 and Maine (M.S.C.E.). He has served as Water Resources Consultant with the U.S. Public Health Service in Denver, CO. Prior to his present responsibility, he was senior staff and manager of the NERCOM Office of Environmental Programs. As Energy Program Director, he manages a staff of seventeen people and is responsible for the planning, development and implementation of the regional energy program with particular concern for the economic and social development of the region.

Dr. Joseph Kestin
Professor of Engineering
Director, Center for Energy Study
Brown University
Providence, RI 02912

WORKSHOP I

Dr. Kestin is an alumnus of the Engineering University of Warsaw (Mechanical Engineering) and of the University of London, Ph.D. '45, D.Sc., '66. He is the author or co-author of some 120 research papers, 4 books and translator of 4 books, among them "A Course in Thermodynamics" and H. Schliting's "Boundary-Layer Theory," now in its 7th edition. He has been a visiting professor at several prestigious universities -- Imperial College (London); Norges Tekniske, Hogskole (Trondheim); University of Paris (Sorbonne); Instituto Superior Tecnico (Lisbon); University Claude Bernard (Lyon). Formerly special advisor to the Chancellor, University of Teheran (Iran). He has been a very active member, chairman, journal editor in activities and journals of the ASME, National Academy of Sciences/National Research Council and thermodynamic publications.

Mr. Herschel A. Klein, Director
Corporate Energy Management and Technical Activities
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WORKSHOP III

Mr. G. Douglas Krause
Manager/Systems Engineering
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397 Post Road
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WORKSHOP II

Mr. A. Paul LaRosa, President
Bayside Engineering Associates, Inc.
286 Summer Street
Boston, MA 02210

Mr. LaRosa is an alumnus of Northeastern University, A.E. (Civil Engineering), B.S. (Industrial Technology). His wide background as a consulting engineer emphasizes civil, transportation and architectural engineering. He was formerly Chief Engineer of Abbott Engineering., Inc., a function he fills in the firm he presently heads. He is active in community affairs, currently serving on the Citizens' Committee of the Metropolitan Area Planning Council 208 Water Quality Study; former member of the North Reading Planning Board and former elected Commissioner of Public Works in North Reading. He is the Massachusetts Secretary of the Consulting Engineers Council of New England, Inc., is President of the Massachusetts Society of Professional Engineers, and is a member of the American Society of Civil ENgineers.

Ms. Christine LeCam, Economist
Massachusetts Department of Manpower Development
C. F. Hurley Building, Government Center
Boston, MA 02114

WORKSHOP I

Ms. LeCam is an alumnus of the University of Lowell, B.S. (Business Administration/Economics) and Northeastern University, M.A. (Economics). She is presently a Ph.D. candidate (Economics) at Northeastern. Her work is concerned primarily with the use of labor market information in the planning and development of employment and training programs. She directs research which currently produces estimates of the institutional supply of labor to occupations generally requiring less than a baccalaureate degree, for comparison with demand information and recognition of occupational shortages. She will discuss the status of central information vehicles at the baccalaureate and higher levels.

Mr. Ermond F. Lewis, Counsellor
Professional Service Center
Massachusetts Division of Employment Security
400-2 Totten Pond Road
Waltham, MA 02154

WORKSHOP I

Mr. Lewis is an alumnus of the University of Maine, B.A. His career has been spent in personnel management and placement. This has included labor, contract and grievance negotiations in industry; owner/manager of an employment agency emphasizing the placement of professional applicants; employment counselling of professional applicants with particular attention to clients facing major changes in career direction.

Associate Dean Joseph S. Marcus
School of Engineering
University of Massachusetts
Amherst, MA 01003

WORKSHOP IV

Dean Marcus is an alumnus of Worcester Polytechnic Institute, B.S. (Chemical Engineering), '44 and of the University of Massachusetts, M.S.C.E., '54. His career parallels all but the first year of the School of Engineering, having begun with his appointment as an Instructor, 1948. He is currently a Professor of Civil Engineering and Associate Dean. His activities have been varied and campuswide, his relations with students, as teacher, friend and advisor are legendary. He received the University-wide Distinguished Teacher Award in 1965. In conjunction with his direction of a program in Nuclear Engineering, 1957-65, he spent 1962-3 with the faculty at the

School of Reactor Technology, Oak Ridge, TN. In addition to his strong role in internal leadership and administration of the School, his outreach activities with other educational institutions -- high schools, community colleges and colleges and universities — are extensive. Currently they involve engineering alumni relations as well as the development of programs of extended education for non-campus students. These have included workshops in energy for high school and community college faculty. He is Chairman of the School-wide committee preparing for the 1980 National Convention of the American Society of Engineering Education scheduled to occur at UMass.

Sister Claire Markham
Department of Chemistry
Saint Joseph College
West Hartford, CT 06117

WORKSHOP IV

Sister Markham has just returned to her position as Professor of Chemistry at Saint Joseph College from her responsibility as Under Secretary for Energy in the Connecticut Office of Policy and Management. Her interest in energy originated with her doctoral research at the Catholic University of America in 1952 where she began to investigate photochemical energy conversion at semiconductor surfaces. This research continued at Saint Joseph Collge, at University of California/Berkeley and at the Norwegian Institute of Technology/Trondheim. She served as U.S. Cooperating Scientist, Indian Institute of Technology/Madras, 1974-1977. Well-known for excellence in undergraduate and graduate teaching, she includes in her experience research in solar energy and the development of courses on energy and the environment for teachers and industrialists, as well as service in State government.

Mr. John J. Matson, Executive Vice-President
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WORKSHOP II

Mr. Frank N. McElroy
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Dean Peter W. McFadden
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WORKSHOP IV

Dr. McFadden is an alumnus of the University of Connecticut, B.S.M.E. '54, M.S. '56 and of Purdue University, Ph.D. '59. For many years he taught at Purdue, becoming Professor of Mechanical Engineering and Head of the School of Mechanical Engineering. He did post-doctoral research at the Swiss Federal Institute (Zurich) and has been a consultant to industry. He has been active in the ASME and ASEE. His research interests have been mainly in the thermal sciences, primarily heat transfer and cryogenics, and in mass transfer. More recently he has been in administrative responsibilities, including the development of an energy program and center at UConn. His present interests include research on energy conservation, energy policy and engineering manpower.

Mr. John J. Miggins, Director
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WORKSHOP I

Dr. David H. Navon
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WORKSHOP III

Dr. Navon is an alumnus of City College of New York, B.E.E. '47; New York University, M.S. (Physics) '50; Purdue University, Ph.D. (Physics) '53. His early career was in industry with the Transitron Electronic Corporation where he finally served as Director of Research and Development. He became Visiting Professor in the Department of Electrical Engineering at M.I.T. 1965-68 and has been Professor of Electrical and Computer Engineering at UMass since 1968. He was a Visiting Professor on a Fullbright lectureship at the School of Applied Science and Technology, Hebrew University, Jerusalem, 1974-75, and was on leave to the U.S. General Accounting Office working on energy-related matters, 1977-78. His principal research interests include semiconductor devices and photovoltaic cells.

Mr. Ronald W. Plutnicki, Vice-President
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New England Electric Company
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WORKSHOP IV

Dr. Charles Polk
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College of Engineering
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WORKSHOP III

Dr. Howard D. Segool
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WORKSHOPS I, II, III, IV

Dr. Segool is an alumnus of Brown University, Sc.B. in Chem., '35 and of Yale University, Ph.D. (Chemistry), '38. Prior to coming to the University in 1965 as Director of Industrial Liaison, he had an extended career in industry in research and development, manufacturing, marketing and management. His principal associations were in the heavy and fine organic chemical industries and textile and industrial adhesive products. He led the innovation of materials and systems now used worldwide as the primary corrosion-protective systems on buried long-run oil and natural gas steel pipelines. Among other activities, he has directed the State Technical Services Program for the Commonwealth, served on the New England Technological Services Board, and on the Governor's Advisory Committee on Science and Technology. He was instrumental in establishing the Massachusetts Science and Technology Foundation, recently legislated into the Massachusetts Technology Development Corporation.

Mr. Norman Seltzer
Chief, Manpower Assessment
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WORKSHOPS I, II

Mr. Seltzer is an alumnus of City College of New York (economics) and holds a Master's degree in labor and industrial relations from the University of Illinois. Early in his career he was an industrial relations analyst in the Central Training Division of the Ford

Motor Company and also served as a labor economist concerned with manpower studies for occupational outlook purposes in the U.S. Department of Labor. He has previously held various positions with the National Science Foundation where he most recently headed a manpower utilization studies program. He came to the Energy Research and Development Administration in 1976 and, with its merger into the U.S. Department of Energy, assumed his present duties. He is responsible for planning, writing and supervising numerous studies and government reports on scientific and technical manpower relative to the energy mission.

Mr. Leo L. Simms — WORKSHOP II
Director of Personnel
Avco Everett Research Laboratory, Inc.
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Mr. Simms is an alumnus of St. John's College (Annapolis), B.A. and of Boston College, M.B.A. His military service includes five years in the U.S. Air Force where he worked as a Russian translator; he is also fluent in German and trained in French. His experience covers a broad area within the engineering, scientific and health care industries. He was formerly Director of Personnel at the Massachusetts Eye and Ear Infirmary and at the Children's Hospital Medical Center. Currently he is concerned with the recruitment and management of the personnel requirements of one of the Nation's leading research centers in lasers, fluid mechanics, molecular physics, medical research, aerodynamics and their associated technologies.

Dr. Marvin A. Sirbu, Jr., Research Associate — WORKSHOP II
Center for Policy Alternatives
Building E40-209
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Dr. Sirbu's training is in electrical engineering with a minor in economics. His interests focus on the application of systemic analysis to policy issues in which technology plays an important role. Recent research activities include a technical, regulatory and market assessment of electronic mail; a technology assessment of office automation; comparison of government policies for the support of new technologies; energy research and development policy; the supply and demand of scientific and technical manpower; and automated ground transporation systems.

Dr. Sirbu teaches the core seminar for M.I.T.'s Master's Degree Program in Technology and Policy and serves on the interdepartmental steering committee for the progam.

Mr. James E. Sloan, Vice-President
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WORKSHOP I

Mr. Sloan is an alumnus of Ohio State University, B.A. '49 (Math), M.S.E.E. '51; with further graduate study at the University of Pennsylvania. His professional career began at the AEC Oak Ridge, TN plant in process engineering. Interrupted by a 15-month period of service in 1962-63 as Director, Integration and Checkout in the NASA Office of Manned Space Flight, he next performed in various engineering and engineering management functions with RCA (1952-1965). Since 1965 he has been with the Raytheon Company as Assistant General Manager of its former Space and Information Systems Division; as manager of Engineering, Equipment Division; and, since 1970, in his present association which includes a range of alternative energy and environmental systems endeavors.

Mr. A. Graham Sterling
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WORKSHOP I

Mr. Sterling is an alumnus of the Massachusetts Institute of Technology, B.S.E.E., M.S. '49. For many years he was associated with Texas Instruments, Inc., finally as Controller, Materials and Electrical Products Group. He has been with Analog Devices Inc. since 1974 in his present position. He chairs the sub-committee of the Massachusetts High Technology Council which is concerned with technical manpower forecasting as a function of business development planning. He is a member of the American Association for the Advancement of Science, the American Economic Association, the American Finance Association, the Financial Executives Institute and the M.I.T. Alumni Officers Council.

Mr. Werner A. Tikkanen, President-Elect
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WORKSHOPS I, III

Mr. Thomas F. Widmer
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WORKSHOP III

Mr. Widmer is an alumnus of the University of Pittsburgh, B.S.M.E. '54 and the Chrysler Institute of Engineering, M.A.E. '56. Early in his career he was Manager of Reactor Mechanical Design at the Westinghouse Atomic Power Division. Subsequently he was Manager of Nuclear Programs, General Electric Missile and Space Division. Here he directed the SNAP-27 Program, resulting in the placement of 5 nuclear-powered scientific stations on the lunar surface during Apollo missions. In his current position since 1969, he is responsible for planning and direction of a product development program which emphasizes the commercialization of new technology in industrial energy conservation equipment.

Mr. Gayle N. Wright, Director
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WORKSHOPS I, II, III, IV

Mr. Wright has staff responsibilities for NSPE programs involving salary surveys and information, fringe benefits, employment practices and other economic interests of its members. He is staff director of the Professional Engineers in Industry practice division, and of the Professional Employment committee.

Mr. Edwin W. Zeitz
Director, Rates and Research
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WORKSHOP III

Mr. Zeitz has been professionally involved with energy policy issues and their effects on economic development since the 1973 Arab oil embargo. Holder of a Master's degree, Institute of Public Policy/ University of Michigan, he was Principal Investigator for the New England Energy Policy Alternatives Study concerning the economic impacts of selected energy policy alternatives thru 1985. He has testified before the Massachusetts Department of Public Utilities and the Energy Facilities Siting Council regarding electrical demand forecasts.

Dr. Armand J. Zottola, Chairman
Department of Economics
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WORKSHOP II

Dr. Zottola is an economist with special interests in industrial sociology and demography. During his graduate program at The Catholic University of America he was for a year an HEW Visiting Fellow in Puerto Rico. He has served on the faculty of economics at Fordham University and, since 1971, has been a lecturer in industrial relations and labor economics in the Graduate School of Business at the University of New Haven. In 1976 he authored a major study for the Department of Vocational Education of the State of Connecticut entitled "Manpower Training Needs of Connecticut's Business and Industry". Liaison with the research office of the Connecticut Department of Labor maintains his awareness of that state's manpower situation.

ABSTRACT

The crucial interrelationships of engineering manpower, technological innovation, productivity and capital re-formation were keynoted.

Near-term, a study has indicated a much larger New England energy demand-reduction/economic/market potential, with a probably larger engineering manpower requirement, for energy conservation measures characterized by technological innovation and cost-effective capital services than for alternative energy supply measures.

Federal, regional and state energy program responsibilities described a wide-ranging panorama of activities among many possible energy options which conveyed much endeavor without identifiable engineering manpower demand coefficients.

Similarly, engineering manpower assessment data was described as uneven and unfocused to the energy program at the national level, disaggregated data as non-existent at the regional/state levels, although some qualitative inferences were drawn.

The dimension of the energy-related engineering manpower demand/supply delta, if any, was not established.

An impressive econometric model was presented describing the influences which historically have generated a cyclical supply of bachelors degree engineers out-of-phase with demand. Twenty-one recommendations to amplify the value of engineering manpower assessment activities to users were delineated.

Workshops disagreed on the need for improved engineering manpower assessment strategies; favored educational attention to career switching into energy endeavors; emphasized technician training; encouraged energy-related emphases within existing degree curricula.

THE PROCEEDINGS

Student-Aid Funds Cut
At California School

★ ★ ★

Demand Keeps Growing
For Engineering Grads

American Council on Education • One Dupont Circle • Washington, D. C. 20036

Volume XXVIII, Number 11 **March 16, 1979**

Senate Committee
Approves D...

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— Vol. XXVIII, No. 11

emand Is Growing or Engineer Grads, ew Survey Reports

The demand for graduating engineers is so strong there just are not enough of them available to meet employer demand, the College Placement Council reported this week. "Many engineering candidates are being deluged with job offers," the council said. CPC said its data show that employers have made 40 percent more offers to prospective engineers at the bachelor's degree level than at this time last year—and last year was the biggest year in college recruiting since the late 1960s.

"Indicative of the engineering crunch is the fact that engineering offers accounted for 61 percent of all bachelor's offers reported in the College Placement Council's second salary survey report of the year," the council reported.

Stepped-up recruiting activity at the bachelor's level also was reported in business-related disciplines which showed an 18 percent increase in offers, and scientific disciplines with a 17 percent gain. Only the humanities and social sciences group, which encountered a nine percent decrease, did not share in the upward trend.

The story is different at the graduate level, the council said. Compared with the March 1978 report, the number of offers to master's-degree candidates declined nine percent and the volume for doctoral candidates decreased 23 percent.

Women received 20 percent of the total number of job offers reported at both the bachelor's and master's levels. This was up from 19 percent and 17 percent, respectively, a year ago. "Compared with just four years ago, however, the gains by women are significant," the council said. "In March 1975 they accounted for only eleven percent of the bachelor's total and ten percent of the master's total."

In terms of dollar averages at the bachelor's level, petroleum engineering continued to be the leader at $1,788 a month, an increase of eight percent since last season. Chemical engineering was next at $1,633, a gain of nearly eight percent. The lowest dollar averages were reported for humanities majors and other social science majors, both at $911.

All but one of the 15 employer groups surveyed in the private sector showed increased activity over last year, with the aerospace/electronics/instruments group registering a 70 percent increase in volume. The lone exception was the petroleum and products group which made about the same number of offe as last year. The most active recruiters were employers in the manufacturing/industrial group. They extend 36 percent more offers than last year and accounted for 71 percent of the bachelor's total volume. Busin employers made 17 percent more offers.

...blic sector, federal job offers increased 38 percent, and local and state government regist ...oth cases, however, volume was limited, CPC said.

... were experienced in all but three areas. Slight gains ... and by mechanical engineering a ... $1,748, a seven percen... ...hanical en...

SUMMARY

Against a backdrop of the foregoing demand/supply scenario depicted by the College Placement Coucil, and preceded by an advance mailing of pertinent preparatory materials, forty-four invited participants convened at the University of Massachusetts on March 1, 1979. Their representation comprised:

	CT	MA	RI	Other	Total
Education	2	10	2	1	15
Government					
State	2	4	-	-	6
Regional	-	2	-	-	2
Federal	-	-	-	2	2
Industry	5	10	1	3	19
Full Attendance	9	17	3	2	31
Partial Attendance	-	9	-	4	13
Total	9	26	3	6	44

All were profesionally identified with engineering education/practice/management; energy policy/technology; or manpower assessment/placement/counseling/training.

In his Keynote, Raymond Bisplinghoff convincingly stressed the crucial relationships that press on our society between energy availablity and utilization, productivity, innovation, our standard of living and life quality, our economy, and the quality and quantity of our human resource in engineering in parallel with our ability to invest in the formation of necessary capital.

Howard Segool explained the context and the planned process of the Colloquy/Workshops.

Edwin Zeitz examined the energy economics of New England with an explanatory reaffirmation that energy-efficient technologically innovative capital is mandatory for a healthy economy in a period of rising energy costs because of its inherent effect on the cost of capital services. Further, he reported analyses indicating that alternative energy supply options for New England promise few significant economic effects in the time frame thru 1985.

Consequently, the regional demand for engineering manpower will be principally identified with the energy conservation market for capital goods, estimated to be much larger (4 times) thru 1985 than the alternative energy supply market. A total near term energy conservation capital market in New England of at least $4 Billion was considered reasonable, with a significant portion going to engineering manpower. (editor's note: postulating a 10% portion going to engineering manpower @ $25K per capita annually, such capital investment would represent an order of magnitude of 16,000 engineering man-years). He suggested that an engineering manpower demand shift to the alternative energy supply market might begin to develop toward the longer term.

Sister Claire Markham, Edward Brodzinsky and W. Robert Keating comprised a panel of state and regional governmental energy program managers which described the perceptions of their offices regarding the regional role in the national energy program. Most notable were the absence of focus and goal definition which would enable even the most speculative engineering manpower demand estimates.

Claude Brenner and Frank McElroy (the latter reading a paper by Jackson Gouraud) respectively described commercialization endeavors at the regional (solar-related) and national levels to accelerate the market penetration of emerging energy technologies. These activities, both undertaken by the U. S. Department of Energy, are unique initiatives for the federal government. These are highly organized, marketing-oriented activities intended to identify the technologies most promising for early commercialization, to champion them and related entrepreneurship, and to assist in the removal or circumvention of systemic barriers to their successful marketing. While the rate of success of these programs will undoubtedly hinge substantially on the quality and quantity of the engineering manpower resource, limitations of this sort were not an expressed concern.

Norman Seltzer described the Manpower Assessment program of the Office of Education, Business and Labor Affairs, U.S. Department of Energy. This modestly budgeted effort is a composite of limited inhouse studies coupled with existing data sources developed by other agencies both within the government and in the non-government sectors. Currently the output has two characteristics: (1) a good deal of unevenness in the depth of available data, and (2) a lack of regional disaggregation. Much is known about engineering manpower supply and demand nationally in a few industries — petroleum and national gas, nuclear. In other energy industries the information is quite spotty and scattered nationally, very limited regionally. Efforts are underway to improve the system and the data base. Overall, for the short term -- a few years -- there is likely to be an excess of demand over supply.

Joseph Marcus (reading a paper by Kenneth Picha) described evidence indicting that the health of the Nation's engineering doctoral programs is of extreme importance to the energy effort. In a U.S. Department of Energy report "Energy-Related Doctoral Scientists and Engineers in the United States 1975" (DOE/IR-0033), it is reported that, of all doctorates employed in energy-related fields, 44% were engineers. In an update of a report presented in September, 1978 to the Committee on Energy and the Environment, NASULGC, concerns were expressed regarding two key issues that have been observed over the last half-dozen years: (1) that doctoral enrollments in the Nation's Engineering Colleges are decreasing, as evidenced by decreasing Ph.D. productivity, and (2) a larger fraction of those earning engineering doctorates are foreign nationals. This could be of great significance if the mix of foreign students is changing and graduates do not plan to stay in the USA. The development of better manpower data for doctoral-level energy-related scientists and engineers is urged.

Armand Zottola and Christine LeCam comprised a panel representing state manpower offices (RI was unable to be represented) and reported the assessment situation in two of the three regional states concerned. Insufficient definitive information is routinely and systematically collected to provide energy-specific labor market information. In one state, inferences drawn from non-specific information suggest that no surprise surge in demand for energy-related scientists or engineers should be expected in the near future. Rather, a stable or incrementally shifting demand for energy-related engineers and scientists accompanied by a superior market situation for supply is to be anticipated. In the second state, a relatively low level of unemployment is indicated in all professional engineering occupations, suggesting a situation approaching equilibrium or a potential shortage of engineers. Here, research is being conducted to determine the feasibilty of constructing a demand/supply model for high-technology manpower which might then be applied to energy-related engineering manpower.

The obscurity of action goals, the absence of definitive regional and national disaggregated engineering manpower data, made it disappointingly impossible for Ronald Frederickson to determine the summary prospectus for the regional demand/supply delta in energy-related engineering manpower. Despite the communication of an enormous amount of related information among people most suitably located to be well-informed and directly or indirectly influential in the success of the national energy program, the elusive delta remained unknown at the conclusion of the Colloquy, Part I - What We Think We Know.

In prelude to the Workshops, Marvin Sirbu described an impressive econometric model whereby he is able to simulate the effect of current market demand for engineers on future new entrant supply to the engineering manpower resource. The number of current engineering graduates is related to demand four years and two years earlier represented by engineering enrollments influenced by economic indicators of which enrolling students become aware. Engineering salaries comparative to alternative salaries are important inputs, probably as proxy for kinds of information available to students in their enrollment decision-making process. A cyclic supply results, out of phase with demand. At least on a short range basis, simulations using appropriately assumed variables will forecast a series of curves forming an envelope into which the actual numbers will fall.

Walter Hibbard completed the preparation for the workshops with a summary presentation of the proceedings of the 1978 Joint Engineering Manpower Commission/Engineering Foundation Conference on "Measuring and Forecasting Engineering Personnel Requirements". This comprised a description of the multitude of engineering manpower assessment activities that are ongoing, their purposes and rationale, the gaps in the kinds of information they produce, unsatisfied user needs. Twenty-one recommendations issuing from the workshops of that Conference, which would amplify the value of manpower assessment activities insofar as user needs are concerned, were described.

Finding that the Colloquy up to this point had been extremely diffuse, that the quantitative form, shape and substance of our national energy program seemed to be eluding us, and in search of foci for the workshops, Nathan Becker charged the workshops with a set of nine assumptive benchmarks to give dimension to our regional engineering manpower demand inquiry.

Whereupon the Colloquy, Part II adjourned; and the workshops convened to deliberate their assigned issues.

It became evident in their reports that the Workshops preferred to consider their issues topically and avoided the assumptive benchmarks with which they had been charged. To be sure, the data base they were able to bring from the earlier dialogues was consonant with such a departure.

Workshops I and II had opposing views as to the need and desirability of a more dynamic demand/supply intelligence system for engineering manpower assessment and communication. One reported it would be redundant to the diffuse information system(s) now in place which should be able to focus more effectively when necessary; and that a more centralized system probably could not substantially reduce the response time inherent in the cyclical nature of the current demand/supply situation. The other was diametrically in support of an immediate need for a more effective system but proposed no model other than "...should develop a complete matrix of energy-related personnel on an industry by industry basis to provide the broadest perspective of manpower requirements and utilization."

Workshops III and IV seemed to agree on the desirability of joint industry/university/government educational and retraining programs for the appropriate redirection of engineers into energy-related endeavors. III extended this to include non-degreed students and technicians, even providing for two-way career switching between engineers and technicians where individual abilities so indicate. IV supported more opportunistic use of continuing education modes now in use, for both maintenance and career growth, with the caveat that government policy leadership, policy commitment, will be necessary before industry will invest further in specific human resource development. Neither III nor IV referenced REPREP (an earlier retraining proposal made to ERDA/DOE by the co-sponsors of this Colloquy/Workshop) as a possible undertaking.

Workshops I and II both strongly favored attention to the great need for training/retraining skilled technicians, allocating this to a production problem for high schools and 2-year vocational schools/community colleges. Not unexpectedly, a call was made for leadership by government in providing funding and awareness. It was inferred that this would free up engineering personnel since "Too frequently, degreed engineers are doing technician work."

It had been repeatedly mentioned during the Colloquy that energy-related engineers are really M.E.'s, C.E.'s, Ch.E.'s and E.C.E.'s working on energy problems. Workshops III and IV reiterated this in reporting improvements to be recommended in energy-related engineering degree curricula: selected emphasis on thermodynamics and energy-related options within existing basic disciplinary curricula; especial emphasis on engineering economics.

Finally, admittedly within the framework of his own conceptions, Israel Katz heard a message from these proceedings that said the following:

> Great and revolutionary technological expectations for the energy future are simply not in the cards. Most of our developments are pretty mature and, if we propose to improve their energy efficiency, we're going to be dealing with refined and very high technology where investments are enormous per unit of achievement. Consequently, we'll be looking for seasoned people, not recent graduates, to achieve results. We have to nurture our seasoned engineers because that's where the knowledge and experience in problem-solving lies.
>
> Where are they coming from? They're the people who have the knowledge and keep updated. The key to keeping updated is to be on a tough job—working neither at partload nor overload but at optimal load—learning on the job. If supplementary education is needed you go to the university, bring in the university, or run a course in-house.

The nature of the beast is such that we have to nurture our most competent people now to handle the opportunities and the emergencies of the future.

At the university the model we might need is one where there is a core of very competent fulltime faculty with adjunct people, professional people in fields of practice who are fully competent to teach!

An Independent Evaluator delivered a complimentary report on this activity which is incorporated in these Proceedings.

GREETINGS

from

Dean Russel C. Jones
School of Engineering, UMass

I'm particularly happy to have this group here because I think its purpose cuts across many of the interests that we in the School of Engineering have. We're entirely concerned with engineering manpower, initially, of course, in terms of our first-time-through product -- that is, the graduates whom we send out who are to some degree, perhaps not as much as some of you in industry would like, weather-vaned to the current needs of our society and its industries and agencies. We also are deeply concerned about good career shifts. I, for example, have made about four right-angle turns in my career and I suspect Dr. Bisplinghoff has made perhaps ten. One finds that the kinds of backgrounds in engineering education and experience that are acquired either facilitate or constrain the numbers and degrees of latitude that one has in making effective shifts of that kind.

In recent years we have gone through a variety of sudden shifts of emphasis in pressing social needs. I asked Howard to note a few comments that I might make here today and at this point he had me saying "even at my young age I have seen several." That's all relative -- Howard has a bit more gray hair than I have. But there certainly have been a variety of crises over a short period of time concerning the needs of our society. I don't prefer to call them crises but certainly a case in point was our response to the fact that the Russians got ahead of us in the space race at some point in time. That's probably why I'm here today, because I was attracted out of industry and into graduate school to try to get an advanced education, which sent me off on a completely different career path at that point. Certainly the environmental effort that we've all been involved in for many years is one, the energy crisis is another, example. It's not clear what the next one will be, perhaps food, perhaps productivity.

So we're particularly glad to bring this group together here on the UMass campus, to have you spend a couple of days taking a look at the product coming through our educational institutions the first time, and how that will serve to provide a manpower base to deal with the energy crisis. And, secondly, to have you look at the folks out there in mid-career and try to describe ways in which a variety of institutions, including higher education, are to be made more useful in helping these right angle turns at which engineers tend to be reasonably good.

Welcome here. I'll be trying to partake of most of the meeting. One difficulty in having a meeting on one's own campus is that a variety of crises come up. I received a call yesterday afternoon saying that my President was going to be on campus today, could I please meet him at 1:45 PM at room such-and-such. In that case I salute and walk over and apologize to Howard. Nevertheless, I anticipate that this will be an extremely good session and I do look forward to being with you for much of the next couple of days.

Welcome to the University of Massachusetts, have a fruitful meeting.

and from

Mr. A. Paul LaRosa, President
Massachusetts Society of Professional Engineers

Gentlemen, thank you for joining with us today. I wish to greet you on behalf of the Massachusetts Society of Professional Engineers, in association with the University of Massachusetts, and to briefly state that there are several major problems that still have to be addressed by our governmental agencies regarding the total energy policy of the United States. In addition to any results from your deliberations over the next two days, its going to be necessary that some action programs and dollars be laid on the line if our country is going to attack the entire energy problem on a working basis.

A brief survey of the engineering population — in the private practice area, industry, education -- and the professional registered engineers in Massachusetts indicates that among our 18,000 people there are probably adequate numbers to start working on these problems. We are eagerly awaiting programs to be initiated where we can offer our services. Up to date the only attacks, in fact, that have been made have been some generalized studies of the problem. Until definite action programs are arrived at and implemented, and I believe it has to be done at the top government level, we are going to be stuck with doing a continuing round of studies and not really begin to dig into specific problems.

We shall have participating from the Massachusetts Society: myself, A. Paul LaRosa — I'm the current president; the president-elect, Werner Tikkanen, who will lead the Massachusetts Society of Professional Engineers next year; our first vice-president, Mr. Nathan Becker who, of course, has been instrumental in their development and is deeply involved in the next two day's programs; and Mr. Ronald Plutnicki, also a vice-president of the Society.

Again, I thank you for your participation in this event and believe that, given the opportunity, our professional groups have substantial staff to accomplish much toward our energy resources planning and development. Thank you very much.

KEYNOTE ADDRESS

TWO CRUCIAL ITEMS ON THE ENERGY AGENDA: ENGINEERING MANPOWER AND CAPITAL REFORMATION

Dr. Raymond L. Bisplinghoff, Vice-President
Tyco Laboratories, Inc.
Waltham, MA

Your chairman has assigned me the unenviable job of delivering a keynote address on "Two Crucial Items on the Energy Agenda: Engineering Manpower and Capital Reformation." Because of the linkages between the two, this is a fitting topic for a conference on engineering manpower.

At the beginning of a keynote address there should be an assumption. My assumption is that the United States will continue to grow in economic and industrial strength and vitality. I will not attempt to define growth in terms of economic indices, but will say that the America I want promises an easing of inflation, higher living standards, better ability to compete abroad and improving quality of life.

It is hardly necessary to point out that my vision of the future does not square with zero growth. I do not need to tell you also that there are some who would take issue with this view. I doubt if there is really a choice. Even with our reduced birthrate we can expect at least 50 million people added to the U.S. total population before the century is over. There will be a 36 percent increase in work-force. At the same time we will be witnessing new household formations at a rate between 25-30 thousand a week -- the equivalent of adding a new Tacoma, Washington or Patterson, N.J. to the nation every few weeks. The new families must be provided homes, clothing, food, transportation, communications, public services and, above all, jobs. I should mention also the necessity of satisfying the demands for public support of welfare and social services which have grown at unprecedented rates in the past decade since the passage of the "Great Society" legislation in the Johnson administration, and which can only be paid for by a concomitant growth in the nation's economy. In this regard, the U. S. Dept. of Health, Education and Welfare estimates, on the basis of current trends, that the present ratio of 6 to 1, active to non-active workers, will be halved by the year 2030. The H.E.W., which now has the world's third largest budget, may well become second by that time if we can pay the bill.

This is a convenient point for the keynote speaker and audience to part company. If you do not agree that the U.S. should aspire to continued and even accelerated growth in economic and industrial strength, there will not be much of the remainder of this speech that will interest you. Indeed, the whole conference will be of little interest since that is surely its underlying premise.

The two key factors that will do most to bring about the America that I foresee are improved productivity and new and improved sources of energy. By improved productivity I refer to improvements in the efficiency of converting resources into valuable goods and services. This implies not only improvements in output per man-hour but also in output per B.T.U. as well. Energy conservation in the sense of more efficient energy conversion is implicit in this definition.

Americans throughout our 200-year history have enjoyed a steadily rising standard of living. The economy has expanded, new jobs have been created and rewards have increased. The American today consumes greater amounts and varieties of goods and services, performs less back-breaking work and has far more leisure than the generations before.

The better life was made possible largely by sustained productivity improvements and new and improved sources of moderately priced energy. Institutional accomodations such as collective bargaining and a broad range of social legislation have assured that the gains in productivity and energy growth are shared widely and reasonably equitably.

But it has become clear in the past few years that the realization of improved productivity along with abundant low-cost energy is not automatic in the future. Careful planning and considerable effort will be required to keep them coming along. If the future is to measure up to the past, the factors that slow growth must be systematically identified and eliminated. They include now the burden of high rates of inflation, a sluggish rate of investment, low capacity utilization, declining rates of expenditures on R & D, spiralling energy prices abroad and a federal policy of regulating the price of hydrocarbons at prices below their replacement cost.

We are faced with the disquieting fact that the nation's ability to moderate inflation and sustain past gains in the quality of life is seriously threatened by the prospect in the 1980's of diminishing productivity growth combined with mountainous increases in the cost of energy. Only if productivity improves at a much faster rate than in the recent past and if we can at the same time moderate the cost of energy, can we come within a country mile of raising or even maintaining the present standard of living for all, including the increasing number of persons not in the active work force.

The nation cannot delay another day taking on the job of undergirding the underlying sources of productivity improvement and energy availability. We desperately need new policies to improve the climate for technological innovation, to increase capital investment and to encourage a business-government environment that is conducive to growth. The challenge underlying all others represents the subject of this conference, namely, to find ways to raise the quality of scientific and engineering manpower, traditionally the key to productivity improvements and energy development.

None of the factors influencing improved productivity and new and improved energy sources is affected more by engineering manpower and capital investment than is innovation. Conventional wisdom claims that innovation is good for the nation. This claim is generally made by economists, with scientists and engineers in agreement. The fact that several groups agree, or even that most economists agree, does give the claim some authority. But, aside from the claims of experts, an objective examination of the historic influence of innovation on productivity and energy growth by any open-minded person shows that it is indeed good for the nation.

Edward Denison, in his studies on the causes of economic growth and productivity gains in the United States over the past four decades, finds that the factor "advances in knowledge" has been the biggest single source of growth. Denison estimates that it accounted for about one-third of the growth in the nation's output in the period 1929-1969.

Results from studies of specific innovations also show high gains. Edwin Mansfield estimated returns to society and to the industries involved for 17 specific innovations. The median societal rate of return was estimated at 56 percent. The median rate of return before taxes to the industries involved was 25 percent. The most important conclusion to be drawn from Mansfield's study is not the specific percentages, but the high rates of estimated return.

An impressive list of authors and speakers have concluded that innovation is lagging in the United States. Reaching a conclusion like this implies that some means are available to measure it. The basic scientist, for example, is prone to judge the health of the innovation process by the size of the federal basic research budget. But, if you are willing to accept a composite of several indices, it is difficult to escape the conclusion that, whereas the 1950's and 1960's were periods of spectacular growth, the mid-1970's have been marked by serious decline. This conclusion is confirmed by downward trends in several indicators ranging from R & D expenditures in constant dollars to issues of common stock in small technologically intensive companies. The proceedings of the National Academy of Engineering Thirteenth Annual Meeting on "Innovations and Entrepreneurs - An Endangered Species" contains a comprehensive summary of these indicators showing their trends.

The ultimate indicator of innovation is productivity. In a little noticed sentence in the 1978 Economic Report of the President, the Council of Economic Advisors stated that the slowdown in productivity growth is "one of the most significant economic problems of recent years." A deceleration in U.S. productivity growth has been underway since the late 1960's. During the first two decades following World War II, output per man hour in the private business sector increased at an average rate of 3.2 percent; during the most recent decade, the rate of increase dropped by one-half, to 1.6 percent a year and more recently to 1.1 percent. This slowdown in growth was fairly pervasive throughout the economy. About two-thirds of the 62 industries for which the Bureau of Labor Statistics reports data showed lower productivity growth for the last decade than for the previous one. Some industries not only decreased in growth but also in absolute value. The level of productivity in coal and iron mining declined during the past decade. After two decades of rapid improvement, productivity in coal mining turned downward at a rate of 4 percent a year. Productivity in iron mining declined only slightly, but this represents a reversal of its previous growth rate. These changes are especially significant because they raise the real cost of raw materials essential to other major industries and are negative contributions to our problems of inflation and of energy supply.

The importance of innovation in spurring future U.S. economic growth is further underscored by the birth-rate decline since 1960. As a result, the work force is expected to increase only about 1 percent per year in the 1980's. Unless this shortfall in work force, coupled with higher energy prices, can be offset by innovations in labor and energy productivity in the U.S., output will fall below its historic trend rate of 4 percent a year.

Technological innovation was for many years primarily an industrial activity, intuitive in nature and self perpetuating. Many successful companies survived for years on the single inventions of their founders. Now government, universities and industry are partners. Their roles are increasingly interdependent. Whereas there has often been a relationship of suspicion and hostility among them, a mutual understanding and willingness to work in harmony will be necessary if innovation is to grow in the future.

Important innovations in modern industry are the result of a commitment to R & D over a long term. By this I mean a commitment to the nurturing and replenishment of scientific and engineering personnel as well as the capital investments required to carry out R & D and construct new facilities. But only a few companies are known that are willing to support R & D long enough to accomplish major innovations. It is clear that innovation in our free enterprise system will prosper only if a climate exists to encourage industry to invest in longer term objectives - to somehow make these longer term investments as attractive on the balance sheet as the shorter term.

The most troublesome deterrent to the longer term investment required for innovation is uncertainty. Changing government attitudes, policies, regulations and laws foster much of the uncertainty. The effect is one of creating a cyclical feast or famine job environment for engineers and a shortening of the time scale for business planning from the ten years required for most innovations to two or three. Company directors are less concerned about the nature of government policies than they are about the prospects for shifts after long-term commitments are made. They can work around known policies, but are unable to foresee the new ones. Today's industrial manager is shelled from all sides by so many new local, state and federal rules that he tends to take on a fox hole philosophy and steer away from commitments that can't be consummated in a relatively short period of time.

Although the role of government in the innovation process is pervasive and overwhelming, federally funded and guided R & D cannot provide the initiative in commercial product development as it does, for example, in military procurement. It lacks focus and connection to the ultimate user. What can be done federally is support of basic research as well as the development and demonstration of selected civilian technologies. For example, significant improvements are still possible in the fuel efficiency of in-use systems, such as automobile piston engines and aircraft gas turbines, through improved understanding of the internal processes of combustion and fluid mechanics obtained through relevant basic research. This is the kind of long-term high leverage investment which is appropriate for government support and welcomed by industry and the universities.

Government has also been successful in fostering technological development by requiring performance specifications in government procurement. The success was most noticeable in the military aviation, space and atomic energy fields. This practice could be profitably extended to government procurement of commercially related products such as trucks, energy converters and like devices.

In my opinion, closer cooperation between engineering schools and industry will be absolutely necessary if more innovation is to be achieved. Like the Japanese, we should not be reluctant to acquire advanced technologies developed abroad. New ways are needed to diffuse technology among institutions and improve communication among different groups in the innovation process. Finding common ground among the scientists, engineers, inventors, manufacturers, distributors, users, government and others in the innovation chain is a challenge; they pursue different and often conflicting goals, and they are motivated by different incentives and rewarded in different ways.

Just as research and development stimulates innovation, capital investment translates the product or process into marketable commercial products. Like the demand for engineers, the rate of capital formation is closely tuned to the economic climate and in periods of prolonged inflation the rate is disappointingly slow.

The recent U.S. record of capital investment is as disquieting as that of innovation. The rate of growth of the capital-labor ratio, which is a measure of capital investment, has slowed alarmingly. The capital-labor ratio increased at an annual rate of 3.0 percent during the 1947-1967 period; during the 1967-1973 period it declined to 2.5 percent a year and then to 1.3 percent during the 1973-1977 period. Since this is a regional conference you will wish to look at the regional performance and compare it with national figures. Massachusetts is a poor capital investment performer. Since 1970, real capital spending in Massachusetts has declined by 20%. At the present time, Massachusetts, with 2.7% of the nation's population, is generating only 1.2% of its new investment.

Real fixed investment in plant and equipment is lagging behind the 10 percent annual rate of increase the Carter administration estimates is needed to bring the economic recovery along a balanced path to full employment as well as to meet the capital requirements of the 1980's. The average increase has been less than 3 percent a year since the early 1970's. An obviously important factor in this weakness is the continued low rate of capacity utilization which discourages new investment. Of importance to this conference is the fact that the most serious aspect of the investment lag relates to energy. Capital investments now being made by business and government are grossly under those required to achieve some measure of energy independence by the end of the century. For example, an investment of 15 billion dollars a year over the next decade in energy-saving plant and equipment would result in enormous savings in energy by the end of the decade. Without this investment and the greater independence from foreign supplies and price-fixing that it will provide, we will surely witness a humiliating and devasting degradation in the standard of living of Americans as we approach the end of the century.

The rate of capital investment in the United States in the past 20 years has been lower than that of other industrial nations with high productivity growth rates. The United States now trails the major western industrial nations in the percentage of total output invested in new factories, machinery and other facilities. Japan, with 29 percent of its total G.N.P. invested, leads with the United States in fifth place at 13.2 percent. This difference, to a great extent, reflects these countries faster economic growth, lower unemployment and higher capacity utilization, as well as tax and other government policies that favor capital investment as compared to consumption.

The changing composition of capital expenditures in the United States is worth noting. It has shifted in two respects. Larger amounts of the dollars invested are earmarked for meeting environmental and occupational safety and health requirements and, in general, satisfying federal regulations. Investments in capital equipment for environmental purposes now account for about 9 percent of investment outlays in the manufacturing sector. The second shift results from the sharp rise in the cost of energy after 1973. This prompted industry to invest more heavily in energy savings equipment and facilities. Indeed, the latter trend is beginning to show a reduction in the ratio of energy to output. Elementary economics tells us that as energy becomes more expensive we should begin to see a substitution of labor and energy-efficient capital for energy-intensive capital. Recent trends confirm that this substitution is beginning to take place and that it is at least part of the explanation for the reduction in U.S. unemployment. It is worth pointing out that although the nation is doing very poorly in terms of raising labor productivity, the exigencies of increasing energy prices are beginning to force improvements in energy productivity.

With the reduction in the attractiveness of long-term investments, small technically based companies - long a major source of product innovation - face increasing difficulties in raising capital for start-up as well as growth. It is claimed that only 181 new small technological company stock issues were underwritten between 1973 and 1977, compared to 1,911 between 1968 and 1972.

The federal and state role in improving the climate for long-term capital investment is obviously of crucial importance. Ways must be found to allow accelerated depreciation on investments in major innovative programs, to make the investment tax credit more effective and to encourage small technically based companies and venture capital enterprises. It would also be helpful if the federal government could reform its regulatory system by eliminating, simplifying and coordinating its rules and regulations. As a resident of this region, I would mention particularly the need for federal licensing reform for nuclear power construction. Without compromising safety, the 10-12 year lead time necessary for reactors could be cut a third or more by eliminating needless red tape -- saving money as well as critical time.

We are about to begin a conference on the regional implications of the engineering manpower requirements of the national energy program. The conference is designed to confront the problem of maintaining the quality of human resources in engineering. Its purpose is to examine in a regional microcosm the engineering manpower problem, if any, in specific context with the emerging national energy problem. You will hear speakers with different points of view, take part in workshops and at the end draw your own conclusions. Your collective wisdom will form policy advice for the sponsoring groups of the conference.

I would be foolish to anticipate your conclusions, but I would be deficient as your keynote speaker if I did not start you off with my perception of the importance of your task.

Scientists and engineers will be absolutely crucial in the struggle for improved productivity and new and improved sources of energy. I claim that our particular society will rise or fall during the balance of the century, depending on the quality of its engineering manpower and services. I claim also that this human resource has been largely responsible for America's rising standard of living in the past and that its availability in the future cannot be taken for granted but must be nurtured along with other critical resources.

Last week Iran's new Khomeini government rejected the continuation of the foreign oil consortium but made a special plea for U.S. engineers to remain in Iran so that the oil industry and other essential technical services can continue to function. Here is a new government which is in a very shaky economic position, obviously hostile to United States and private sector interests in the Middle East, recognizing the value of U.S. engineering manpower in solving its current and future problems. But, a shortage of technically qualified engineers is rapidly matching the lack of available capital as a barrier to industrial expansion and energy development in the United States. If the nation somehow finds the will to make the capital investment in energy required to work out of our energy dilemma, a major shortage of technically qualified engineers will clearly develop. I purposely selected the phrase technically qualified engineers. I sincerely hope that engineering educators will, above all, do a thorough job of educating technically qualified engineers; that they will make graduates so proficient in the fundamentals of science and engineering that they can move from one field of engineering to another; that they will not yield to pressures to dilute further the technical proficiency requirements of engineering education. American industry now needs, above all, graduates with solid grounding in the fundaments of science and engineering who are motivated toward a career of technical achievement.

In your deliberations during the next two days don't forget that you are dealing with a problem of absolutely crucial importance to the future of this region and the nation. You must provide the leadership because it is not likely to be found elsewhere. Good luck!

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COLLOQUY, PART I

WHAT WE THINK WE KNOW

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THE OBJECTIVES AND THE PROCESS OF THIS COLLOQUY

Dr. Howard D. Segool, Director
COMTECH/School of Engineering
University of Massachusetts

Dr. Bisplinghoff has communicated a great deal of integrated information, a sense of responsibility, a sense of urgency and a target, several targets, at which to shoot. We are grateful that he has joined us to provide a background of national and world dynamics within which we must find our way, and to inspire us to our task.

My job now is to try to focus our orientation on what we're going to do this afternoon, this evening and tomorrow. We are about to engage in something resembling the traditional New England town meeting on a subject and against a world backdrop that is indeed even more ominous than when Nathan Becker and I first discussed the engineering manpower question with ERDA officials in early 1976. At that time the crisis seemed to have receded from the precipice of October, 1973 when the Mid-east oil producers not only cut their output and embargoed shipments to the United States but nearly quadrupled crude-oil prices overnight.

You will recall that when the dust had settled and supply rearrangements had been made, the United States found that it had fallen into its deepest economic recession in 40 years. During 1974-76, however, various adjustments had occurred and our economy had made a somewhat respectable recovery by late 1976.

However, the crisis circumstances never really did disappear. Instead, a chronic condition replaced them. Whereas in 1973 the U.S. dependency on imported oil was 37%, today it is nearly 50%. Whereas our imported oil bill in 1973 was $8.1 billion, today it is over $40 billion annually. And there is certainty that it will rise in stages by at least 14-15% during this year with the expectation that a 20% or more annualized rise is most likely, due to the immediate turmoil in Iran and its repercussions.

For an industrialized society such as ours, an energy crisis of this magnitude translates into a crisis of survival. Our focus on Southern New England, one of the great industrial and population concentrations of the Nation, as well as its most dependent region vis a vis imported oil, will serve to magnify the worst aspects of the national dilemma.

As our region proceeds to cope with its share of the problem of national survival, certainly at front and center stage will be our engineering resource that is applicable to technological fixes in areas of energy production and conversion, in energy transportation and distribution, in energy conservation and utilization, in the associated problems of environmental preservation, and in all the machinery and equipment, process, structural and architectural, and instrumentation design, manufacture and construction that will be required to rehabilitate, retrofit and replace our capital infrastructure and manage it efficiently.

The aim of our colloquy is to lay a basis of understanding among us regarding the apparent magnitude of the job to be done and of the engineering resource we have or can expect to have applicable to its doing, as viewed through the eyes of informed representatives of industry, of education and of government, which are society's principal agents for getting it done.

When the subsequent workshops deliberate their issues, they will want to know:

- How sensitive is the New England economy to alternative energy policy elections? What impacts do alternative policies suggest for our capital and engineering intensive industries?

- What do our state and regional energy program specialists see as appropriate roles for their states and for the region in the energy program as it is currently defined? What demands do these roles suggest will be made on the engineering manpower resource?

- What specific technology initiatives can be anticipated? What opportunities do they represent for our economic base? What are the implications for engineering manpower demand?

- What does the big picture of engineering manpower demand and supply look like?

- What does the state and regional picture of engineering manpower demand and supply look like? Are we really equipped to know?

- Is there a recognizable demand/supply delta? Is it consistent with the magnitude of the engineering job to be done? What parameters need to be considered in reducing the delta?

- How does engineering manpower demand/supply behave in the marketplace?

- What is an engineering manpower demand/supply intelligence system?

Our program is planned to inform us as comprehensively as possible regarding the outlook on each of these and on related questions.

In total, each of us will decide, before he goes into his workshop, the extent of reliability, the extent of reassurance, the extent of comfort we feel with the evidence this Colloquy portrays as to the capacity of our region to deal with its survival.

The workshop responses will tell us that next we must do.

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INTERRELATIONSHIPS OF ENERGY POLICY AND THE NEW ENGLAND ECONOMY[1]

Mr. Edwin Zeitz, Director
Rates and Research
Massachusetts Department of Public Utilities

INTRODUCTION

Let me try to provide some of the economic background that I think is part of a look at what engineering manpower requirements in New England are going to be. I think I'm one of those economists that Dr. Bisplinghoff mentioned and I would certainly say that innovation is good. Perhaps I can give you some kind of insight as to why economists think innovation is good, why productivity has slowed down in the last few years and some of the factors that are driving the relationship between energy and the economy.

We have come together here to address a relatively detailed question: How a changing world energy situation, and our National Energy Program, will affect engineering manpower requirements at a regional level. In my talk, I will attempt to provide some of the conceptual framework which I believe should surround such an inquiry. We are all aware that the changing energy picture has had, and will continue to have, significant effects on the national and on the New England economy. As principal investigator for the New England Energy Policy Alternatives Study I have had the opportunity to examine some of the important interrelationships of energy use and the New England economy. In this study we attempted to forecast the economic effects of different energy policies and scenarios in New England. The simulations we made provide some insight as to the likely effects of the National Energy Program and give some magnitude as to regional engineering manpower requirements.

Virtually every good or service we purchase contains an energy component. As you all know, energy is a pervasive and necessary factor in our economic system. Thus, increasing energy prices and supply constraints in particular fuels, which go hand-in-hand, have had and will continue to have significant effects on our economy. In a recent article Professors Edward Hudson and Dale Jorgenson estimated the effects higher energy prices have had on the U.S. economy. They estimated that the

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[1] The opinions presented here are strictly those of the author. No official policy inferences are to be taken by the U.S. Department of Energy which funded the referenced NEEPA research, any State Energy Offices or the Department of Public Utilities.

average energy price increase which occurred between 1972 and 1976 (from \$1.57 to \$3.22/10^6BTUs) alone had the following effects on the 1976 economy: GNP was reduced by 3.2%; energy consumption was reduced 8.8%; and the demand for capital services was reduced, resulting in a reduced capital stock of \$103 billion (1972\$). This last item is the kind of lag in capital investment to which Dr. Bisplinghoff referred. Let us examine the nature of these effects, and the manner in which the economy adjusts to higher energy prices. It is here that we can determine those forces which will drive an increased demand for engineering manpower.

MICROCOSMIC VIEW OF ENERGY SUBSTITUTION

Since only a few of us here call ourselves economists, a brief discussion of some basic economic principles is in order. Rather than present a description of the model used in the NEEPA study to estimate economic impacts and forecast energy demands, I will present a microcosmic view of the economic forces resulting from higher energy prices. (I shall be glad to answer any questions regarding the design and use of this model, a description of which was recently published in the New England Journal of Business and Economics. For those of you who may be interested, let me say, by way of description, that the model, called the New England Macro-Economic Energy Model (or NEME), is a regional version of the Hudson-Jorgenson model mentioned earlier. It is an "Input-Output" model with particular detail on energy use. It incorporates behavioral parameters estimated for New England and can simulate specific energy use scenarios.)

Let's consider a simple production example such as the manufacture of wooden blocks. There are undoubtedly a variety of mixes of capital, energy and labor that could be used to produce these blocks. For instance, if we start with cutting down the trees, we could use a fairly low capital -, low energy - intensive process, using axes and quite a lot of labor. At the other end of the scale, we could use massive chain saws or even heavier equipment which would be more energy -, a lot less labor - intensive. Similarly in other unit operations of the manufacturing process. Typically and historically, we find that in most production processes as you increase the amount of capital used you increase energy use also. If the significant change in a national economy is a change to higher energy costs, one adjustment that might be made in production processes would be to invest more capital in ways to save energy, if and where such efficiency options exist.

The dependence of the efficient use of capital on energy costs has led economists to look at the combination of capital and energy as something called "capital services". In terms of the cost of capital services they find that as energy costs increase the cost of capital services must always increase unless there are innovative changes in technology. That is why innovation is so important because, without it, a shift to greater capital intensity — the characteristic of a thriving industrial economy — will always result in an increase in the cost of capital services as energy costs rise. Energy-efficient, innovative capital is a requirement of a healthy economy in such a situation.

The significance of this has been illustrated by recent events in the U.S. — a shift in labor demand along with a large reduction in demand for capital services. Even though the GNP fell by 3.2%, employment fell only half a million, a fairly small decline compared with a substantial decline in the output of the economy. In the short run, labor tended to substitute for capital services.

Pursuing this line of thought, we can recognize several important principles to be kept in mind as we move on to discuss the interaction of energy and the economy:

1. Capital, labor and energy are substitutable in virtually every production process, the alternatives being defined primarily by technology but also by the availability and cost of investment capital, labor and energy.

2. The nature and quantity of capital used throughout the economy is a primary factor in determining the type and quantity of energy used.

3. Very little capital is employed productively without an energy component; virtually all capital usefully employed in the economic system requires energy. The cost of used capital, called capital services, includes the cost of capital and the cost of energy.

4. For a production process at an optimal mix of capital and energy, a rise in energy prices must result in an increase in the cost of capital services EXCEPT for the occurrence of favorable technological change.

5. Labor will not substitute for energy in a direct sense but rather in the sense of substitution for capital services. This labor substitution is not what we call engineering manpower, which rather is the manpower employed in the development of new more energy-efficient capital stock or in the more energy-efficient modification of existing capital stock.

ENGINEERING MANPOWER MARKETS

From the preceding, we see that one principle of economic behavior is primary in determining the size of the energy-related engineering manpower market. The ability of the economy to substitute capital for energy and to invest in more energy-efficient capital will strongly influence future engineering manpower requirements in the region. The results of the NEEPA study indicate a significant potential market for energy-related capital investment.

In this section, I will describe some of the specific factors influencing this capital investment market in New England; and our estimates as to the magnitude of these investments.

While engineering manpower requirements associated with specific investments will vary considerably, these figures should provide some guidance as to the size of the energy-related engineering manpower market and the effects of government programs on this market.

The remainder of this century will see significant transitions in New England's economy and energy use patterns. This period presents considerable uncertainties in energy supplies. The only certainty is higher energy prices, and even here the rate of increase is uncertain. The transition in the way energy is used in our economy, and even in the forms of energy used, will step up engineering manpower requirements. The actions of the federal and state governments, through programs such as the National Energy Plan, will generally tend to accelerate the rate of adjustment, further increasing the need for engineering manpower.

The opportunities for energy-related engineering are naturally divisible into those aspects associated with energy supply and those associated with energy demand (use). In general, the higher energy prices of the future will provide opportunities for engineering innovations probably second only to those of the industrial revolution itself. The increase in oil prices - the predominant energy form for New England - provides an opportunity for new energy forms (and some older ones) to become cost competitive. I am sure most of you are aware of the many energy supply alternatives currently being investigated. Since many of the supply alternatives are quite long term, markets for engineering manpower in several supply areas will develop somewhat slowly and for the next ten years will probably be confined to basic research. Since the NEEPA study only considered simulations through 1985, only a few supply options had a potential of any significant penetration and those considered had few significant economic effects. The supply options which might be considered for the near term in New England include: cogeneration, coal, solar, low-head hydro, wind power, and wood. Nuclear engineering manpower requirements are well defined by the electric utilities' construction plans, though government policy could increase or decrease this market.

SUPPLY ALTERNATIVES

In the NEEPA study, we considered cogeneration (which is also a demand alternative, in the sense of conservation), increased coal use in manufacturing industries, and active and passive solar energy for heating and hot water in the residential and commercial sectors. Government policy and several aspects of the National Energy Plan will influence the development of these supply options. Since one government objective is to reduce oil use and New England's oil dependence, we estimated the penetration level on an economically efficient basis. Thus, any savings in oil costs is offset by increased capital costs for the alternative supply.

The National Energy Plan provides several features which will stimulate the development of these markets. Tax credits will subsidize these markets and regulatory changes may make it easier for cogenerators to sell power. It is difficult to predict how quickly new energy supply technologies will be adopted. The following economically efficient estimates will provide a ball-park idea of the size of these markets in New England.

The cogeneration option probably has the largest potential with total investments approaching $800 million (1985$). I would imagine the engineering manpower required to install 1679 megawatts of cogenerating capacity (1985) to be quite substantial. These figures, which are fairly large, are based on estimates made for Massachusetts by the Governor's Commission on Cogeneration, and would permit companies investing in cogeneration equipment to earn an 18% after-tax return. With more efficient cogenerators providing roughly 6% of New England's electric demand, total energy use would fall nearly 2%.

If New England manufacturers increased coal use to the pre-air quality standards levels of the late 1960's, they would quadruple their projected coal use in our base case. Again, federal tax credits will stimulate this market though the cost of meeting environmental standards may continue to be a problem. However, engineering manpower will be required in the emissions control areas. Coal could make up roughly 10% of manufacturing energy use.

Tax credits for solar power are fairly generous. The penetration figures used in our simulations were provided by the Massachusetts Solar Action Office. A great deal of the energy contributed here is in the form of passive solar and as a consequence would be incorporated in new buildings at no additional cost. These figures indicate an investment of $80 million in solar hot water heating equipment in both commercial and residential applications. These applications of solar power could provide nearly 2% each of the commercial and residential sectors' energy demand by 1985.

It remains to be seen how the tax credits of the National Energy Plan will stimulate the development and use of alternative energy supplies. New England's potential development opportunities on the supply side are significant, approximately 16% of total demand. However, there may be considerably greater opportunities on the energy demand side of the economy. As energy prices rise powerful market forces come to play which shift the way in which energy is used in production processes. Higher energy prices make virtually every production process, and every piece of energy-using capital, an opportunity for engineering innovation.

DEMAND CONSERVATION

The majority of New England's capital stock - machines, buildings, housing appliances, etc. - was designed with a certain set of parameters in mind. One of these, the price of energy, has changed. The opportunity exists to redesign all new capital to conform to the new parameters. There is also the opportunity to develop devices and methods for improving the energy efficiency of the existing capital stock. There is not only an opportunity here but a chronic need for innovative engineering approaches to using energy efficiently. As I shall discuss further, economically efficient conservation potential can create vastly superior economic outcomes. The more innovation we can find here the more we can move our economy forward.

The extent of the effect of the NEP tax credits will have is uncertain. We are able to estimate the effects market forces alone would have and these are incorporated into our base projections (Exhibit 1). However, if the NEP together with state energy programs could achieve what we consider high conservations levels - roughly 30%, the 1985 New England economy would gain at least 50,000 jobs, and have a 2% higher GRP. That number of new jobs corresponds with a 1% reduction in the unemployment rate, a significant number.

I do not believe existing programs will get us that far. They may get us as far as our 20% conservation scenario (see Exhibit 1) roughly half-way between the 10% conservation resulting from market forces (see base projection, Exhibit 1), and the more than 30% which we think is economically attainable. The tax credits will contribute a 4-8% conservation, roughly estimated, in addition to base case market conservation of 10%. Those tax credits combined with state energy programs and building and lighting standards may bring total energy savings to 20%, representing a GRP increase equivalent to about 33,000 new jobs and a reduction in oil consumption of about 63 million barrels.

In relating conservation potential to engineering manpower markets, there are, then, two outcomes to consider: A strong conservation case attaining perhaps a 30% savings in energy, and a weaker conservation case, attaining a 20% energy savings, representing the likely effects of government actions. As with the supply section, the total investment required to attain the simulated conservation is my best indicator for the size of the market. In the following, the lower number corresponds to the weaker conservation case. The commercial conservation market ranges in capital investment from $1.7 to $2.4 billion (1974$); industrial conservation from $1.3 to $1.6 billion (16%-20% conservation) and residental $.9 - $1.2 billion. A total near term conservation market in New England of at least $4 billion appears reasonable, with a significant portion going to engineering manpower. We believe such investments could be put in place by 1985 presuming, of course, that the human and non-human resources are made available and are allocated.

To summarize, then, what I see as the principal factors to keep in mind when considering the interrelationships of energy policy and the New England economy and the region's engineering manpower requirements:

1. There are two energy related markets which may require engineering manpower: development of supply alternatives and energy conservation. These markets exist due to higher energy price and the forces which direct the economy to adjust to those higher prices.

2. Government programs and policies will affect the rate at which these markets develop. On the supply side the NEP will have stimulative effects of uncertain magnitude, and may permit marginally economic supply technologies to gain early market penetration.

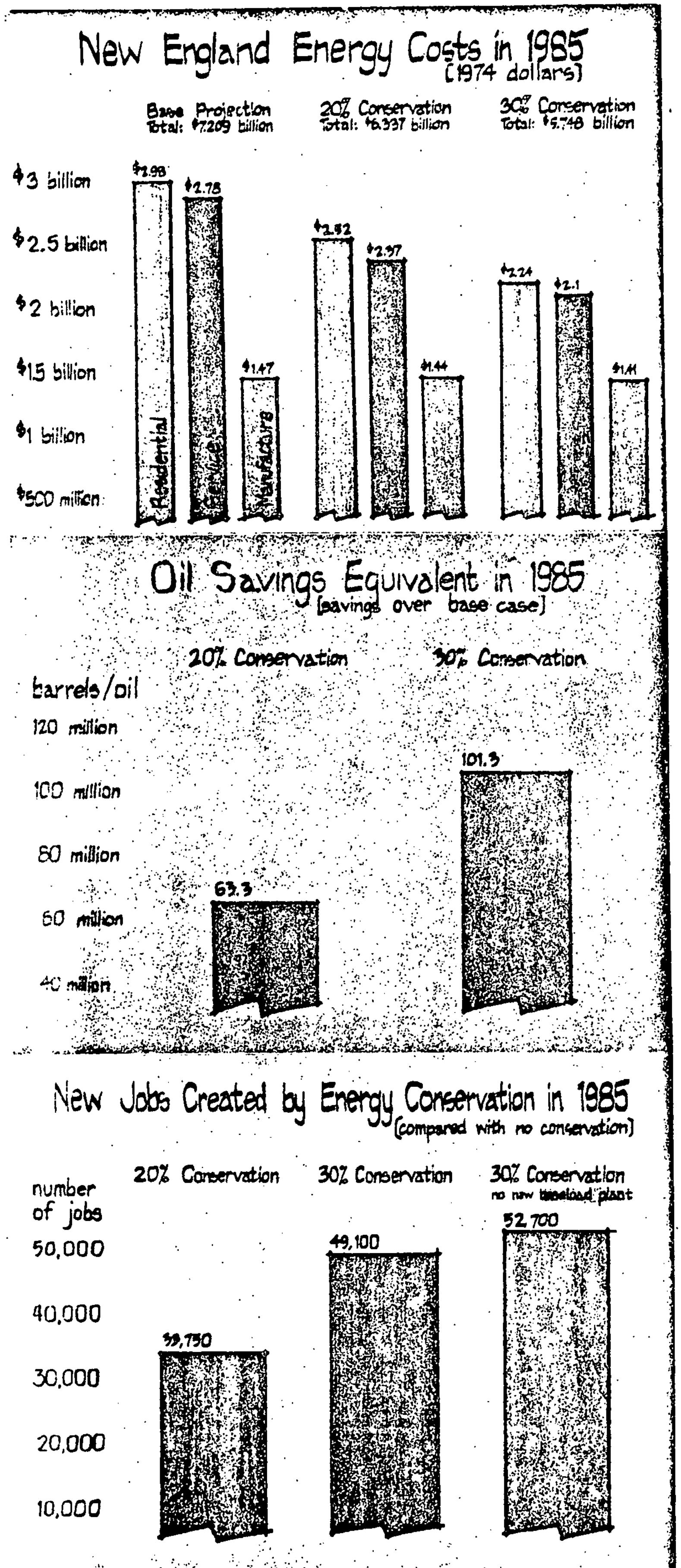
   On the other hand the National Energy Plan and State Energy Programs may double the size of New England's conservation market compared to what it would be if left to market forces alone.

3. The energy conservation market in New England is much larger than the alternative-energy supply market (4 times) through 1985. Depending on the engineering requirements of these markets this would indicate larger near term engineering manpower requirements in the conservation area, perhaps shifting towards alternative supply development in the longer term.

I am very glad to have had the opportunity to speak to you today. Personally, this Colloquy has already been a success. I do not think I had fully recognized the importance of engineering manpower in the economy's transitional adjustment to higher energy prices.

Engineering manpower is important not only in a quantitative sense but also in a qualitative sense. As our simple economic example showed, the economy's long-run response must be to substitute capital for high-priced energy without increasing the cost of capital service. This is true whether the additional capital is to allow use of a different energy form or to increase the efficiency of energy use. It is the engineer who will be responsible for developing these new capital substitutions. Innovative designs can have a very significant effect in smoothing an economy's transition to high energy prices.

Figure 1


New England Energy Costs in 1985
(1974 dollars)
Base Projection Total: $7.209 billion
20% Conservation Total: $6.337 billion
30% Conservation Total: $5.748 billion
$3 billion
$2.5 billion
$2 billion
$1.5 billion
$1 billion
$500 million
$2.98
$2.78
$1.47
$2.52
$2.37
$1.44
$2.24
$2.1
$1.41
Residential
Oil Savings Equivalent in 1985
(savings over base case)
20% Conservation
30% Conservation
barrels/oil
120 million
100 million
80 million
60 million
40 million
63.3
101.3
New Jobs Created by Energy Conservation in 1985
(compared with no conservation)
20% Conservation
30% Conservation
30% Conservation
no new baseload plant
number of jobs
50,000
40,000
30,000
20,000
10,000
39,750
49,100
52,700

A PANEL

PERCEPTIONS OF THE REGIONAL ROLE IN THE NATIONAL ENERGY PROGRAM

by

Sister Claire Markham
Immediate Past Undersecretary for Energy
Connecticut Office of Policy and Management

As I see the National Energy Act, speaking from the Connecticut Office viewpoint, there are several things which have not yet come into national energy policy legislation for which we feel that, as a region, we should argue more forcefully.

One thing that seems apparent is the lag in the development of solar energy, which surely in Connecticut we would want to look toward for supplying a good part of the energy needs of residential and commercial buildings, the heating needs at least. There's a difference in the way it's being subsidized and what we have for other forms of energy. Oil, gas, nuclear are subsidized at the supplier/producer end, but solar is attempting to get in by being subsidized at the user end, which means that the consumer has to put up the front end money. I know that tax credits are a help but, nevertheless, I find that people are very hesitant about this. It means an investment without seeing all around you that it's working well -- there aren't that many examples yet of how well solar energy is working.

Just to give you an example, in December I went to the opening of some solar condominiums at Summerwood in Old Saybrook, down at Sandy Point in Connecticut. The developer was Nolan Kirschner, Eric Wormser was the designer. They were putting up 75 condominiums which were already on their way before they got a grant to add solar space and hot water heating to 7 of them.

When I was there, a rainy day in December, the fourth day of rain we had had in a row, the condominiums were still being heated by solar energy that had been stored from the previous Wednesday, the last day of sunshine. The temperature was a nice comfortable 68°. Now granted, they had had workmen in and out Thursday and Friday, probably keeping the temperature at 55° for those two days, but nevertheless the stored heat was still there, ready to come on again on Saturday. Nolan Kirschner said that to get the solar system onto those 7 condominums required enormously more planning than to put up the whole 75 with the rest of them on heat pumps. There were any number of reasons. To add insult to injury, all of the other condominiums had been taken except those 7 solar ones.

So, between the planning for financing and the planning for solar systems there is little confidence that a building inspector can okay a design and that it will work and he won't be liable for it. The whole business of managing the solar rights and property deeds etc., all pose barrier after barrier to getting this in place.

I don't think that we can argue too forcibly, from our vantage point in New England, for increased funding for the regional solar centers that are supposed to assist in the commercialization of solar energy. I just don't see anywhere near enough of it going on. Virtually nothing for low cost housing development where the enterprise cannot come from the consumer, the user.

I think we need a lot more research in advanced solar systems. I used to think that solar energy would come in first probably in the southwestern part of the United States, but I don't think they have that big an advantage any more. We have two-thirds as much solar energy in combined duration and intensity.

There are cogeneration systems that are very attractive. For example, the new types of roof shingles that are being experimented with which would produce some electric power. These offer better roof cooling and can supply heat at the same time. I think we have distinct advantages for systems of that kind.

I think we need a lot more research and to continue to develop and subsidize suppliers. We need basic research on materials to bring those costs down.

Regarding manpower needs, I think there's a real need for more experimenting, more research on hydrogen technologies. I think there's a need for research and development on such things as photo-assisted electrolysis of water, for example.

The advanced nuclear systems are, of course, another whole area where the manpower need is very great. It seems to me that nuclear engineering has, if anything, been deemphasized in most our our academic institutions during the past decade, probably because of the general unpopularity of nuclear systems. Now I'm not sure that it's going to be all bad that we didn't rush into the types of breeders that were being proposed a few years ago. I think there are much more promising systems that are being explored, can be developed and do need more research: different kinds of fuel cycles; combinations of fuel generating centers, which may be few and far between and heavily guarded, that will generate fuel such as thorium, uranium and mixed types, not plutonium. I certainly don't think that the technology that, at least reportedly, is going into place in Russia looks like something we would want to duplicate here. In that and in nuclear fusion, which I surely hope eventually, at least in the next century, will give us many preferable alternatives, there are a lot of research and manpower training needs right now, but I don't think there is anywhere enough investment.

I can't fail also to say a word about what I think is needed in order to really make it possible for more women to become involved in some of these advanced technologies. I don't think any of the NSF programs for women in science are really aiming at the right group yet. They're aiming at college students, and this is fine. Where you have college students in scientific programs you may be able to strengthen their resolve to stay in them. But you're not going to get more women thinking about them by aiming at that group. I think it's at the junior high school level, and in the effort to give women more opportunities to explore mathematics and basic sciences at that level that emphasis is really needed to turn around our whole societal concept of whether women have much to contribute to these fields except just by the chance that an exceptional one gets into it.

We have, I think, in New England a relatively smaller amount of industry on the whole than the rest of the country. I know Connecticut is about 18% compared with some 35-36% for the county as a whole. What we have is a large component in really high and mixed technology and I know that the industries in Connecticut are very concerned that people who are applying for jobs cannot pass 9th grade level reading and arithmetic proficiency level exams, and so forth. I think there are a few good experiments in process like the one between Hartford/East Hartford High Schools and Hamilton Standard, which is part of United Technologies, where they have an optional program, a kind of pre-apprentice program, which Hamilton runs after hours, like 5 to 9 at night. I think this ought to be watched. I don't think it should be an option only for students who are in non-academic tracks. I think that some of our young people who are going to supply our engineering needs, highly specialized needs later on, would also profit by an opportunity to see what is really going on in some of these high technology industries, to think about it and to begin at an early age to collect ideas of how it might be done differently or better.

Looking at the whole picture of manpower needs, I don't think we should forget those lower levels, although I certainly think that we need a lot more support for university, academically orientated research and certainly for the engineering schools.

Those are a few of my perceptions.

<u>by</u>

Mr. Edward Brodzinsky, Assistant Director
Massachusetts Office of Energy Resources

As with nearly all workshop sessions that I've attended recently, I fully expect to learn much more than I'm going to be able to contribute. I'm not an expert on energy. There are very few experts on energy since, as we've come to know it, energy is a new field. Most of us are reconverted something elses. We've heard reference to the 90-degree turns that I'm sure everyone in this room has made at least once in his career. I've made my own 90-degree turns -- I happen to be an architect.

I think that perhaps most of the people in this room are engineers. The energy field to-day includes economists, biologists, physicists -- virtually every technical field there is has some input to make into what we group into the term "energy". My point is that in the energy field and among the manpower that currently makes up its workforce, are people who probably, for the most part, did not start out with a career in energy in mind. I think that's okay. I think its very healthy that this is a very cross-discipline field. It's a new field that's being fed from many and diverse sources of manpower. I think there's a potential for synergistic effects to happen, that the sum total of all our expertise is probably going to provide something much greater than each of the separate parts.

From my perspective as Assistant Director of the Massachusetts Office of Energy Resources, in charge of commercial extension services, I can see several different roles for professionals in the field of energy. There's the auditor role, a role that virtually did not exist five years ago. These are people who have to be able to look at an existing building or an existing set of construction documents and analyse where and what energy problems are there and how to solve them. You get into real problems when you have nuts-and-bolts people on one side versus theoretical designers on the other. I think there are lots of ways of solving that problem. We have contractors to our office, for example, who have formed joint venture amalgamations in order to solve a specific problem we may have elaborated in a Request for Proposal.

Then there's the whole area of design professionals themselves. The question of how you design a building for energy efficiency didn't exist a few years ago. I always find it interesting when someone says "Look at that building that was designed 10 years ago. That architect, that engineer must not have known what he was doing. I mean, obviously that building isn't efficient." The point is that there were different standards then and that new building may have been perfectly acceptable 10 years ago, but isn't now. We have new standards.

Most of you have probably heard of BEPS, building energy performance standards, which are about to be promulgated by the U.S. Department of Energy together with HUD. These are standards for energy performance in a building. Most designers, most architects and engineers in this country have never designed to a performance standard. Europeans have. This has been a fairly common design approach for 15, 20 years already. The point about BEPS is that here's a whole new aspect of design that design professionals are going to have to learn about and deal with.

A third area that I think has a new importance in our world is the educational role, the training of those engineers and architects, the training of government employees, to know where special efforts need to be put.

Let me talk briefly about a few programs that are in our Office to give you an idea of things that we see as important. Most of you have probably heard of the schools and hospitals program which is about to go into gear. DOE is about to make $900 million available to the states to retrofit existing building for energy conservation. I daresay that overall that's a big chunk of money to be trusting to the building construction market. If there are design professionals out there who aren't aware of energy conservation, and if they want to have a piece of that action, they are going to have to learn about it.

We have other programs in our Office whereby we are hoping to foster some demonstration projects in various conservation technologies, focusing mostly on state facilities. We have a commercial building audit program in which we try to address a number of different sections and the quite specific problems that certain building types have, i.e. retail stores, office buildings, churches, schools, hospitals.

To sum up, let me make my point again that I think there's a challenge here. Energy being a new field of concern, there are many new and unexplored opportunities for engineers and architects, opportunities for design solutions that aren't here yet but are going to have to be.

An architect friend of mine likes to tell a funny story that states the whole technological problem in a nutshell. Without belaboring the story, the punchline says that if you had never invented the sailboat you couldn't just stick a pole up in a canoe, hang a bed sheet on it and have something to rival a clipper ship. There are all sorts of nitty gritty design details that make the ship work.

The same point is true of energy. You just can't stick a group of collectors up on a house and say you've designed a solar house. There are many more basic changes that have to happen in the way we design buildings. That's the exciting challenge that I see.

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by

Mr. W. Robert Keating
Director, Energy Program
New England Regional Commission

I would like to thank you for inviting me to participate today in this colloquy to discuss the engineering manpower requirements necessary to help us address the national energy problem and New England's contribution to that solution. It's a pleasure to be back here at my alma mater.

As explained earlier to me, my role here today is to provide some insight into the regional role in the development and implementation of the national energy program, especially as it relates to engineering manpower needs.

While we panelists may focus on different specifics when relating our perceptions of the regional role, I believe we would all agree that the solution to the national energy problem does not lie in one document called the National Energy Act nor in one agency. Each person — each area of the country needs to and should contribute in its own way to helping us solve the current and long-term situation. Generally, society expects engineers to help develop solutions both directly through new technologies and energy production facilities and by providing the tools for our citizens to take individual or collective action.

With respect to the situation in New England, I must say that, both from the standpoint of policy and engineering, it is not only time but it is imperative that we lead in the development of new technologies. Currently, New England's energy costs (on a BTU basis) are 26 percent above the national average and New England has been constantly criticized for relying on other parts of the country and the world to meet its energy demand. These high costs and the lack of commitment to any specific energy resource development mean that New England has the most to contribute and the most to gain.

From the national perspective, because of our high costs, New England can become the commercialization testing ground to bring on new technologies while they are still in the cost reduction stages. Before technologies would be cost effective in other parts of the country, they would be cost effective here. (Hawaii, surprising parallel, is making great headway by being a testing ground for wind and biomass.)

Within New England, there is much to be done if our indigenous resources — wood, wind, solar, hydro etc. are to make a realistic contribution to meeting our energy needs. New, more efficient technologies and, in some cases, further research and development are needed if these resources are to be properly and effectively utilized.

In the area of wood, new harvesting, handling, processing, and burning technology may be needed if we are to see further growth in the use of wood in the residential and commercial sectors; industrial, plant, and combustion engineers need to consider and to be trained to assess wood-fired systems as well as those relying on oil, gas, and coal. At the Commission we are currently undertaking a program to inform people in the commercial section about the potential economic benefits of using wood and the technologies they should be considering.

For hydro, New England, with over 9000 possible dam sites recently inventoried by the New England River Basin Commission, needs reliable, cost effective turbines and "dam packages" for easy installation that will be responsive to the low-head flows. Much of this technology is already developed and is being used in Europe. However, American firms generally do not build or provide such technology.

Architectural engineers need to think solar and conservation when designing a building. Building placement and orientation, structural materials, etc. are all important. Again, groups such as NERCOM, my Commission, through our work with the Canadian provinces, and NESEC, the New England Solar Energy Center, are working to identify specifics and to educate designers and builders as to what is appropriate for the northeast.

In the area of wind, technology for interface with utility grids, standards for wind energy conversion systems (WECs) and siting, and problems in the maritime climate of icing and salt spray are all matters that need to be addressed. In this latter area, the Commission is working with the eastern Canadian provinces to establish a wind research test facility to help develop WECs appropriate to the northeast.

In a wide range of these and other so-called "alternative energies" we are seeing an increasing push toward the use of small-scale technology. Here we are basically talking about technology which can be applied by an individual or at a local level. Despite the traditional "do-it-yourself" attitude with this technology, engineers are still needed to develop systems that are easy to install, operate, and maintain. I believe we will see more of a demand for engineers who can design such devices.

With respect to the more conventional resources (e.g. coal, oil, gas, nuclear), if New England is going either to develop or continue to exapand our use of such resources, we will need to do so in an environmentally sound manner consistent with our other economic development priorities.

<u>What does all of this mean for engineers?</u> First, that solutions to New England's energy problems will require major engineering innovations and inputs; and second, that the implementation of these energy solutions will be accomplished through the political and social change processes.

In terms of what these trends mean for engineering education, they are, in many ways contradictory. On the one hand certain areas of research and development involve increasingly complex and innovative technology requiring highly specialized engineers while, at the same time, implementation and application of solutions in real world situations require engineers who understand other technical and social disciplines (i.e., growing crystals, photovoltaics, applying solar energy devices to homes).

The problem that we are currently seeing for energy is one that most people believe will occur for a wide range of resources. In the future, we will be seeing our engineering geared more toward better understanding of the science of materials; we will be looking at recycling, lighter and stronger materials, less energy-intensive materials, and materials which use renewable resources. We will also be interested in conservation; new conservation equipment, retrofit problems, new building and equipment designs, appliance standards, automotive standards, transit systems, etc. We will also be applying new technology to energy management; e.g., computer sensor charging of automobiles and computer monitoring of building fuel consumption. We will also see a totally new approach to problems. Where before we were constrained by "good engineering practice" or "standard operating procedures" the scientist and engineer will be given more of a chance to experiment and develop new approaches. Some people are already beginning to think that the problem of the automobile will only be solved with a complete rethinking of the power supply to the personal car.

Other areas where engineers will be needed include such areas as load management and energy storage. Since the more efficient energy is that which is produced at a constant level, allowing for optimization of all parameters, much of the interest in controlling electrical demand is in the area of load management. Similarly, when excess electricity would be produced if a plant operated at a constant output, there is need for developing storage capability for that energy.

Another area we will see engineers in is the tapping of waste streams. There is a lot of interest in recycling and energy recovery from municipal and industrial solid waste; there is also waste at the tail end of powerplants. Cogeneration and district heating are technologies currently already in wide use in other countries; they need to be adapted to U.S. needs. Similarly, technology may provide a solution to the use of waste heat from power plants drawing upon the technology being developed for Ocean Thermal Energy Conversion (OTEC).

Waste disposal will be another area where engineers are needed. How do we transport and dispose of the waste being produced in nuclear powerplants? This question has been asked for the past twenty years and the solution is still assumed to be ten-fifteen years off.

What the future demands is that the engineer must be more interdisciplinary. He/she must not only understand energy use and material sciences but he/she must also know how to respond to the public if his/her technology is to be accepted and used. Along this line, there will be a need for engineers who can understand technology and help it develop so that it fits with society's needs. Science, technology, and public policy are major up-and-coming fields simply due to the interdependence of these sectors.

It is not enough to train engineers who can devise technical solutions — although, as I have said, many new techniques certainly need to be devised — true solutions to New England's energy problems will require engineers who can communicate with political decision-makers and with the public. As our energy system enters into a period of rapid change and reorientation, it becomes more and more important for engineers, with their essential insights into the technological limitations and potentials of new energy sources, as well as using existing sources more efficiently, to be willing to enter battles in the political arena.

Politics and social change are not areas in which engineers are traditionally trained. Engineers, like much of the rest of society, find these realms frustrating and irrational. People simply do not respond according to any known laws of nature. But it is into this mire which engineers must wade if we are to solve the Nation's energy problems. As things become more complex -- as they clearly are -- there is a great temptation to retreat into the world of our speciality and assume that it is someone else's responsibility to implement the solutions we have devised in the laboratory. But unless engineers become intimately involved in the social and political processes which will ultimately shape the region's, and therefore the nation's, energy future, then the job will not get done.

In conclusion, I would just like to state that, although the National Energy Act signed last year by President Carter has often been referred to as the "lawyers' and consultants' relief act of 1978", a careful look at why the act was created and the implications of that act will lead one to the understanding that there is going to be a lot of work out there for the engineers too.

DISCUSSION

Question: I've heard quite a bit of general information, about engineering needs and needs for conservation and innovation etc.. My question has two parts. First, what base do you people use in coming up with these concepts? Is there some base that the government has determined which gives you something from which to build your projections? The second thing, has anybody in your organizations made an attempt to quantify how many engineers or groups or companies are going to be needed, or how much of what you're saying is going to happen? We seem to be heading in a qualitative direction, all agreeing that we have to do something, which I think has been a hallmark of the energy program to date. But I'm not hearing any hard numbers from anybody. I'm just curious if that's deliberate or if it's just to indicate we're not sure yet what we're going to need.

Response: With regard to your second question, my agency has not put together any quantifying parameters as to what the specific engineering needs will be in the future. I'd like all the members of the panel to respond to this part of your question, also.

With regard to the base from which we make at least some of our statements, in my case they come from my perceptions of the National Energy Act and what has been outlined, and on the funding authorizations and appropriations that are being made as we move along.

Response: I think we haven't gotten as far as forecasting engineering manpower requirements. I think we're at the point where we might begin to do that in that we have some idea of what kind of investment potential exists in the New England economy. Part of the reason I presented the magnitudes of various energy investment scenarios is that I think those are the numbers you start from to figure out how many engineers you'll need and get some idea of the potential. But to my knowledge, I haven't seen anything in the way of actual manpower forecasting. The U.S. Departments of Energy and Labor have a long term joint project to inventory engineering manpower requirements, and complete labor requirements for a variety of energy projects. There is some action at the federal level to identify manpower requirements but I don't believe that's directed at the regions in which we're interested.

Response: I think its a little premature to talk about those kinds of things in terms of numbers. One thing that is important to keep in mind as we speak to-day -- there are no energy engineers. There are mechanical engineers, electrical engineers, civil engineers, etc. etc. -- those are the people who are probably going to be doing the work, so we're not inventing a whole new group of people. We ought to start thinking in terms of how these individuals are going to fit into the kinds of work that is necessary.

Response: Before he had to leave, Dr. Bisplinghoff anticipated the question that has arisen and slipped me a note proposing that, for purposes of our discussion and in the absence of a well-defined base, we might adopt one or another benchmark, such as:

(1) What would the regional engineering manpower requirements be if we were to achieve a 10% annual rate of increase in real fixed investment, realizing that we have been averaging 3%, since this is the Carter Administration's goal for economic recovery?

(2) What would the regional engineering manpower requirements be if the nation made the investment necessary to provide 90% energy independence by the turn of the century?

In other words, he realized that in the absence of well-defined goals we will need to make reasonable assumptions to establish median and upper-boundary benchmarks on the requirements for engineers.

THE COMMERCIALIZATION OF SOLAR ENERGY TECHNOLOGY

by

Mr. CLAUDE W. BRENNER, Vice President/Operations
Northern Energy Corporation
Northeast Solar Energy Center

This part of the colloquy is titled, "What We Think We Know." It should also perhaps be subtitled, "What We Know We Don't Know." For while there are some things about the commercialization process that we think we know, there are far more things we don't know, particularly about the commercialization of solar energy technology. For one thing, it's never been done before. So what we are doing is applying common sense, good business practice and learning as we go.

Before we review our approach to solar energy commercialization, however, it is worth placing solar energy in the context of our grave energy situation. Now much has been written about the energy crisis, and it would be tedious to repeat either these discussions or the arguments that justify the relatively new attention to solar energy as an alternative solution to the problem. But certain statements do help us to place value on the problems and respond to its demands.

From Energy: Global Prospects 1985-2000, the Report of the Workshop on Alternative Energy Strategies: "The basic danger of the world energy situation is that it could become critical before it seems serious. Most governments and businesses - for many legitimate reasons - focus their efforts within a time horizon of five to ten years. With such relative shortsight, the energy future does not seem serious.... The time for decisive action is now."

From The National Energy Plan: "America's hope for energy to sustain economic growth beyond the year 2000 rests in large measure on the development of renewable and essentially inexhaustible sources of energy.... The Government should aggressively promote the development of non-conventional resources despite the fact that they face many uncertainties. The danger of too much mutual skepticism is that it may become a self-fulfilling prophecy."

From A Perspective on the Energy Future of the Northeast United States, Brookhaven National Laboratory, June 1976: "The Northeast now obtains more than 90% of its energy supplies from outside the Region, and over 40% of these from foreign countries. This makes the Northeast highly sensitive to decisions now being made.... Unless concerted action is taken at both the Federal and State levels, the energy future of the Northeast will remain precarious."

The warnings, challenges and urgency expressed in these three statements have been heightened by other voices and other events. Even now, in March of 1979, we are experiencing yet again the consequences of our unpreparedness for unexpected interruptions in the reliability of our supply of oil.

The sun is reliable. In our latitudes it rises every morning of the year. It does not appear forever at the winter solstice as our prehistoric ancestors feared that it might. It is indeed the inexhaustible source of energy that the National Energy Plan refers to.

But we know all of this. We as a nation have embarked on a major program to develop solar energy technologies and bring their applications to the marketplace. With all the false starts, debates over priorities, administrative reorganizations and budget difficulties, we have, nevertheless, set about to accelerate the commercialization of solar energy.

Now what does that mean? The Federal Energy Administration Task Force in 1977 developed the following definition: "Accelerated commercialization is a joint government-private sector process (which embraces) government actions that are taken to increase the rate, level and breadth of both acceptance and utilization of a new type of product, system, technique, manufacturing process or service. The general objective of such government actions should be to achieve the maximum market penetration rate of the new type of system, at a given level of government expense, while minimizing any possible negative sociopolitical impacts of the system. Such government actions, in general can take the form of:

- stimulating market demand

- stimulating the early development of viable, self-sustaining--i.e., not requiring government subsidies--industry/market infrastructures

- mitigating, where possible, any technical, economic, legal, institutional, or environmental constraints."

Despite its prolix character, this definition is as good as any. What it really tells us is that if we are to accelerate the commercialization of these technologies in our capitalistic free-enterprise system, we must find ways to meddle with free market forces, to intervene, to cause things to happen in the supply and demand relationship that might not otherwise happen. The vehicle that the government through the Department of Energy is using to achieve these purposes is the network of Regional Solar Energy Centers. The Regional Centers were established at the same time that the Solar Energy Research Institute was settled in

Golden, Colorado. There are four of them: The Northeast Solar Energy Center in Cambridge, Massachusetts, serving the six New England States, New Jersey, New York and Pennsylvania; the Mid-American Solar Energy Complex, in Eagan, Minnesota, serving 12 midwestern States; the Southern Solar Energy Center in Atlanta, Georgia, serving 16 southern States, the District of Columbia, Puerto Rico and the Virgin Islands; and the Western Solar Utilization Network, in Portland, Oregon, serving the 13 western States, Guam and the Pacific Trust Territories.

Let me pause here to tell you what the Regional Centers are and what they are not. The Regional Centers are not research institutes. They are agencies whose primary function is to promote the commercialization of and encourage the widespread use of solar energy. Their activities stress commercialization, information dissemination, incentives to industry and the creation of new solar businesses, and solar energy-related jobs. As Secretary Schlesinger announced in March of 1978: "The primary mission of the Regional Solar Energy Centers is for them to be the Department of Energy's lead institutions related to the regional commercialization of solar technologies and conservation integral to solar applications. In carrying out this mission, the Centers will utilize and manage federal funds for the purpose of stimulating the private sector to develop solar energy/conservation products, processes and services while at the same time removing the barriers to consumer use of these resulting technologies."

But why the emphasis on a Regional approach? Why can't a centralized institution work the problem nationally? Because the problem has strong Regional content. Climate is a key variable. Solar systems designed for Albuquerque won't necessarily perform in the Northeast. Snow, pollution, wind, solar insolation--all vary by region. Energy demand, energy usage and energy sources also vary by Region. Similarly, population density, buying habits, tastes in housing style, condition of housing stock, level and type of industrialization, available financing, and the impact of the local utilities all have Regional content. In addition, consumers and small businessmen in all regions find it bothersome and often ineffective to travel to Washington to promote their solar interests. A strong regional response, is therefore, appropriate.

Let me pause here and give you a brief history and status report of the Northeast Solar Energy Center. The first of the Regional Centers to get underway, Northern Energy Corporation received a six-month grant on 10 May 1977 to write a plan for the implementation of the Northeast Solar Energy center, or NESEC as we call it, to serve the nine-state Region earlier referred to--the New England States, New Jersey, New York and Pennsylvania. The plan was delivered on time and under budget. We are now under a short-term contract implementing a score of the tasks proposed, and are looking forward to negotiating a five-year contract for the operation of the Center in the next month or two. Headquartered in Cambridge, Massachusetts, we now have a staff of roughly 80 people, including lawyers, architects, educators, bankers and biologists, in addition to technologists, engineers and managers.

In spite of appearances, the Northeast Region does represent a quarter of the Nation. While we have only 5% of the land mass, 24% of our population lives here. It is not surprising, then, that 86% of Northeasterners live in metropolitan areas. But it is unnerving to know that we in these nine states burn 57% of the No. 2 heating oil consumed in the country. Boston, not Chicago, is the windy city--its average wind speed of 12.7 miles per hour is the highest measured of any U.S. city. The northern tier of states is 85% forest land, and even New Jersey, the most heavily industrialized state in the country, is 50% forested. These and other issues dealing with energy usage and energy resources set the framework for the Regional character of our efforts.

Now the Regional Centers are unique--not merely different from each other, but unique as institutions and unique also in their common purpose. To understand our approach to commercialization of solar technologies, therefore, we must first understand these two uniquenesses.

As institutions the Centers have no organizational precedent. There is no model. Managed and operated by a private non-profit corporation, the Centers are funded by the Department of Energy to provide services to a diverse collection of interest groups that comprise each regional solar constituency, while at the same time being required to be responsive to the energy policies and programs of the states of their region, individually and collectively. There is, in fact, a triangular interface between the Center and its market, unlike a conventional business enterprise where the business entity and its market interact across a single interface.

Traditionally the market defines a need, establishes a demand and furnishes money to drive the business. The business responds with goods and/or services to its customers. But the Centers have three interfaces. They receive their programmatic direction and funding--that is, demand and money--from the Department of Energy across the first interface. But they do not provide this customer with goods or services (other than contractually required reporting documents). Rather, the goods and services are delivered across a second interface to the Center's constituency, which includes industry, universities, the utilities, the legal, financial and insurance communities, labor unions, architects, engineers and builders and, overall, the general public. This constituency, the Center's market, in turn governs the Center's work, direction and output by placing its distinct individual and collective needs upon the Center. Finally, the system is biased across a third interface by the requirements imposed by the states for their energy programs as noted earlier.

The uniqueness of the Center's purpose is equally apparent. This is the first time in our history that federal funds will be used to assist in developing and commercializing products and services that will be used by the consuming public at large. Federal funds have been used in the past to assist in developing products, but only for purchase by the

Government itself, as in the case of military or space procurements, or by one segment of industry, as in the case of the airlines. The use of Federal funds for consumer purposes is unprecedented, and because, as I've noted earlier, this has never been done before, no one quite knows how to do it. There are no road maps, no cookbooks, again, no models. And here lies the splendid and welcome opportunity for innovation, imagination and certainly inspiration to tackle the problem that has elements of those two together with political and institutional characteristics as well.

It must also be recognized that when we talk about solar technology, we are talking about six, and by some authorities even seven, technologies. These include the obvious active and passive solar space and water heating technologies, solar thermal power, biomass, wind energy, photovoltaics, ocean energy systems, and some would include low-head hydroelectric power in this list. The Department of Energy has identified several solar technologies as presently ready for commercialization, including solar water heating, small wind systems, and biomass systems. As I will point out later, the approach to commercializing one does not necessarily apply at all to any of its sister technologies.

So what do we do? To a large extent pragmatism is the rule. First we are to remove the barriers. There are really only two--emotional and economic. Certainly there are others; amongst them, legal and to a certain extent even technical, but they will yield far more readily once the emotional barrier has been overcome. The principal issue here is that we neither believe nor do we want to believe. It is much more comfortable to blame the Seven Sisters, or the ubiquitous "they" (as in "Why don't they...?), than it is to face the reality that our renewable resources are not only running out, but may be interrupted at any time by forces beyond our control.

The President's Domestic Policy Review has concluded that limited public awareness of and confidence in solar technologies is a major barrier to accelerated solar energy use. Of course. How can there be public awareness of, let alone interest and confidence in, solar technologies, if there is still such limited public awareness of the seriousness of our energy situation overall? I refer you to my opening quotation from the Workshop on Alternative Energy Strategies.

The barrier of public indifference is expressed in a variety of ways but may be summarized as the eight myths of conventional solar wisdom. These are: Solar is a futuristic technology; solar energy is not appropriate for the Northeast; solar energy will have minimal impact on our energy future; solar is not economic in terms of payback period; solar requires subsidies to succeed in the free marketplace; subsidy or not, solar volume will not take off with improved economics; there are really no more barriers left to solar commercialization; and finally, solar is the answer to all the nation's energy problems.

We identify these eight positions as myths because they are all demonstrably incorrect, and the marketplace--the consuming public--must be taught this. Clearly then, the first step in commercializing solar energy is to create a demand in the marketplace by educating the public. A massive outreach and education program is indicated. We are embarking on that at the Northeast Center at all levels and all sectors of the community. This program of education--of raising the public consciousness--is designed to address all the myths as well as the primary and secondary barriers to the adoption of solar energy in the Northeast.

There are many things the consumer wants to know. He is interested in system performance, installer education and certification, service and maintenance. He is also concerned about high first costs, available financing, and additional homeowners insurance. He may want to know his return on investment. In this event, the solar industry already carries a self-inflicted wound in the form of the so-called "pay-back period" type of anaysis--an analysis that ignores non-economic buying factors, while assuming no possibility of appreciation of solar system value. We are meeting these needs with a broad-band program of education of the general public through the medium of pamphlets, newsletters and a general press, radio and television campaign.

In the realm of formal education, we will be working with the education departments of each of the states in our region to help introduce solar curricula for grades K through 12 that have been developed by the University of Southern California and the State University of New York at Albany under contract to the Department of Energy. We are working with vocational training schools and community colleges throughout the region to introduce solar courses at those levels. We will be working with universities and colleges to help them deal with the issues of introducing courses related to solar energy in all fields of endeavor where such material is relevant--this includes not only the technical courses, of course, but business courses, sociology courses, economics, law and the like. We will also work in the university environment to introduce seminars for practicing professionals who can participate in the continuing educational program to learn of the impact of solar energy on their professions.

At a different level, we have conducted workshops and seminars for bankers to prove to them that loans for solar installations are risks worth taking, for insurance underwriters to discuss the issues of undue risk that do not exist with solar installations, with architects to teach them the fundamentals of passive solar design principles, with trade union leaders to point up the importance of solar energy to job considerations and the role the unions must play, and eventually with every element or vested interest group of the private sector.

Creating a demand is one thing, assuring that there be a supply is another. The solar water heating and space heating industry is in a parlous state. We do not have precise figures as to the number of small companies that have failed in the last eighteen months, but it is in excess of 100. Even worse, this year some major forces have withdrawn from the marketplace. PPG Industries and Libby-Owens-Ford announced just weeks ago that they both would be withdrawing from the manufacture, distribution and sale of solar flat plate collectors. Others, we know, are making their hard business decisions as the risks are assessed.

There is a reason for this of course, and it goes back to the interaction with the marketplace. Once it was announced that a National Energy Act might contain tax credits for people investing in alternate energy systems, the demand for solar systems virtually dried up while the Congress laboriously lumbered through the process of passing that Act. Even though the credits were to be and, in fact, are retroactive, the consuming public were not apparently willing to take the risk, and waited to see for sure. From the time of first announcement to its passage, approximately 18 months passed, a period of tremendous stagnation in the solar industry, both regionally and nationally. And now that the Act has been passed, the lost momentum shows very little sign of recovering.

The solar industry needs help, and we are attempting to furnish that help. One form of assistance addresses the removal of all the barriers that still remain to the introduction of solar energy in this region. For example, we recently completed a comprehensive study of the legal barriers to solar introduction and have published a report, Barriers & Incentives to Solar Energy Development: An Analysis of Legal & Institutional Issues in the Northeast by Arnold R. Wallenstein, available on request. As a companion activity we have completed a study on product liability and conducted a region-wide legal seminar on the issue of solar access.

As a result of this effort, we hope ultimately to assist state legislatures in the drafting of legislation friendly to the adoption of solar energy. Already, we have had significant success in one state. Working with a consultant, we have had legislation drafted to accelerate solar energy use in Connecticut. Utilizing the expertise of a lawyer, who is a member of the gubernatorial Connecticut Solar Energy Alliance, prime issues ripe for legislation were identified, bills were drafted, and reviewed both by the Alliance and this Center. Subsequently, Governor Grasso accepted nine of the ten bills prepared, and endorsed them as her Administration's Solar Energy Legislative Package for 1979. NESEC staff will testify on these bills before the General Assembly's Committee on Energy and Public Utilities, and will continue to provide technical assistance and testimony to the Legislature and the State Energy Office, as requested, to assist in the passage of these bills. Finally, the legislation will be used as models for other states in drafting their own initiatives.

We have, in our 15 months of active operation, done other things. Here is a partial list.

- A series of installer training courses was conducted, in conjunction with the National Solar Heating and Cooling Information Center. More than 1,700 plumbers, carpenters, roofers, and do-it-yourselfers attended the one-day sessions. This comprised 32 groups in 22 cities throughout the nine-state Northeast Region.

- In conjunction with Brookhaven National Laboratory and the American Institute of Architects, a series of 12 one-day seminars on the techniques of passive solar design was presented to some 600 architects and engineers.

- A market tracking system is being developed that measures market penetration and takes the pulse of the emerging Northeast solar industry.

- A preliminary study of buyer motivation and market demographics has been performed as a by-play of the response to the HUD Hot Water Initiative in Connecticut. Correlations with census data help identify high potential towns for solar. Additionally, since only about one-third of the 169 cities and towns in Connecticut have passed the solar property tax exemption, we have a mechanism for analyzing the effect of removing this potential barrier.

- We are promoting a solar demonstration at the 1980 Winter Olympics at Lake Placid, New York.

- Working with the Northeast Chapter of the Solar Energy Industries Association, we have developed a preliminary review of the various available funding mechanisms that exist in each of the nine states.

- Intensive workshops involving the banking and insurance industries have been successful in opening up constructive dialogue with these important institutional partners.

- Two hundred homes throughout our Region are currently being monitored to determine solar hot water system performance characteristics.

- Construction techniques for solar greenhouses are continually being taught to urban and minority groups, to schools, and even to inmates in certain minimum security prisons.

- But the keynote to the Center's activities has been face-to-face outreach activity. Over the last few months, over 150 technical requests have been serviced; 75 entrepreneurs have had discussions on funding strategies for solar ventures; over 100 formal marketing discussions have been held and over 500 solar industry contacts have been made. More and more legal and financial professionals seek us out for advice about solar energy. That is what we are all about. We are here to help the private solar sector.

A more direct form of assistance to the solar manufacturing industry is currently focused on a specific short-term issue. We are undertaking an intensive marketing effort to sell solar hot water systems using the incentives of the so-called HUD grants and the tax credits of the National Energy Act as economic drivers.

Roughly two years ago the Department of Housing and Urban Development established the so-called Hot Water Initiative. In this program, $4.1 million was set aside to provide some 10,250 $400 grants to homeowners as economic incentives for them to install hot water systems in their homes. Eleven states are participating in this program, and the selection of grantees and administration of the funds is conducted by the state energy offices, each of which was given administrative funds for this purpose. The eleven states include all the New England states, save Maine, together with the Middle Atlantic states -- that is, New York, New Jersey, Pennsylvania, Maryland and Delaware -- and Florida in the South.

When the program was initiated, a $400 grant was judged to be approximately one third of the $1,200 to $1,500 cost that a solar water system could be installed for at that time. There seemed to be such enthusiasm for these grants that many states considered holding lotteries in order to insure fair and equitable distribution amongst the multiple applicants for the apparently limited number of grants.

The fact of the matter is that two years into the 30-month program, less than one third of the grants in the eight participating states of the Northeast Region have been claimed. (For example, in Massachusetts only 220 of 1,375 grants have been taken up.) The reason for this is simple -- the present price of a solar hot water system installed according to the requirements of the HUD program is now nearer $2,500, approximately twice the original estimate. The cost increase has come about because the HUD program demands, first, that the system supply at least 50% of the daily hot water requirements of the grantee family, and secondly, that the manufacturer furnish the grantee with a five-year warranty for its installation. Inflationary factors on labor and materials have added their increments as well. A grant of $400 against a $2,500 installed cost which may even now be climbing towards $3,000 is hardly an incentive at all.

With the passage of the National Energy Act, however, the tax credits, amounting to 30% of the first $2,000 and 20% of the next $8,000, coupled with the $400 grant can be shown to amount to a reduction in overall cost of 40% or more.

Using these economic incentives as our theme, we are mounting an intense marketing campaign with the objective of seeing the remaining 5,500 HUD grants in the eight participating states in our region allocated by the time the program formally ends at the end of this fiscal year. This is an ambitious program, but it is an exciting and challenging one, one that will give us for the first time a quantitative indication of the effectiveness of the Regional Center as a stimulator in the supply/demand system, towards achieving our objective of accelerating commercialization of solar energy.

Working with the state energy offices, with the manufacturing industry and the installing industry, our role will be to furnish an industry-wide marketing and sales campaign through the print and electronic media. In addition, we will function as coordinator with the state energy offices as well as with the industry in order to determine both strategic and tactical changes in our program as shifting circumstances during its course may determine. We will help create the demand, confident that the industry can furnish the supply.

As exciting as the HUD Hot Water Initiative program is to us, it must be put in perspective. At roughly $2,500 per system installed, it amounts only to about $12 million worth of business for the solar industry in the next six months. That may keep the wolf from the door, but it is hardly a saving infusion. Our efforts will not stop after this program is over. There are a large number of other opportunities that must be pursued. Applications in multi-family dwellings, low-rise and high-rise apartment buildings, commercial applications, industrial and agricultural process heat all await attention and support by this Center. Our approach again will be to use the generic one of creating demand through education as to the attractiveness of solar energy as an alternate form and through the removal of secondary barriers to its adoption in all of these other potential applications.

The question may well be asked: Is the fuss and the fury worth it? We think so. The DOE has estimated that one quadrillon BTUs -- that is, one quad -- of solar thermal energy, approximately 1/75 of our current national annual use, will have the following impact. It is the equivalent of starting 10,000 new small companies with $1 to $5 million annual revenues. It means 1 to 5,000,000 job years. It means enough energy to heat half a million homes for twenty years. Indeed this is not trivial. Our efforts will continue.

What happens after we succeed? We will measure success by the establishment of a solar industry capable of meeting the demands of its marketplace, regulated by its own professional societies, supported by second, third and fourth level suppliers and subcontractors and governed by the conventional mechanisms of supply and demand, all on a time scale faster than would normally take place. Let us recognize that for most new industries, this marriage of supply and demand takes 20 to 25 years to reach maturity. It is our objective to bring this about, at least in the solar flat plate collector industry, in from seven to ten years for this region. When this is done, we will withdraw, but that does not mean that the Northeast Solar Energy Center ceases to function, because we will have addressed only one of the solar technologies that may be commercializable.

But what may work for one solar technology may not apply at all for another. Woody biomass is a good example. As I noted earlier, the nine states of our Northeast Region are rich in forest resource. The three northern tier states -- Maine, New Hampshire and Vermont -- have approximately 85% of their land mass covered by forest. Already in those states, significant strides are being made in the introduction of wood energy conversion systems of one form or another, both in private homes and for industrial usage. Wood burning stoves in homes, wood gasifiers in commercial operations and wood-fired boilers for utilities are all examples of what is being done. Vermont, a state of some 400,000 people, has declared its energy independence and has seen some impressive changes in energy usage. In 1974, only 7/10 of 1% of Vermonters burned wood exclusively for home heat. Today, that figure is closer to 20% and some 65% of Vermont homeowners now use wood for at least a portion of their heating.

But the kind of intervention in the form of marketing and sales efforts, removal of barriers, and introduction of incentives that may work for the solar flat plate collector industry and for the passive architectural design approach will not apply necessarily to wood. One of the principal reasons is that there is intensive competition for other uses of the resource.

It has been said that if nature hadn't given us wood, we would have had to invent it. The wood products industry, which includes the pulp and paper industry, the furniture industry and, of course, in the Northeast, the housing industry, places a higher economic demand on the forest product than does the energy consumption industry. For some in the forest products industry, it is a sin to burn wood. Certainly, good wood fetches a market price in the products area at least ten times that which it would realize as a source of energy. On the other side of the ledger, the amount of energy consumed in manufacturing wood products is only approximately 1/10 as much as that consumed in manufacuturing products from competing materials.

But there remains a reasonable source of wood even in the face of these competing uses, nevertheless. These include the residual material left after harvest, as well as residues from the manufacturing process itself. In addition, the U. S. Department of Agriculture is now looking into so-called energy plantations -- that is, short rotation wood crops that may be grown in large quantity and harvested frequently as an energy source.

Once again, the role of the Northeast Solar Energy Center in helping establish a solar energy industry based on wood energy conversion systems will be as intervenor, stimulator, catalyst. Clearly the competing-uses issue is a barrier that must be dealt with on its own terms. Just as in the case of solar thermal applications, the total conversion of our Regional forests to energy consumption is not the answer. A balance must be struck. We must work with the industry, with the managers and owners of the resource, with the manufacturers of the conversion systems, with the individual state energy offices and interested parties in developing a sound, self-sustaining industry that will answer at least part of our energy needs.

And so it is with each of the other technologies. Wind energy conversion systems, photovoltaic systems, ocean energy systems will bring with them their own sets of problems that we must address in terms of their interactions with the institutional, political, economic and technical forces that govern the commercialization process. We will learn as we go, and we will become more proficient as we learn. But we are motivated constantly by our principal objective -- namely, to relieve the regional dependence on oil, especially foreign oil, and gas.

We hope to achieve a double-barreled effect. By establishing new industries, we hope to benefit the regional economy by the creation of new jobs. At the same time, by meeting the objective of furnishing alternate forms of energy to heat our homes and help power our industries generally, we will aid the economic health of the region as well. This region, which presently pays 35% above the national average for its energy, can then look forward to a revitalization of its economic health.

We have noted before that commercialization of solar energy at an accelerated pace will take vigorous new ideas, new uses of Federal funds, a new role for the States. Imagination and innovation must infuse the process. But in the final analysis, while Federal and State assistance are vital, it is the private sector spurred by the profit motive that will do the job.

Acting as a catalyst on behalf of its regional constitutents, the Northeast Solar Energy Center will play a strong role in helping the job get done faster and more effectively.

FEDERAL INITIATIVES FOR THE COMMERCIALIZATION OF EMERGING ENERGY TECHNOLOGIES

Mr. Jackson S. Gouraud, Deputy Under Secretary
U. S. Department of Energy
(read by Mr. Frank N. McElroy, Senior Program Analyst)
(U. S. Department of Energy)

I am happy to be here today, happy to have this chance to talk to you about the Department of Energy's approach to commercialization. To begin at the beginning, why does an agency of the Federal Government have a commercialization effort at all? Most Government agencies certainly do not have them. Well, the answer to that question is the Department of Energy's unique charter: we are charged with insuring that the citizens of this country can continue to enjoy the kind of society to which they have become accustomed, and the kind of society they will evolve in the future. We are here to see that the Federal Government does everything possible to encourage the development of alternative domestic energy resources, so that this Nation is not exposed, either militarily or economically, to serious disruptions of its energy supplies.

To put it another way, what we in DOE are doing in our commercialization effort is to sort out the technologies that can help us, and figuring out how to move them along quickly to the marketplace. We are easing the economics, the regulations, the barriers holding them back. We are using the rational and coordinated efforts of the Federal Government to help market those technologies that can solve our energy problem. I am not going to waste your time and insult your intelligence with a long harangue on why we really do have an energy problem. I don't think there are many Doubting Thomases here today, however many there still may be out there in the rest of the country. Let me just mention two or three facts: Last year we had to import almost half of our oil, at a cost of some $40 billion dollars; this had bad effects on both inflation and our balance of trade, the strength of the dollar here and abroad. Our use of oil in the next few years will increase, not decrease, and some time in the next decade rise above the world production level; when that happens, if we let it, we can expect prices of fuel to go sky-high. One last fact: Iran's problems have taken 6 million barrels of oil a day out of the world's supply picture; that has to be made up somehow, including our portion of it.

So we have an energy problem: to find and develop alternative energy sources, to reduce our dependence on imported oil. And we in DOE have a commercialization effort, to try to help these alternative technologies move along quickly into the marketplace.

But again, why the Federal role? Why isn't this a problem for the private sector to solve? The answer to that question is that it is a problem for the private sector to solve. Our job is to remove the roadblocks so private industry can and will move forward quickly, with a better chance of success. In more normal times, the movement of a new technology from the laboratory to the marketplace might take a dozen or more years; in this case, we just do not have that much time to wait. Any economic, environmental, institutional or technological barrier standing in the way of the technology's progress must be, as far as possible, eliminated, and that is the Federal role, that is how we can best help the process.

Let me now just briefly outline for you how we went about our commercialization effort. In April, 1978, Under Secretary Dale Myers established a Commercialization Committee, which I chair, consisting of the Assistant Secretaries of DOE. This high-level, highly visible committee met early in April, and asked, "What do we have in the pipeline that can be commercialized now to help solve our energy problem?" We asked about each technology, its technical readiness, its economic potential, and its acceptability institutionally, environmentally, and in the market. We refined the list to the most promising technologies for further commercialization efforts, and we had concept statements written for each one: tight, factual descriptions of the product, its physical characteristics, its cost and benefits.

The technologies we considered were grouped in four market categories:

Under Liquid Fuels:	Enhanced Oil Recovery Coal Liquefaction Oil Shale
Under Gaseous Fuels:	Unconventional Gas Recovery Low Btu Gasification Medium Btu Gasification High Btu Gasification
Under Electric Markets:	Utility Atmospheric Fluidized Bed Combustion Combined Cycle/Integrated Gasifier Fuel Cell Power Plant Hydrothermal/Geothermal Low-head Hydropower Photovoltaics Large and Small Wind Systems
Under Direct End Use:	Urban Wastes Cogeneration Industrial Atmospheric Fluidized Bed Combustion Solar Hot Water Passive Solar Heating Oil-fired Heating Equipment High Efficiency Motors Air-fuel Ratio Combustion Control Electric and Hybrid Vehicles

Subsequently, the Cabinet-level Solar Energy Policy Review Committee identified two additional technologies with significant near-term commercial potential: Wood Combustion, and
Industrial and Agricultural Solar Process Heat.
These were added to our lists. Still later, further review indicated commercial potential in two more technologies, that have now been added to the group: Annual Cycle Energy System (ACES), and
Non-battery Storage for Utilities.

We established Task Forces, using a matrix-type management. Typically, each Task Force numbered about ten, and all were staffed with support from the Assistant Secretary for Environment, from Planning and Evaluation, and a cross-section of other elements of the Department. The Task Forces reported their "readiness" findings to the Commercialization Committee, one technology each evening.

Simultaneously, we took steps to assure that there would be some checks and balances on our analysis of the Task Force reports. We wanted "other opinions," including "outside opinions." Let me cite a few:

1. Four market research firms put together "focus groups," to get consumer reaction to product concept, marketing plan, cost and so on.

2. Special task forces for certain technologies were created by the National Association of Manufacturers, American Boiler Makers Association, Edison Electric Insitute, American Gas Association, Interstate Natural Gas Association, International Brotherhood of Electrical Workers, Oil, Chemical and Atomic Workers International Union, United Brotherhood of Carpenters, and the U. S. Conference of Mayors.

3. There was an independent costing analysis by ESOC (Engineering Societies Commision on Energy).

4. A group of retired industry vice presidents for research and development reviewed our Task Force reports.

5. We had independent environmental analysis, and

6. We received input from public interest and consumer interest groups.

The Chamber of Commerce also interacted with us. We have a genuine desire in DOE to hear the views of industry, public interest people, environmentalists, and others. We want our product to be useful, and economical, so that the private sector can make money while helping to solve the energy problem in an environmentally acceptable way.

Secretary Schlesinger, in Congressional testimony last year, put the situation this way: "There will be no single solution to our energy problems. It will not be nuclear, or solar, or coal-derived synthetics, or biomass energy. Instead, the Nation will need a set of measures which together will contribute to the solution of the United States' energy problem. We as a Nation will have to work together to allocate available resources to bring to bear a whole range of technologies, regulator mechanisms, and tax and pricing approaches to make this transition as quickly and effectively as possible."

By the end of last August, the Task Forces had done their jobs: The current readiness of each technology was determined, and key barriers to commercialization had been identified. Costs for each candidate and reference technology were prepared on a life cycle basis, except for certain conservation products, where payback time through fuel savings was used. Commercialization profiles were used to evaluate the relative importance of each potential Government action (Federal, State, and local) in overcoming barriers to commercialization. Commercializtion strategies were written, recommending the most effective Government actions.

At a series of new conferences last November, we announced the technologies this commercialization process brought to the top of the list, the technologies we feel offer the greatest near-term potential. We called them "the winners", but that doesn't mean there are any losers, that doesn't mean other technologies are being put on the back burner. On the contrary, all the technologies are being brought along as fast as is feasible.

The technologies with the largest quad potential are: Enhanced Oil Recovery, Unconventional Gas Recovery, Industrial Atmospheric Fluidized Bed Combustion, and Wood Combustion.

Technologies that are "ready now," although with more limited supply potential, are: Solar Hot Water, Passive Solar Energy, Low-head Hydroelectric, Industrial and Agricultural Solar Process Heat.

Conservation products that will contribute to supply by reducing wasted energy are: Oil-fired Heating Equipment, High Efficiency Motors, Air-fuel Ratio Combustion Control, Pilot Light Substitution/Electronic Ignition.

Although the Task Forces have been dissolved, the function of technology analysis is continuing, under the management of the responsible Assistant Secretaries. In our so-called Second Round, we reviewed and are adding to the Winners list these technologies: Wood Combustion, Solar Industrial and Agricultural Process Heat, and also the Annual Cycle Energy System (ACES), and Non-battery Storage for Utilities.

Together, the contribution to be made by these technologies is significant. Some, of course, will prove more valuable than others.

The Assistant Secretaries refined the strategies proposed by the Task Forces, and completed the plans and budget needed to implement our commercialization effort as part of DOE's regular budget development activities. Special stress had been laid on plans to overcome barriers to commercialization. The Department plans on continuing this commercialization planning effort, refining its analysis on the basis of review and further study. To stimulate future discussion, DOE is making available single copies of the final draft of each Task Force report, upon request. Write to: The Department of Energy, Distribution Section, Room B-447, 12th & Pennsylvania Ave., N.W., Washington, D.C. 20461.

Now, we all know that nothing happens unless there is someone in charge. Industry recognized, some fifteen or twenty years ago, that this complex world has become very specialized. To deal with this, the post of "Product Manager" was developed. Basically, that is the person who must deliver to management a plan for penetrating the market, including the money needed to achieve this goal, and the actions that must be taken, with benchmarks against which to measure progress.

It seemed to us the same need existed in DOE, so we established the position of "Resource Manager," who for all practical purposes fulfills the same role as Product Managers in the private sector. The Resource Manager will provide Department-wide point of focus for the coordination of all activities required for the earliest commercialization of his technology. His scope of responsibility includes environmental and regulatory coordination; planning and budgeting of programs; industry/government liaison; marketing; marketing research; cost/pricing and penetration estimates. This is an innovative step for Government, and we expect it to be a very fruitful one.

That, then, is a brief look at our DOE commercialization program. I hope you don't feel it was too brief, or not brief enough. We are optimistic about our commercialization efforts. We feel we have analyzed the need broadly and in depth, and have a basic commercialization structure well in hand. Now it is a matter of getting on with it, with your understanding and assistance. Because one thing is dead certain: the Federal Government cannot do it alone. To change our energy supply systems and our energy consumption habits is a job for everyone, working together, to do.

Thank you.

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THE DEMAND/SUPPLY PROSPECTUS FOR ENERGY-RELATED ENGINEERING MANPOWER

Mr. Norman Seltzer, Chief/Manpower Assessment
Office of Education, Business and Labor Affairs
U. S. Department of Energy

It's a personal pleasure for me to be here with you today at the University of Massachusetts since it's a return to an area where I enjoyed my very first working-life vacation more years ago than I care to contemplate. I was also looking forward to visiting with my former boss at ERDA, Ken Picha, but it seems that rekindling old memories of struggling for bureaucratic survival was more than Ken could bear, and so I learn he's temporarily fled to the secluded environs of Colorado to spread his gospel.

I am grateful for your invitation on other grounds, as well. In particular, because it provides an opportunity for me to get a brief non-Washington perspective on the situation in energy engineering. The non-Washington perspective is different and is important for effective manpower assessment and the opportunities to obtain that perspective do not come frequently enough.

For my contribution, this evening, I want to draw upon some of the information we have available to assess the energy engineering manpower situation. Unfortunately, our information is limited at best and is particularly limited at the regional level. I will of course provide what information I can about the regional sitation. However I plan to learn far more than I give. In that way, I'll be better informed next time around.

In the course of my comments this evening:

First, I'll review our Manpower Assessment program as presently constituted at DOE's Office of Education, Business & Labor Affairs, (affectionately known as EBLA).

Second, we'll consider a few of the implications of the current bottlenecks in the supply of engineering manpower.

Third, we'll run through some facts relating to engineers in the New England region. (As I indicated, this won't take long since we don't know that much.)

And finally, I'll touch upon the energy engineering manpower situation in general and review the market in two specific energy industries, oil and nuclear energy.

To begin, lets talk about our ongoing manpower assessment program. As you will note, I will be citing information drawn from both goverment and non-goverment sources as well as from studies sponsored by our office.

I want to emphasize, though, that all of this material, regardless of source is part of our office's manpower information base. From the outset, way back even in ancient times, i.e., over two years ago, we formulated a multi-faceted program through which we could develop, step by step:

- A comprehensive information system which includes baseline data related to the supply of and demand for energy manpower;

- A program to identify and utilize existing data sources developed by other groups both within the government and in the non-government sectors;

- In-depth assessments of requirements for developing the various energy sources and technologies;

- Methodologies to assess the employment impact of energy developments, policy decisions and initiatives.

By joining forces with other DOE offices and other Federal agencies, we have been able to stretch our very modest budget to some extent. We have been able to supplement rather than duplicate. We have initiated the development of new data only when absolutely necessary to fill in gaps.

- Considering our modest resources this policy has worked out fairly well thus far. For example, in the area of concern here today, we have developed statistical profiles of three different groups of energy related scientists and engineers: New entrants into the work force; experienced employees; and separately, those with doctoral degrees. All three profiles draw on data originally collected by the National Science Foundation.

- A different kind of relationship was established to develop the Construction Labor Demand System, a national model which will enable us to anticipate the capital and manpower requirements within each geographic region of both energy related and non-energy construction activities. Thus far, forecasts are being obtained for some 29 skilled crafts but over the coming year we anticipate developing requirements for engineering and other technical manpower. This system is being developed through a joint venture by our office, TVA and the Department of Labor. We could not have funded it alone through our meager budget.

A third type of relationship involves supporting private organizations or another Federal agency for our direct purpose. For example: the BLS has been collecting and compiling data for us on nuclear-related employment in professional, technical and skilled occupations for many years and this is now quite comprehensive.

Finally, we draw to the extent possible on the work of private organizations. For example: I'll be citing data collected by the Society of Petroleum Engineers on the outlook for engineers in oil and natural gas.

There are a number of problems with this approach of course. For one thing, we are not in a position to set priorities when other groups are involved. As a consequence, the depth of our information is uneven and we do not yet have information in all energy areas. But hopefully the concern for better employment and manpower data is growing and we do have a number of interesting projects cooking in the data oven. Let me cite some examples:

- Comprehensive studies of coal mining productivity and occupational and training requirements for expanded coal production are underway and should be completed by the end of this year. Because we happen to be so very prescient, we've been able to assist the President's Commission on Coal in their efforts. Also complementing these coal studies is a pilot study to estimate labor requirements for constructing, operating and maintaining coal gasification plants; and a study to develop baseline data and estimated future requirements for operator and maintenance technicians in fossil-fueled power plants. In a few of these projects, we have been able to supplement the efforts of EPRI - the Electric Power Research Institute.

- The first national studies of Solar and Geothermal employment and future requirements have been proceeding for over a year now. In the near future, a substantial amount of employment data related to the development and commercializtion of all solar technologies will become available, including information on all types of engineers and other technical and skilled occupations. (Preliminary estimates indicate that some 7,000 engineers were involved in all solar activities last year, primarily in R&D work).

- We initiated some exploratory work in the field of conservation by supporting a pilot study in California to assess the impact of selected conservation measures related to construction and residential building on various occupational skills and requirements.

In summary, we are attempting to reach the point at which we will be able to provide, if you will, a one-stop shopping service on energy manpower data at the national level. It will be sometime before we have good regional information but be assured that, in almost all of our efforts, the concern for developing such regional data is paramount.

Next, before turning to the current engineering employment situation, let me place on record some traditional reservations about manpower forecasting. Three caveats -- First, let me repeat that I'm using information I have available. This means that there is a good deal of unevenness in the depth of my data. For example, unusual as it may seem, we have more complete data on nuclear energy employment than we do on coal. As I said earlier, studies of the coal industry are underway. However, I proceed on the assumption that it's better to provide some information than none. Unfortunately, this does not make for a balanced and symmetrical presentation.

Second, as we all know, employment forecasting is a hazardous business at best and for detailed information requires careful analysis on an industry-by-industry basis. This poses a real problem in the case of energy-related employment because industries can't be clearly defined. An industry consists of a group of enterprises which market a common product or group of products. In this sense we talk about the insurance industry or steel industry.

When we deal with energy, though, we are really categorizing in terms of fuel rather than the industry for which the fuel is used. Nuclear energy fuels enterprises both in the weapons industry and nuclear medicine. Solar energy ranges from the mundane, home space heating, to the more exotic, ocean thermal conversion. Further, many energy technologies are in the pre-commercialization stage. I suppose that if they belong anywhere, it would be in the R&D industry.

What this means, of course, is that we deal with manpower in a large number of industries and activities ranging from the mature to the vaguely defined. As a consequence, energy-related employment is subject to so many different pressures, that such forecasting is fraught with even more uncertainty.

A couple of examples of pressures beyond our control will establish the point. Employment in both nuclear energy and R&D energy-related technologies are heavily dependent on federal funding and the federal money spiggot is very volatile. Next, if it isn't revolutions in Iran throwing both oil and perhaps total employment forecasts for a spill, we can depend on coal mining health and safety regulations or enviromental protests against nuclear fueled electric power plants. In the energy field, we can be fairly certain that the next crisis is coming; we just don't know the direction it's coming from, what form it will take, or how it will affect manpower requirements.

Now that I've seeded the air with doubts and uncertainties, I'm ready to review what we know about the energy engineering labor market in general and the situation relating more specifically to energy related engineering specialities.

The facts about the general engineering labor market are simple and straight-forward, and you are surely as well or better informed about the immediate situation than I am. You know about the salaries new graduates are currently being offered. You know about the number of job offers per graduate.

It seems to me that engineering employment is currently an important national problem. It is interesting, in passing, to note how quickly circumstances change. The questions listed in the briefing notes for this colloquy emphasize energy implications for mid-career engineering training, courses for underemployed engineers and changes in curricula to meet energy engineering needs.

The overwhelming engineering manpower reality, though, is that this is an excellent period of engineering employment opportunity. There are far more engineering jobs in virtually every specialty than there are engineers, and this situation will continue for the next year or so. Engineering salaries continue to rise — the data I have are two years old and are already considerably behind current levels. That's how fast salaries are increasing.

I'm sure that there are in this region underemployed, and even some unemployed, engineers who can indeed benefit from mid-career training. I submit, though, that they are uninformed about the many opportunities throughout the country.

The real agenda before this colloquium in March 1979, is whether we need to take special action to qualify more engineers more quickly to meet current shortages. Further, since we are here dealing with engineers in energy related industries, there are additional questions. What meaningful action should (or could) be taken to effect a shift of professionals from non-energy endeavors to energy related activities? So far as current student populations are concerned, the key question is, what action, if any, can be taken to encourage students to qualify themselves through energy related curricula (or, is any needed)?

Lets look at demand first. In it's most recent occupational outlook forecasts, the Bureau of Labor Statistics anticipates that there will be more than 1.4 million engineering jobs by 1985, an increase of 25% over the 1976 level. BLS estimates that growth and replacement needs will result in an annual average of 56,500 job openings each year for the forecast period.

Further, virtually every engineering specialty shares in this expansion. To repeat, demand will continue at a high plateau for the immediate future.

Now what about supply? Using projections made by the National Center for Education Statistics, BLS estimates an average of 62.3 thousand bachelor of engineering degrees for the period, one-third more than the average of the 1970-75 period. As usual, students demonstrate their reality orientation and respond rapidly to the growth in job opportunities.

Based on current enrollments, the 62.3 thousand degree-per-year figure is probably a little optimistic. Just recall that the 1949 GI Bill based enrollments generated an all time high of 52 thousand bachelor of engineering degrees - considerably under the current forecast. Regardless, even assuming that reasonable numbers of scientists and high level technicians will enter the engineering job market to take advantage of opportunities, we can anticipate that the engineering labor market will continue to be relatively tight for the next year or two.

I'm sure you've noted the numbers: 56.5 thousand annual job openings and 62.3 thousand annual degrees. But this does not mean more graduates than jobs next year. Just to make BLS whole, in its "tight" forecast the numbers can be accounted for. It is anticipated that 85% of these earning degrees will seek employment as engineers (it was 80% for the 1970-75 period) so that through 1985"... It appears that the number of persons likely to seek employment as engineers is roughly equal to the number of job openings."

For the immediate future then, through 1981 or thereabouts and perhaps longer, there will be an excess of demand over supply. For your industry here in New England, the local engineering education industry that is, it may mean large classes and the possible loss of some faculty to higher paying jobs in industry.

This region, the New England region, might be considered, at least in terms of present fuels, as "energy-poor". It is not rich in the currently dominant fuels: coal, oil and natural gas. Nor has the region developed extensive industries using the fuel which a decade ago was considered fossil fuel's apparent replacement, nuclear energy. (As you know, there's less certainty about that, at least for the moment). And, of course, the currently hot one, solar energy is not nearly as accessible here as it is in the sunbelt regions.

What that could mean is that your local colleges and universities train engineers for export. We do have some information about mobility drawn from the special post censal surveys conducted by the National Science Foundation. I referred to this data earlier, compiled for a statistically representative sample of over 1 million scientists and engineers in the 1970 census.

Based on this information, New England appears to be holding its own in the manpower balance of trade. In 1976, 55% of all who obtained their bachelor of engineering degrees in New England colleges and universities were employed in New England and 40% who received Masters degrees were working there. Since 56% of all engineers employed in your region received their bachelors degrees in New England and 47% of the Masters employed were New England degreed, engineering degree imports seem to balance engineering degree exports. In passing, it should be noted that on a variety of indicators, mobility patterns for energy related engineers are remarkably similar to those of the total population.

Next, I'd like to take a couple of minutes to describe some of the things we know about the energy engineering workforce. My information here is drawn from the special N. S. F. sponsored post-censal survey of scientists and engineers which I mentioned earlier and from the follow-on 1976 Survey of Natural and Social Scientists and Engineers.

For one thing, we know that the energy engineering workforce is growing. In 1976, a greater percentage of the experienced workforce reported that they were doing energy related work, than the percentage who reported two years earlier. Further, more of the new entrants into engineering report that they are in energy related work than does the experienced workforce (21% compared to 13.4%).

Again, the medium salary for energy related engineers was 6% higher than for non-energy. Since the age profile of the two groups, energy and non-energy, is nearly identical, energy related engineers clearly earn more than their peers. A similar differential was reported by new entrants.

The higher earnings in energy engineering is of course explainable in part by the fact that energy related engineers are more likely to be employed in private industry. 80% of the experienced energy engineering workforce was employed in private industry in 1976 compared to 66% for all engineers.

Turning next to the percentage in energy engineering by relevant engineering specialty, the array is about what we would expect:

- Two-thirds of the mining and petroleum engineers and two-thirds of the nuclear engineers consider that they perform energy related work

- as do 25% of the chemical engineers

- 18% of the mechanical engineers

- and 15% of the metallurgical and materials engineers.

Also, in every one of these specialities, a higher percentage of new entrants reported themselves as doing energy related work than did the experienced workforce. The energy engineering trend is obviously up.

Now, we're ready to turn to energy engineering employment in specific industries. As I sail, I'll try to give some information about a couple of key industries where such information is available and skip the rest.

I'll start with the situation in the dominant fuel industry, petroleum and natural gas. I recognize that there are probably not overwhelming numbers of Petroleum Engineers graduating from colleges and universities in this region, but I think the situation is instructive.

The data I cite is from a survey conducted in 1978 by the Society of Petroleum Engineers. During the five year period from 1973 to 1977, the industry's engineering employment grew by 50%, or 2800. About 1 of 3 engineers hired were degreed petroleum engineers, but the 41.5% growth in the number of petroleum engineers was less than the 50% percentage increase for all engineers. It is likely that the lower growth for degreed petroleum engineers is a result of short supply since most companies report that they fell significantly short of their petroleum engineering recruiting goals for most of the period.

For 1978-82, the industry forecasts that the numbers of engineers at work will grow by 9.4 percent (contrasted to 50.2% for the previous five year period). The demand for degreed petroleum engineers will be a little higher with a 16 percent growth anticipated.

Now there are problems with both the 1973-77 experience and the forecast for 78-82. Let's take the actual '73-'77 numbers. Universities graduated 1554; organizations hired 1247; on this basis, an excess of graduates. But companies reported that their hiring objectives for the period were nearly 2600 and that only about half could be filled with new engineers. On this basis, a surplus of jobs over graduates. Finally, 1850 were actually placed in entry level petroleum engineering classifications -- well above the 1247 hired from colleges. This confirms the impression that there weren't enough graduates to fill the necessary jobs. The current vacancies for petroleum engineers reconfirm the shortage impressions.

A similar numbers game can be played for the forecast period 1977 to 1982. Oil companies expect to add over 1700 engineers but only about 1200 of these would be petroleum engineers. Schools anticipate that over 3800 petroleum engineers alone will graduate during the period.

Therefore, all we can say with certainty is that the outlook should be reasonably good for the 1980 graduating class. After that we will look carefully and forecast again. It should also be noted that currently the National Petroleum Council, per request from Dr. Schlesinger, is undertaking a detailed materials and manpower requirements study which we will follow closely.

Next, let's turn to employment in nuclear energy. This is the fuel that energizes industries which have travelled at least in part the distance from R&D to commercialization. In the present case, it also means that the trip has involved a shift from the public to the private sector. The numbers are clear.

In 1968, 30% of the 142,000 employed were in the private sector; 70% in the public sector, primarily at GOCO's, the Government-Owned Contractor-Operated Atomic energy establishments.

In 1973 private employment exceeded public for the first time and by 1975 the trend was well established with 55% employed in private industry and 45% in the public sector; in 1977, of the total 227,000 employed, 57% were in private and 43% in the public sector.

There is one major advantage to this shift -- stability. Public sector employment in atomic energy is almost totally dependent on federal expenditures and that spiggot goes on and off rather erratically. Private sector nuclear energy employment is tied to levels of business activity and is more stable.

Engineering employment trends have generally paralleled total employment. The percentage of engineers had grown to nearly one-fourth of the total nuclear employment in 1977 compared to 16% in 1968.

A shift required in engineering specialties is occurring as a result of the public to private shift. Relatively fewer EE's, ME's and Chem.E's are required in the private sector. The largest growth has involved Civil Engineers who constituted 6% of private sector engineers in 1968, over 11% in 1975, and 13% in 1977.

Turning to the New England Region, past available data indicates a picture here of stability. For example, in 1963, slightly over 7000 were employed in nuclear energy here in New England. This represented 5.1% of total atomic energy employment. Twelve years later, in 1975, 5.3% of the total nuclear energy workforce was in New England, about 10,500. In 1977, this rose to over 6% and a total of 13,800.

This stability is somewhat unusual since most regions were not stable. For example, the Mountain States employment share declined from 21% in 1963 to 13% in 1977 while South Atlantic grew from 8% to 12%.

In summary, the nuclear energy employment in this region should be stable with more opportunities for civil engineers and somewhat fewer opportunities for EE's and ME's, although please note that EE's and ME's continue to be employed in significant numbers.

The same outlook exists for nuclear energy in the near term for the nation as a whole; a continued slight growth in private sector employment. However, the longer term employment is so dependent on uncontrollable events, that I hesitate to forecast. It would be difficult at this point to guess at the outcome of issues dealing with waste disposal, safety, environment and the rest. I can't anticipate too well the impact of further oil emergencies or federal fiscal constraints. My crystal ball nowadays resembles more a pinball machine going "tilt".

That's the situation in nuclear energy. As I said earlier, we have scattered information about energy engineering employment in other industries, with substantially more in process. Six months from now I'll be able to give both more variety and more depth.

For our colloquy though, I'll stop here.

- You know what our Manpower Assessment program is attempting.

- I've tried to give a little dimension to the energy engineering labor market and will, if time permits, answer questions to the extent I can about your concerns and interests.

Again, thanks for inviting me.

HISTORY REPEATING ITSELF? TRENDS IN U.S. ENGINEERING DOCTORAL PRODUCTION

A Paper Entitled

ENGINEERING DOCTORATES AWARDED AND ENROLLMENT TRENDS IN THE USA

Dr. Kenneth G. Picha, Director
Office to Coordinate Energy Research and Education
University of Massachusetts

(read by Associate Dean Joseph S. Marcus)
(School of Engineering/UMass)

In September 1978 a report was presented to the National Association of State Universities and Land Grant Colleges, Committee on Energy and the Environment, which discussed the state of manpower assessment regarding future doctoral level manpower availability to work in energy-related fields. An update of data included in the September 1978 report is presented as well as a finer breakdown in several engineering disciplines. Two issues seemed key -- it is well known that doctoral enrollments in the Nation's Engineering Colleges are decreasing as evidenced by decreased PhD productivity and, secondly, it is anticipated that a larger fraction of those earning engineering doctorates are foreign students.

The Energy and Environment Committee expressed real concern regarding engineering doctoral productivity since many of its members recalled the immense national effort of the 60's to increase engineering doctorate productivity. If one goes back to engineering doctoral level productivity in the 40's and 50's, one finds the level stayed constant at about 600 per year for all engineering disciplines until about 1962. The missile crisis and the subsequent space race led various federal agencies and private foundations to initiate major programs to address geographical balance in doctoral productivity and, accordingly, to create new centers of excellence. Doctoral productivity moved from 600/year to over 3000/year within a ten year period.

The greatly exaggerated press reports of unemployed or underemployed engineering doctorates in the early 70's had an immediate effect on enrollments and production of doctorates as the following table shows.

Engineering PhD Degrees Awarded and PhD Enrollments

	72-73	73-74	74-75	75-76	76-77	77-78
Total Engr. PhD's	3487	3362	3318	2977	2814	2573
Foreign Student PhD's	708	1014	—	1060	995	874
Full Time Enrollments	13460	11904	—	—	—	12359
Full Time Enrollments (Foreign students)	—	—	—	3042	—	4383

These data are selected from several Engineering Manpower Commission reports. Unfortunately, changes in data collection resulted in some data being unavailable.

The following table presents data on engineering doctorates awarded to U.S. Citizens and Foreign Nationals in selected engineering disciplines which have a very close relationship to the solution of national energy problems.

Engineering Doctorates Awarded to US Citizens and Foreign Nationals in Selected Disciplines

	1974		1976		1977		1978	
	US	FOR.	US	FOR.	US	FOR.	US	FOR.
Chemical Engr.	256	147	202	131	195	106	153	106
Civil Engr.	249	144	208	174	165	161	170	114
Electrical Engr.	501	199	439	205	380	194	341	183
Mechanical Engr.	316	130	240	105	195	105	198	106
Mining Engr.	3	5	14	12	15	9	23	7
Petroleum Engr.	6	13	8	7	7	13	6	13

Engineering manpower specialists have been aware for some time of the large fraction of doctorates in mining and petroleum engineering which were earned by non-US Citizens. The phenomenon of decreasing interest in doctoral study on the part of the US Citizens is clearly reflected in the dramatic decrease in doctorates being awarded to US Citizens in the four traditional engineering disciplines of chemical, civil, electrical and mechanical engineering. It is also of interest to note that doctorates in these fields awarded to non-US Citizens has remained relatively constant over the past four years.

Although the Energy and Environment Committee was concerned about all energy related manpower needs, data for disciplines other than engineering are less complete. In a U.S. Department of Energy report "Energy Related Doctoral Scientists and Engineers in the USA 1975" November 1977, #DOE/IR 0033, it was pointed out that energy-related population accounted for just over 20 per cent of the doctoral degrees and doctoral level employment in engineering. "More specifically two employment areas (engineering and earth; environment and marine sciences) each had five fields in which over 25 per cent of those employed were involved in energy-related activities." Of all doctorates employed in energy-related fields, 44 per cent were engineers. Thus the health of the Nation's engineering doctoral programs is of extreme importance to the energy effort. We must have better data on the enrollment trends, doctoral production and the extent of foreign students being trained. The latter point could be of great significance if the mix of foreign students is changing and graduates do not plan to stay in the USA after completing their work. Fortunately, the EMC is once again collecting such data but have the data for only 1976-77. The National Research Council is also collecting such data and publishing the data in "Summary Report 1977 Doctorate Recipients from United States Universities". Their number for total engineering doctorates awarded in 1977 differs slightly from the EMC data in that a total of 2641 doctoral awards are shown rather than 2814. The following data concerning recipients of engineering doctorates in 1977 is interesting since it does give some indication of likely manpower availability.

<u>Engineering Doctorates Awarded in 1977</u>

Total	2641
United States Citizens	1457
Non-U.S. Citizens (Temporary Visa)	773
Non-U.S. Citizens (Permanent Visa)	325

The total of 2555 differs from the 2641 since 854 individuals receiving doctorates in 1977 did not report their citizenship at time of doctorate. Note that non-U.S. Citizens earned 43 per cent of all U.S. engineering doctorates awarded in 1977. These numbers for 1977 engineering doctorates were confirmed during a telephone conversation with Dr. Charles Dickens of NSF. He provided the data in the following table.

Nationality of Engineering Doctorate Recipients

	1972	1976
Total Eng. PhD's Awarded	3476	2791
Per Cent Received by U.S. Citizens	67.0	56.0
Per Cent Received by Non-U.S. Citizens with Permanent Visa	18.0	14.1
Per Cent Received by U.S. Citizens with Temporary Visa	15.0	29.4

The complete data for the years 1972-1977 are attached as Appendix I. Data on post-doctoral students collected by NSF were also studied. These data confirm the concern that most of our high level engineering training is focused on foreign nationals. With decreasing awards to engineering doctorates, part-time engineering masters programs believed to be the educational goal of most young American baccalaureate engineers, and increasing Arab students interested in engineering doctorates, the Nation could be on a course that would result in the numbers of young Americans earning the engineering doctorate reduced down to the levels of the 50's.

Although our report is not definitive, there appears to be sufficient data to indicate a very serious problem for the next decade. It is recommended that appropriate Federal agencies move quickly to develop better manpower data for doctoral level energy-related scientists and engineers.

APPENDIX I

PERCENTAGES OF Ph.D's AWARDED BY CITIZENSHIP AND MAJOR FIELD, 1972-1977

Total Science (Excluding Engineering)

	1972	1973	1974	1975	1976	1977
U. S. Citizens	82.6	81.7	80.6	81.6	82.6	82.8
Permanent Residents	6.6	6.5	6.0	5.5	4.7	4.5
Temporary Visa Holders	10.8	11.8	13.4	12.8	12.8	12.7
Number of Science PhD's	15651	15782	15339	15527	15298	15000

Engineering

	1972	1973	1974	1975	1976	1977
U. S. Citizens	67.0	64.5	59.0	57.9	56.4	57.2
Permanent Residents	18.0	16.7	17.2	14.2	14.1	12.7
Temporary Visa Holders	15.0	18.8	23.8	27.9	29.4	30.1
Number of Engineering PhD's	3476	3339	3121	2961	2791	2641

Source: National Science Foundation

Comments Regarding K. G. Picha's Paper

J. S. Marcus

1. Has it been determined that there is a need for doctorates and, if so, how large is this need?

2. The problems cited in the paper regarding the energy industry are as valid in other technological areas as well.

3. Academe, like the real world, has difficulty getting information on which good predictions can be made.

4. Students choose majors for a variety of reasons. One of them is frequently the current state of the economy. Little account seems to be taken of the fact that, by the time the student completes his work, the market may have shifted.

5. The number of doctoral students is inversely proportional to the state of the job market. In "good times", students go to work to take advantage of the many jobs and high salaries and graduate enrollments shrink. The reverse phenomenon is valid when the market is poor.

6. Neither industry nor government is willing to take long-range gambles in support of graduate students. If a long-range need can truly be predicted, why does not someone make support commitments for graduate students as a "fly-wheel" to short-term perturbations in the economy?

A PANEL

REGIONAL DEMAND/SUPPLY PERCEPTIONS OF ENERGY-RELATED ENGINEERING MANPOWER : CONNECTICUT

by

Dr. Armand Zottola, Chairman
Department of Economics,
Central Connecticut State College

It is my task to offer my perceptions on the general labor market conditions which allocate energy-related scientists and engineers in Connecticut. Before commenting on our situation, I believe that it should be pointed out that "energy-related" is not a classification, as yet employed, by the Connecticut Labor Department. Indeed, it appears that only in the last three-odd years has any effort been made, even at the federal level, to survey manpower pools with this kind of dis-aggregation in mind.

Fifteen months ago the U.S. Department of Energy did publish[1] the results of a survey covering "doctoral scientists and engineers". The results indicated that "nearly 8 percent of the 263,000(20,850) indicated that they spent a significant portion of their professional time in energy - and-fuel-related activities." Nationally, 45 percent were engaged in research and development, 30 percent managed/administered R & D activities, 10 percent were teaching in the area, and the remaining 15 percent were occupied by "other" miscellancous commitments. Presently, there is no way of knowing if this national pattern holds for such personnel in Connecticut. The disposition of holders of the masters and bachelors degrees is unknown.

Surely, one of the results of this gathering should be a recommendation that the U.S. Department of Labor, through its Bureau of Labor Statistics, make every effort to develop a regionally dis-aggregated, supply-demand model for all energy-allied occupations.

Until that task is completed, it is important, especially given the events of the past few weeks, to ascertain the current and near term patterns that will characterize the energy industry on both sides of the labor market.

In the spring of 1978, Nordlund and Mumford, writing in the Monthly Labor Review[2], suggested that the industries with the following Standard Industrial Classification codes (SIC) accounted for the greater part of America's energy industries: 11, 12, 173, 3433, 3511, 3532, 3533, 3566, 3612, 362, 367, 374, 291, 295, 299, 40, 42, 46, 44, 491, 492, 506, and 554. With this listing applied to Connecticut's Survey of Manufacturers the following energy-related industries were identified and are summarized in Table 1.

Table 1

Energy-Related Industries in Connecticut: 1975

SIC Code	Name of Industry	Total Employees	Production Workers
361	Electrical Dist. - Equip.	4,800	3,000
362	Electrical Indus. - Apparatus	3,700	2,100
364	Electrical Light, wiring equip.	5,300	3,700
3643	Current-carrying wiring devices	3,200	2,100
367	Electrical, components, access	6,500	4,800
3679	Electrical components	2,700	1,900
		26,200	17,600

Source: U.S. Department of Commerce, Bureau of the Census, Annual Survey of Manfacturers, 1977, Table 3.

In 1975, the manufacturing labor force in Connecticut was 398,500; therefore, 6.57 percent were directly employed in the production or distribution of energy. Of the total employed, 67.17 percent were production workers, leaving 32.83 percent as administrators, researchers or other non-production employees. In other words, our universe of potential energy-related engineers and scientists is reduced to 8,600. Obviously, most of these were involved in general administration.

The demand for energy-related personnel can be approximated even more tightly by referring to the Department of Energy survey quoted above. In 1975 there were 328 doctoral scientists and engineers employed in energy-related activities in Connecticut, representing 1.6 percent of all such personnel nationwide. If we were to assume a staff ratio of 2:1 for holders of the bachelors and masters to the doctorates, then we arrive at the estimate of 984 energy-related scientists and engineers employed in Connecticut in 1975. That number might be taken as a crude approximation of the demand for such personnel at that time.

To make room for dynamic conditions in this analysis the following caveat is too tempting to pass up. At this time, the only significant application for power plant construction before the Connecticut Public Utilities Control Authority is for the nuclear facility called Millstone III. This application may be said to be in a holding pattern. The application is made by Northeast Utilities, whose personnel rolls have actually declined continuously throughout the 1970's! One might ultimately observe that no net change in their employee ranks might be anticipated even if construction is renewed on Millstone III. This possibility of stable or declining employment, becomes even more appreciable when one reviews the energy-consumption patterns in Connecticut in the recent past.

Table 2

Gross Energy Consumption - Connecticut

(measured in trillions of Btu's)

1960	- 499.35	1968	- 650.89
1961	- 506.62	1969	- 684.25
1962	- 524.47	1970	- 708.01
1963	- 536.12	1971	- 733.47
1964	- 560.43	1972	- 766.46 (peak)
1965	- 560.94	1973	- 745.63
1966	- 602.93	1974	- 737.16
1967	- 608 56	1975	- 691.77

Source: U.S. Department of Energy, Energy Information, Administration, Federal Energy Data Systems, Statistical Survey, Washington, D.C., 1978.

What Table 2 indicates quite clearly, along with substantially more data in the reference, is that a sharp reversal in energy consumption has been in process since 1972. Given the time-consuming behavior of the state's PUCA in granting approval for new construction, it is hard to believe that we shall be surprised by any surge in demand for energy-related scientists or engineers in the near future. It is more reasonable to anticipate a quiet stability.

The supply-side of the market is not likely to hold any unpleasant surprises for Connecticut either. A short time ago the chief economist for Northeast Utilities shared an interesting story with me. In the process of filling a small number of nuclear engineer positions recently, the company had the luxury of choosing from among 600+ applicants! This was all but impossible to believe. However, the answer lies in the field of labor economics. Nuclear engineers are cleared in a national labor market. Under such conditions, the employer in a position to offer the highest salary package is likely to enjoy the greatest selectivity. Labor market supplies can also be influenced by the cultural advantages which a region offers, the climate, the cost of living, and the general quality of the community in which the firm is based. Sometimes all of these elements outweigh the economic provisions of a company offer.

The evidence suggests the possibility of a relative shortage of engineers on a national basis. This conclusion is supported by the rapidly rising incomes being offered to engineers, especially the rapidly rising incomes being offered to engineers, especially upon graduation. Such a relative shortage should be self-correcting. The labor markets for engineers are responsive to shifts in demand with a three-to-four year lag. In the short-run however, existing shortages lend an advantage to firms with the highest ability-to-pay. In a state with an abundance of amenities external to the job, labor supplies, particularly of professionals, will be superior.

In summary, the short-term situation in Connecticut appears to be one of stable or incrementally drifting demand for energy-related engineers and scientists accompanied by a superior market situation as far as supplies go.

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REGIONAL DEMAND/SUPPLY PERCEPTIONS OF ENERGY-RELATED ENGINEERING MANPOWER in (MASSACHUSETTS

by

Ms. Christine LeCam, Economist
Massachusettts Department of Manpower Development

The Research and Program Development Division of the Massachusetts Department of Manpower Development has the following overall responsibilities: To undertake labor market research to guide the formulation of employment and training policy by state and local officials; to describe and assess economic developments within the state as a whole and within local labor areas throughout the state that have implications for the employment and training system; to produce and provide labor market information for use in the planning of educational, employment, and training programs by CETA prime sponsors and public vocational education planners; to conduct research into specific labor market problems in order to guide the development of new programs for selected target groups in the state's economically disadvantaged population; and finally to develop and maintain a comprehensive, uniform, statewide evaluation system for CETA Title Two employment and training programs.

Because our responsibility is to the employment and training system the focus of much of our occupational research has been on 'trainable' occupations; specifically those occupations which require less than a baccalaureate degree. Two research projects in our office may be of interest to this group: they are the labor supply project and the demand-supply matching project. The first project, labor supply, is a cooperative effort between R&PD and Northeastern University and is funded by the Division of Employment Security. This project, which is near completion, identified 15 high net demand occupations in the Boston SMSA. These high net demand occupations are projected to experience substantial openings due to both growth and replacement demand through 1985. The study examines for these 15 occupations the related public and proprietary vocational education programs as well as the related CETA skills training programs. In addition, the study includes interviews with approximately 300 firms in the Boston Labor Market Area to obtain information on hiring requirements and hiring practices of firms employing these 15 occupations.

An extension of this original project is currently on-going in R&PD and is referred to as the demand/supply matching project. The goal of the project is to provide planners in the employment and training system with knowledge of the current and projected demand for occupations as well as information on the numbers of individuals being trained in each area. In the past, planning for training programs has typically taken into consideration only the demand for a specific occupation and has ignored supply side questions such as the numbers currently receiving training in a given occupation. Generally, public and private vocational education programs, CETA skills training programs and community college programs offer training in skills that prepare students for employment in more than one occupation. Thus, completions in these programs can not readily be translated into estimates of the institutional supply of labor to these occupations. R&PD has been working to provide a methodology for translating training program completions to estimates of the occupational supply of labor which can then be compared to information on anticipated occupational job openings. This information will provide a basis for beginning to identify where occupational shortages and surpluses occur. Further research will then be necessary to determine why these mismatches occur. This research is being conducted for approximately 280 Census occupational titles. These occupations were selected because they require less than a four-year degree for entry.

This research on the demand and supply of labor on-going in R&PD relates to this conference in two ways: first, the expansion of energy-related industries requires both professional and non-professional manpower, shortages of trained manpower in either category will inhibit the growth of these industries; second, similar problems and information needs will arise whether developing a demand-supply model to identify shortages or surpluses of professional or non-professional manpower.

The remainder of this paper will be devoted to the types of labor market information that would be helpful in developing an understanding of the demand for and supply of energy engineering manpower. A first step in analyzing energy manpower is to identify by Standard Industrial Classification (SIC) codes those industries which comprise this field and further to examine historical trends in employment in these industries. Information on industry employment can be obtained from the ES202 series, which is a quarterly employment report of employment and wages provided by establishments covered under Massachusetts Unemployment Insurance Laws. The ES202 survey is conducted by the Division of Employment

Security (DES) and currently accounts for approximately 92% of total statewide employment. From this source we know that employment in petroleum refining (SIC 291) in Massachusetts has risen from 15 persons in 1973 to approximately 235 persons in 1977. Further, employment in the electric services industry (SIC 491) peaked in 1974 with 12,700 persons employed; however, employment in this industry dropped to 10,230 in 1975. By 1977 this industry recovered somewhat with employment of 11,000, although this is still below the peak employment. In the industry, gas production and services (SIC 492), employment peaked in 1973 with 5400 persons employed but has steadily declined to 4,800 persons employed in 1977. The ES202 cannot be used to determine employment in nuclear and solar activities or other energy-related industries. The reason for this is that these industries are included in SIC codes which also include non-energy-related industries. Consequently, employment reported for these SIC codes includes both energy-and non-energy-related employment and is of little assistance. Surveys should be developed to obtain information on energy employment not readily available from the ES202.

The second important piece of information is knowledge of the occupational compositions of energy industries to determine the manpower requirements of these industries. This information is necessary as the types of jobs openings and the required supply of labor will differ by industry. For example, according to one study, nuclear energy utilizes fewer trades people per professional scientist or technician than does solar energy. The ratio of trades people per professional is 2 to 1 for nuclear energy while for solar energy the ratio is 9 to 1. This fact has important implications on the demand for different types of skilled manpower in Massachusetts. Information on occupational staffing patterns is available for many detailed industries in Massachusetts from the Division of Employment Security. This information is gathered from a survey of firms in each industry in Massachusetts. Again, this information must be supplemented by additional surveys to obtain information on the occupational staffing patterns of specialized energy industries.

An understanding of the dynamic factors within industrial and occupational areas can provide valuable insight into both the nature and extent of labor market activity among energy-related industries and occupations. In particular, information regarding labor turnover (i.e., new hires and separations resulting from layoffs or quits) can provide some indication of how labor transactions are related to either overall labor market tightness or specific structural factors such as the skill requirements or relative wages among various industries and occupations. Unfortunately, the major source of labor turnover data provides information regarding separations and accessions for manufacturing industries only. This data is produced jointly by the Massachusetts Division of Employment Security (DES) and the Bureau of Labor Statistics (BSL) for manufacturing industries at the two digit SIC code level of specification for the seven major labor areas and for the state as a whole. This level of specification is not sufficiently detailed to examine the functionings of energy-related industries. It would appear that special surveys of energy-related industries will be required to obtain adquate labor turnover information for the appropriate industries and occupations.

When examining current supply and demand imbalances, an analysis of the number of unemployed and existing job openings is a good starting point. Although people who are employed may compete with the unemployed for existing job vacancies, a comparison of unemployed to job openings can provide a measure of overall labor market tightness as well as specific occupational shortages. Those occupations with a larger number of job openings than existing qualified unemployed individuals would appear to be occupational areas that may be experiencing shortages. Currently information is produced by the DES on the characteristics of the insured unemployed by occupational area for Massachusetts and provides some indication of available labor supply. It should be emphasized that the insured or covered unemployed represent only a portion of all the unemployed. In addition, the occupational detail available is often too aggregated to relate to energy-related occupations.

Analysis of this information indicates a relatively low level of unemployment for engineers. In 1975, according to the Characteristics of the Insured Unemployed, there were approximately, on average, 900 electrical engineers registered as unemployed with the Division of Employment Security. By 1977 the number of unemployed electrical engineers had dropped to approximately 240, and has remained at this level through the first half of 1978. For nuclear engineers, the figures are much lower. In 1975, there were no nuclear engineers registered as unemployed. However, in 1977 an average of 42 persons were registered as unemployed with DES. This appears to have been a short-term lay-off because, for the first half of 1978, no nuclear engineers were reported unemployed. Examination of the number of unemployed reported in all other engineering occupations also indicates a relatively low level of unemployment. The ratio of the number of reported unemployed engineers to the engineering labor force indicates a relatively low unemployment for this group and may provide evidence of either a situation approaching equilibrium or a potential shortage of engineers.

This information can then be compared to existing job bank orders that are also available from the DES. It should again be pointed out that many firms do not list job openings with the DES and the job bank represents a portion of existing job openings. On an optimistic note, the DES and BLS are currently engaged in a pilot job openings survey (JOS) which is designed to collect the number of job openings by industry and detailed occupation. It is hoped that successful completion of this project will result in an accurate measure of industry and occupational vacancies which can then be compared to the number of unemployed. This effort may then result in the ability to estimate a ratio of unemployed to job vacancies by industry and occupation and improve our capability of identifying shortage occupations.

Information on future industry and occupational employment is also necessary so that shortages and surpluses of manpower do not occur. This is particularly important for energy-related industries which require high level technical manpower. The long lag time associated with educating and training of engineering manpower is an important factor and must be taken into consideration if critical shortages of highly trained manpower are not to occur in the future. Currently, projections of employment through 1985 for 201 detailed industries and 421 detailed occupations are available from the Division of Employment Security. These projections are based on industry employment from 1958 through 1974 and occupational patterns reported in the 1970 Census and national occupational change factors. These projections rely primarily on straight line time trends in industry employment and consequently are not particularly useful to the many of the energy-related industries which have just recently begun to develop in this state. Research is necessary to refine and develop manpower forecasting techniques so that they are more applicable to energy-related industries and manpower.

Further, information on the hiring requirements and practices of firms employing energy-related engineering manpower is also a necessary component of an occupational information system for energy-related engineering manpower. Information on hiring standards and requirements, wages, and promotion opportunities is generally not available but could be generated by sample surveys of firms employing energy-engineering manpower. The findings of these surveys could be utilized to determine if the type of training being conducted is suited to the industries' needs. In addition, this information could be used to develop occupational profiles which could in turn be used to counsel students in making career decisions as well as guiding job seekers.

The final component of an occupational information system for energy-related engineering manpower is knowledge of the type, level and magnitude of training in existence. Specifically, this requires information on the types of engineering-related programs offered, and the absolute number and type of degrees awarded. This information is reported to the National Center for Educational Statistics (NCES) and is obtained from the Higher Education General Information Survey (HEGIS). The results of this survey are published annually by the Massachusetts Post-Secondary Education Commission (1202 Commission). This information will provide a basis for developing estimates of the occupational supply of labor originating from post-secondary institutions to energy-related engineering occupations. In addition to the information on the number of degrees awarded it is necessary to obtain follow-up information on program graduates. This is necessary to determine the number of engineering graduates who do not eventually become part of the region's occupational supply of labor to energy-related industries. This leakage from the region's incremental supply of energy manpower may occur as a result of migration to other regions, graduates competing for jobs in non-energy-related industries, graduates who continue their education, and finally graduates who take jobs unrelated to their training.

Comprehensive follow-up information is necessary to determine the number of graduates who remain in the region available for placement into energy-related industries. Presently, many universities may conduct individual follow-up studies of their own graduates; however, often this information is not in a form which is readily useable. A consistent statewide follow-up system conducted by all institutions offering engineering programs is necessary to estimate the available institutional supply of labor to energy-related occupations.

In conclusion, there is insufficient information to accurately describe the current or projected demand-supply condition for energy-related engineering manpower. Massachusetts is not unique in this respect, as most states do not routinely collect energy-specific labor market information. What can be done at the present time is to recommend analysis of all existing data pertaining to energy manpower and to supplement this data with special surveys on those areas where our information is incomplete. A brief analysis of industry employment data indicates an increase in employment in petroleum refining, a slight decline in employment in electric systems over the past five years and a slight decline over this same time period in employment in gas production and services. The reason for the decline in employment in electric and gas is unclear from this simple analysis of employment trend data. Little can be said of employment trends in industries related to nuclear or solar energy in Massachusetts. Our perception is that it is increasing, however this has not been documented by a comprehensive survey of firms in these industries for Massachusetts.

Analysis of the occupational characteristics of the insured unemployed from 1975 to June of 1978 indicates a relatively low unemployment in all professional engineering occupations. Information on the incremental supply of labor originating from post-secondary institutions has not been analyzed. However, research funded by the Department of Manpower Development is being conducted by MIT to determine the feasibilty of constructing a demand-supply model for high-technology manpower. This research should provide insights into both the demand and supply conditions for engineers which can then be applied to energy-related engineering manpower.

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SUMMARY PROSPECTUS FOR THE REGIONAL DEMAND/SUPPLY DELTA IN ENERGY-RELATED ENGINEERING MANPOWER

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I had thought that perhaps by this time I would be able to put some charts and graphs here on the board, summarizing what we've heard, draw some lines and discover the elusive delta where they cross; and then that I could sit down. However, that appears not to be the case. I need to find another way to describe the situation I have heard discussed.

My first introduction to the energy crisis occurred when I was age 13. Where I lived, at that particular time when I was growing up, we didn't have electricity. I lived in a rural area and it was my job to crawl up a 30-foot tower and repair what at that time we called a "wind charger". I don't know that many of you know what a wind charger is, but it's a 32-volt system that provided electricity for us. While we may talk about conservation, you don't know what conservation is until you have to depend upon the wind and your battery goes down and your lights start to go yellow. In that respect I've had an early introduction to energy and the need for conservation.

I must admit that when our conference first started I thought that perhaps the heat level that was being generated here would be connected with the amount of light that would also be generated by this time. However, it appears that we don't have the kinds of statistics that would shed a great deal of light on the questions about which I am most concerned.

I'm basically in the business of training vocational counsellors, helping rehabilitation counsellors, school counsellors and those who work with people making mid-career changes, doing workshops and research in that whole particular area. In that connection I want to second what some of the speakers, nearly everyone here, have said regarding the need and concern for the engineering profession to recognize that the problem we're talking about is not necessarily only a technical one. I think that's implicit but I'd like to make it explicit: I think it's political, educational, sociological, and deals largely with concepts of life style. I was happy to hear the Sister when she talked about working in the high schools because, in my work with high school counsellors, and in the whole career education effort now going on in most states, the effort is being made to begin a turnaround in the notions that many youngsters have had about technology, and their rejection of technology as a source of answers.

In connection with our concerns for technological manpower, I think it may be very important to come to grips with this attitudinal question, attend such events as Earth Day and talk with young people in junior and senior high schools, even in elementary school. I've been very interested to learn that there's an entire curriculum being developed along these lines that will be useful from kindergarten clear thru the 12th grade.

My summary is going to be very short. Partially because its difficult to summarize all the diverse ideas that are here. Also, I don't want to try to summarize them because I think, in part, that will ruin it. Sometimes we saw different things that were very important to us and I would hate to say that they are not important by my summary comments.

One of the things was clear. I'd like to look at this like a fraction in which we have a common denominator. From our first speaker we heard that there is a backdrop of concern relative to manpower that deals with questions of productivity. You're all well aware that the statistics for productivity have been declining. Those of us who are in the business of counseling and working with people recognize it. Somehow, maybe by counseling and career planning, we can increase productivity. I wish I could give you some research data that says that definitely is true, that when we provide people with concepts of a career ladder it helps, or if they plan early and develop a long term career pattern we can increase productivity. It doesn't always work -- it works for some people but not for others.

Another issue is very much present, a complex issue, also a part of our common denominator. This issue involves many different factors: inflation, what's happening in Iran, what's happening in terms of lack of capital, and what has happened to that capital because of an increased need to use that capital for energy. Also included in our common denominator is our birthrate change. Most of you probably have read that recently the birthrate tipped up a little bit. We're not too sure whether that line was quavering last year but recent statistics indicate that it's going up. The fertility rate of those people in the 25-30 age range for some reasons -- maybe they've discovered something -- has increased in some respect. That has led to the increase in birthrate. It's now about at the junior/senior year in high-school that the population level drops off. That's going to be moving into the colleges and universities in the next few years, and it will be low for a period of time that we have yet to learn about. So much for the kinds of issues that comprise our denominator.

On top of our fraction, in our common numerator, a number of engineering issues were pointed out. I'll summarize these very, very briefly in terms of their impacts on manpower. I sense, in terms of the data presented here -- maybe more will be presented tomorrow -- and from my own experience in working with people in industry as well as from some very informal surveys, that the expectations or demands are going to be fairly stable in energy-related manpower. I think that's something that came across to-day not only because there's a lack of data otherwise but because some of you had some good hunches, obviously much better than mine. However, it appears that there's not going to be a big demand for people to go into the energy field.

I think another thing that I was expecting, and sometimes people are misled by, is something called "energy engineer" -- that we're going to have an occupation involved with energy engineer or energy technician. It appears clear to me that we need to be sure that we communicate to our young people, in terms of career planning, that the energy field is interdisciplinary. It's a multifaceted thing of concern to "engineering" whether it's mechanical, electrical, industrial, or whatever the case may be. All of those areas will be concerned with energy, energy production, energy conservation.

Probably the biggest thing that I heard to-day was the need for universities to turn to, and maybe industry to cooperate in, doing a lot of inservice training for those people who are already in industry. I think the turnaround time for people to go through a 4-year program with an energy focus is going to be too long. From what I hear, the crisis will occur and we'll know about it when we line up as we did back in the early 1970's at the filling station. We were there sometimes at 6:30 at night to line up to get gasoline. Then we will become very aware of it. It will probably take something like that before we act. So I think that universities ought to be doing some things, hopefully in terms of providing career ladders, providing some training for those people already in engineering.

One of our national problems right now, that sort of belongs in the common denominator, that I want to mention, is the whole question of underemployment. As you know, that's a national problem, probably not so much in engineering. It's the source of some problems in mental health that relate to work, some problems in terms of productivity. There's a sense of expectation as we encourage youngsters in our schools, thru our career education programs, to expect a good job, the good life. As I look at the statistics, and maybe there's some correction needed here, those good jobs aren't increasing as much as the demand and expectations for those good jobs are. I think it's important for us to clarify, in our statistics about manpower, that the issue of not necessarily being able to find that good job immediately upon leaving high school or college is there. It's something you have to plan for over a longer period of time.

I want to close, then, with these comments. One point that was made that I want to re-emphasize uses the word "adaptability". I think in terms of industry, in terms of education, in terms of government, the notion about adaptability, and being able to quickly turn around and respond, has been one of the trademarks of the engineering field. I hope that's maintained. I hope, in terms of that, that we recognize that engineers, by and large, are what I call multipotential. It's possible for them to understand that they can go into many different fields that relate to this whole energy crisis, or look at in terms of their own field, rather than think about it as a particular speciality.

Probably the final result of our presentations so far, and what we've heard discussed, is that we've learned a little bit about what questions to ask. Maybe if what comes out of the conference to-morrow is that were better able to ask those questions at the university, of ourselves and of industry or of government in terms of what it can provide, along with responses to those questions, it will better help us after we leave to-morrow to take more concrete, more specific, probably not so grand kinds of steps. Hopefully we can come up with some very specific steps that will enhance the manpower level and enhance the ability of the manpower level that presently exists to adapt to conditions and to change.

Perhaps it will also get us involved as a professional, as a total university, with schools, with young people, to make them aware of what is happening in the energy crisis. We need to be aware of what's hapening, what kinds of skills are needed and how we can best adapt those skills to our needs.

Thank you all very much.

COLLOQUY, PART II

IMPORTANT WORKSHOP CONSIDERATIONS

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A MARKET MODEL OF ENGINEERING MANPOWER DEMAND AND SUPPLY

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(herein is reported a more formal, more complete version of the transcribed conversational presentation which is reported in the Appendix)

1. INTRODUCTION

Substantial fluctuations in recent years in the number of college graduates in science and engineering have called into question traditional models for forecasting the supply of new entrants to technical and professional labor markets. In this study, we present the results of an investigation of recursive econometric models for explaining and forecasting future numbers of degree recipients. These models show substantial improvement over traditional trend extrapolation models in predicting future fluctuations in the supply of new graduates.

Better forecasting models are of increasing interest — to college administrators for forecasting enrollments, to government planners for assessing the manpower needs and impacts of government funding programs, and to students for assessing future career possibilities. This study is aimed primarily at professional labor market analysts, and focuses on the methodology and validation of the models presented, rather than on actual forecasts. Some sample forecasts are presented, however, in an effort to check the operation of the models as forecasting tools.

We begin with a review of recent trends in the number of new graduates in selected professional fields. Weaknesses in traditional models for forecasting manpower markets are discussed, and a theoretical framework, based on recursive or cobweb models is presented. Empirical validation of these models for bachelors and PhDs constitutes the bulk of our study. These models are then used to construct simplified forecasts of future graduates for several disciplines and degree levels. Finally, we present some preliminary results concerning the stock of scientists and engineers, which will be the focus of Phase II of the present study.

2. PRINCIPAL FINDINGS

The major finding of this study is that recursive cobweb models offer significant improvement over trend extrapolation models in explaining fluctuations in bachelors and PhD graduates in engineering and the sciences. Moreover, the underlying assumptions of the model are validated by empirical results in a number of fields. These results are:

- that enrollments respond swiftly to changing market conditions in various specialties at both the undergraduate and graduate levels;
- that the rate of completion by enrolled students is also responsive to changes in market conditions at both the undergraduate and graduate level;
- that market conditions, as reflected in starting salaries, depend both on demand variables and on current supply (e.g., graduates);
- that salaries available in alternative occupations exercise a significant influence on field choice;
- that demographic factors -- such as numbers of high school graduates -- are significant in explaining trends in bachelors degree recipients.

Suitable demand indices are developed which significantly improve our ability to explain undergraduate degree trends. These indices range from aggregates such as total R&D spending to field specific indicators such as the medical school acceptance rate as a predictor of degrees in biology.

For PhDs we are able to demonstrate the responsiveness of enrollments and completion rates to market conditions, but have had only limited success in formulating reduced form equations for forecasting purposes.

Finally, our models have been used to construct forecasts of future behavior in several markets. Perhaps the most interesting is our prediction that 1978 will be the peak year in the current surge of engineering enrollments, which will steadily decline over the next several years.

We turn now to a more detailed summary of our report.

3. HISTORICAL TRENDS

The number of degree recipients in various technical disciplines over the past 15 years has -- for most fields -- been marked by an initial period of steady growth, followed by a near universal downturn, beginning around 1972. This pattern, which can be found in fields ranging from mathematics to history, appears closely related to significant changes in government policy, including R&D spending and numbers of fellowships granted, which parallel the changes in degrees wanted. Related changes can also be observed in such variables as starting salaries for degree recipients, and in the unemployment rate for technically trained persons.

For example, real starting salaries for all college graduates rose sharply between 1960 and 1969, ranging from a low of 24.3% for electrical engineering majors to a high of 34.6% for accounting majors, compared to a growth rate of 17.4% for economy-wide average hourly earnings over the same period. In contrast, real starting salaries underwent a sharp decline in percentage terms between 1969 and 1974. Percentage declines ranged from 6% for metallurgy majors to 16.1% for mathematics majors and 17.3% for humanities and social science majors. A decline in starting salaries for MS and PhD candidates relative to BS candidates in many fields preceded the 1969 turning point in absolute real starting salaries. Especially in engineering, relative starting salary ratios, MS/BS and PhD/BS have declined markedly, possibly starting before 1962.

Traditionally, technical BS candidates have enjoyed a substantial starting salary advantage over their non-technical classmates, but in percentage terms, the technical BS premium fell somewhat throughout most of the 1960's. In 1961 technical BS recipients earned 20% more, but in 1970 only 14% more, than their non-technical classmates, though this tendency appears to have reversed slightly after 1970. This reversal may account for the relatively strong rebound in enrollment levels for engineers in the last few years.

The unemployment rate for professional technical workers relative to all workers has risen markedly since 1968. Moreover, the ratio has not declined substantially since its 1971 peak. In addition to the general increase in this ratio, its historical pattern of cyclical fluctuation has recently been reversed. Customarily, the ratio of unemployment rates (professional to overall) would be expected to be negatively correlated with the business cycle, as employers hoard professional labor relative to non-professional labor during cyclical down-swings. In contrast, during the 1970 recession, the unemployment rate ratio moved sharply pro-cyclically.

In terms of occupational status, the recent relative deterioration of the labor market position of new college graduates is even more pronounced. Among new college graduates taking jobs in 1958, all but 13.8% of men, and all but 10.5% of women, obtained employment in professional or managerial positions. In 1971, by contrast, the comparable proportions were 30.5% for men and 24.4% for women. Thus a growing proportion of new college graduates have been taking first jobs outside the traditional areas of management and the professions.

Changes in the relative labor market situation of new PhD recipients are also evident. College and university-level teaching jobs are less abundant. Thus a higher proportion of new PhDs are taking first jobs outside academia; among these remaining within the universities, a higher percentage are taking post-doctoral fellowships rather than regular teaching or research positions.

Changing trends in professional labor markets have numerous implications for constructing models of student behavior. First, it shows that the number of degree recipients has not been following a smooth trend. Moreover, the fact that there has been a similar downturn in several fields suggests a common external origin for the observed behavior. Second, the decline in degree recipients has been coupled with a decline in salaries, suggesting an economic explanation for the data. This view is reinforced by the statistics on unemployment. The observed correlation, or lack of it, between various fields suggests which fields are substitutes and which are complements -- information useful for constructing models. Finally, the changing pattern in eventual job types of degree recipients is important in constructing demand indices for college graduates.

4. REVIEW OF MANPOWER ANALYSIS METHODOLOGIES

Two primary methodologies have been used in analyzing labor markets, "manpower requirements" techniques and "rate of return" analysis. In essence, the requirements analysis forecasts labor demand while the rate of return approach forecasts the supply. The fact that neither attempt to forecast both demand and supply jointly, and the restrictive nature of the models themselves, form the basic problems with both approaches.

Under certain conditions, the requirements model may produce very accurate forecasts. When industrial composition fluctuates widely among industries with different skilled labor ratios, and when supply is assumed to be perfectly elastic, requirement predictions may be correct. But these are very strong assumptions! They are necessary because the requirements model not only assumes fixed demand coefficients, but also ignores the interaction between supply and demand.

By not accounting for market interaction, requirements forecasts actually produce cumulative errors which exaggerate shortages or surpluses. As has been shown, in periods of excess demand wages will rise; demand falls and supply rises. Thus, the "shortage" is not as great as predicted.

Manpower analysis based on rate of return methodology is an application of the human capital theory of labor supply. Decisions to invest in education and supply the resultant type of labor are assumed to be based on a person's expected lifetime income in one occupation relative to others, or on his expected lifetime income in one occupation relative to others, or on his expected return to his investment. Using this approach, the model predicts rates of return and designates occupations with greater than average return to investment to be shortage areas, and conversely interprets low returns as implying a labor surplus.

Rate of return analysis is clearly applicable when the supply curve is infinitely elastic at the prescribed rate of return. If the long run supply curve is inelastic to any extent, it can reflect either surpluses or shortages at a given rate of return. Furthermore, by disregarding demand, rate of return analysis can never predict the magnitude of a shortage or surplus. This fact severely limits the use of the model for policy purposes, while causing serious doubt about the validity of the predictions themselves.

Both models also fail to include policy variables, such as government fellowship support or federal research and development expenditures. Without a direct specification of the relationship between policies and quantities and prices in the market, the task of reducing undesirable shortages or surpluses is virtually impossible.

The deficiencies noted here should not detract from the usefulness of these models or from the real need for manpower forecasts. Instead, the problems point out possible improvements in the mode: a more equal emphasis on supply and demand sides; inclusion of wage and price data; a specified market adjustment process for price and quantity interaction; and last, the addition of policy variables. The cobweb model is a way of making these improvements.

5. RECURSIVE COBWEB MODELS

A new approach to modeling the fluctuations in professional labor markets has recently been developed by R. B. Freeman at Harvard University. The key assumption of his "recursive" models is that there is a lag from the time supply decisions are made to the time the supply reaches the market. Suppliers then are forced to commit themselves to a given level of output before the price at which that output can be sold becomes known. The price expectations used in making supply decisions, in turn, are assumed to be some function of past prices. The actual price assumed is to be set by the interaction of demand with the available supply. This assumes a perishable good that suppliers can not hold off the market in speculation if the market price at the time of final production is below their expectations. The final assumption is that supply is competitive: no one supplier can affect the market by his actions.

This system, in its simplest application to high-level manpower markets, can be modelled in four equations which are all in log form:[1]

5.1 Supply of New Entrants

$$ENR = a_0 + a_1 SAL^* - a_2 ALT^* + u_1$$

[1] R.B. Freeman, "A Cobweb Model for the Supply and Starting Salary of New Engineers," Industrial and Labor Relations Review, Vol. 29, No. 2, January 1976, pp. 236-248.

5.2 Salary Determination

$$SAL = c_o + c_1DD - c_3GRAD(-1) + u_3$$

5.3 Supply of Graduates

$$GRAD = b_o + b_1ENR(-4) + b_2[a\ SAL^*(-2) - (1-a)SAL^*(-4)]$$

$$- b_3[a\ ALT^*(-2) - (1-a)ALT^*(-4)] + u_2$$

5.4 Salary Expectations

(a) $SAL^* = SAL;\quad ALT^* = ALT;$ or

(b) $SAL^* = \quad SAL + (1- \ )SAL^*(-1)\ ;$

$ALT^* = \quad ALT - (1- \ )ALT^*(-1)\ ;$

Where

ENR = first-year enrollments

SAL* = expected starting salaries four years or more in the future

ALT* = expected alternative salaries four years or more in the future

SAL = actual starting salaries

ALT = actual alternative salaries

GRAD = number of graduates

DD = index of demand

The first equation postulates that the decision to enroll in a field is based on a comparison of future income expected in the chosen field as compared to the likely alternatives. The equation further assumes that the shape of the salary/age curve is similar from field to field, so that the entire stream of future earnings can be represented by a single parameter, an estimate of future <u>starting</u> salaries.

This equation can be modified to include demographic factors -- such as the decline in the number of 18-year-old high school graduates. Structurally, the demographic shift should enter into the enrollment equation; thus Equation 5.1 becomes:

5.23 $$ENR = a_0 + a_1 \; SAL^* = a_2 \; ALT^* + a_3 \; HGRAD + u_1$$

or

5.24 $$ENR = a_0 + a_1 \; SAL^* - a_2 ALT^* + a_3 \; EN + u_1$$

where HGRAD and EN are the number of high school graduates and the number of 1st year college enrollments respectively.

The second equation expresses the notion that salaries increase when there is an increase in demand, and decline when there is an influx of new graduates.

The third equation, sometimes referred to as a "completion equation", relates the supply of graduates to the number of freshmen enrolled four years earlier. On the average only about half of the number enrolled each year as freshmen will complete their degrees in a field such as engineering. This completion rate is modified according to any changes in expected salaries from the time of the initial enrollment decision to the junior year, after which few persons change their major. The lag between enrollment and graduation is not always four years; in many cases students work part time and take five or more years to finish. In the case of PhDs the time to completion has a substantial variance.

Finally, the last equation(s) offer two alternative assumptions about how students estimate future starting salaries. Equation 5.4a asserts that students use current starting salaries as their estimate of future starting salaries. Equation 5.4b assumes an adaptive model where future salaries are calculated on a weighted average of current salaries and past estimates.

5.1 Reduced Form Equations

Equations 5.1, 5.2 and 5.4b, can be combined into a reduced form which no longer contains salaries explicitly.

5.5 $$ENR = d_o + d_1\ DD - d_2\ GRAD(-1) - d_3\ ALT(-1) + d_4\ ENR(-1) + u_5$$

We can reduce this equation still further by substituting a simplified form of the completion equation

5.6 $$GRAD = e_o + e_1\ ENR(-4) + u_6$$

to get

5.7 $$ENR = f_o + f_1\ DD - f_2\ ENR(-5) - f_3\ ALT + f_4\ ENR(-1) + u_7$$

With the exception of engineering, first year enrollment data is unavailable for undergraduates. Therefore, in order to predict graduates we must construct a model which eliminates enrollment as a variable.

5.9 $$GRAD = h_o + h_1\ DD(-3) - h_2\ GRAD(-3) - h_3\ ALT(-3) + h_4\ GRAD(-1) + u_9$$

A reduced form equation for graduates is more difficult to estimate than an equation for enrollments, since the number of graduates is the result of a concatenation of two processes: the initial enrollment decision and a later completion decision. Adjustments, arising from student field switching, dampen the impact of earlier demand variables, and make the actual lag structure far more complicated.

Equations 5.7 and 5.9 are examples of what are referred to as recursive or cobweb equations. They are identified by the presence of a lagged endogenous term with a negative coefficient. It is this term which gives rise to the oscillatory behavior of a cobweb or recursive model. The negative sign is due to the depressing effect which the number of graduates has on salaries and hence on future numbers of graduates. The lag is a consequence of the delay between the enrollment decision and arrival on the market as a graduate. In the following, the presence of a lagged endogenous term with negative sign will constitute a major test of the validity of the behaviorial assumptions we have set forth in the preceding analysis.

Our model is also based on the assumption that external conditions, particularly the demand for graduates and the available alternative salaries both strongly influence enrollment and completion decisions.

A simple trend extrapolation model would fail to capture the influence of these variables. The significance of the exogenous variable terms in our results represents both a confirmation of our behaviorial assumptions, and an indication of the improvement in forecasts that can be expected with these models as opposed to simple trend extrapolations.

6. BACHELORS DEGREES

Figure 1 summarizes regression results for 16 fields, showing that the recursive model performs very well. In thirteen of sixteen regressions the cobweb term (the dependent variable lagged three years) is significantly negative, of which ten are significant at the 95 percent level. In all cases the variable is negative, as expected. Cobweb oscillations occur because entering freshman cannot accurately predict the demand for their services three years hence.

At first glance the demand indices and alternative salaries do not seem to fare as well as the supply variable. They are significant over fifty percent of the time. Detailed analysis shows that this is often due to the necessary use of suboptimal demand variables in the social science fields. Demand indices are significant in all cases in which the demand for a specialty can be fairly directly pinpointed. Eventual employment positions of graduates in the social sciences and in aggregate science fields are not well known, so our demand indices work poorly. The engineering and science fields perform considerably better: demand is strongly positive in eight of nine disaggregate fields.

Two job opening variables are tried in the biological/chemical and educational fields respectively, the ratio of the number of medical school applicants to acceptances and the yearly number of teaching graduates hired to teach. These variables are significant as hypothesized.

One demand index measuring the demand for high school teachers is tried in several liberal arts fields. Its use is based on the fact that many bachelors' graduates enter teaching at the high school level. This is particularly true for social science and humanities graduates, but also true for science graduates who teach in special college preparatory programs. The use of the number of high school students in grades 9-12 as a demand index does not produce significant results. Most liberal arts graduates may consider teaching high school to be a last resort, in which case they will not respond to demand.

The salaries of professional, technical and kindred workers (LALTE) is the alternate salary series used in most regressions. Evidence is presented from the structural equations in engineering which suggests that enrollments respond not only to salaries but more directly to the factors which determine salaries including demand indices and supply. As hypothesized, the two demographic variables, first year college enrollments (EN3) and high school graduates (LHGRAD4) produce significant

Figure 1

Endogenous Variable	C	LG...1	LG...3	LALTA3 LALTE3	DEMAND		EN	Method	Rho/DW	Period	R^2	SEE
Engineering **	7.6	.74	-.37	-.83	.14 LRDA 3		.32M	OLS	DW=2.19	1953 -	.984	0.32
LGENG	(4.6)	(11.4)	(-10.6)	(-2.2)	(2.5)		(2.7)			1975		
Aeronautical Eng.	16.4	. .50	-.15	-2.4LALTA2	1.05 LFAL2		.20	CORC	.35	1956	.928	.085
LGARO	(3.1)	(3.3)	(-0.9)	(2.3)	(3.7)		(0.5)		(1.6)	1975		
Science	1.21	.85	-.18	-.44	.08 LRDA3		.42	OLS	DW=1.87	1953 -	.997	.030
LGSCI	(1.0)	(5.8)	(-2.1)	(-1.5)	(1.3)		(3.5)			1975		
Physical Science	5.44	.74	-.23	-.94	.39 LRDA3		.32	OLS	DW=1.87	1953 -	.994	.037
LGPSC	(4.0)	(5.3)	(-3.3)	(-2.9)	(3.9)		(2.3)			1975		
Physics	9.31	.86	-.38	-1.42	.54 LRDA3		.19	CORC	-.47	1952 -	.992	.034
LGPHY	(7.2)	(13.4)	(-10.7)	(-5.1)	(7.4)		(1.9)		(-2.5)	1975		
Chemistry	6.49	.92	-.17	-.96	.26 MED3	.33 LHEA3	.26	OLS	DW=1.85	1953 -	.986	.033
LGCHM	(3.0)	(6.5)	(-1.4)	(-2.6)	(2.2)	(2.0)	(1.8)			1975		
Geology	-3.3	.74	-.33	.48	1.28 LPN3		-.17	CORC	.91	1953 -	.950	.103
LGGEO	(-.4)	(4.7)	(-2.2)	(.61)	(1.4)		(- .51)		(10.3)	1975		
Mathematics	5.84	1.09	-.51*	-1.27	.70 LRDA3		.22	CORC	-.27	1953 -	.996	.049
LGMAT	(3.1)	(4.9)	(-3.4)	(-2.9)	(3.8)		(1.3)		(-1.3)	1975		
Life Science	5.52	1.06	-.12	-1.14	.28 MED3	.36 LHEA3	.32	OLSQ	DW=1.96	1953	.997	.033
LGLSC	(2.4)	(6.1)	(-1.3)	(-2.9)	(1.9)	(2.0)	(2.5)			1975		
Biology	7.07	.95	-.19	-1.45	.23 MED3	.65 LHEA3	.47	OLSQ	DW=2.08	1953 -	.997	.045
LGBIO	(2.3)	(6.9)	(-1.9)	(-2.9)	(1.7)	(2.7)	(2.5)			1975		
Agriculture	-11.5	.76	-0.09	1.99LALTA3	-.35 NFO3		-.10	CORC	.79	1953	.984	.052
LGAGR	(1.8)	(4.3)	(-0.5)	(1.6)	(-0.5)		(-0.5)		(6.1)	1975		
Social Sciences	2.97	1.22	-.33	-.71	.09 LRDA3		.29	OLS	DW=1.56	1953 -	.998	.034
LGSSC	(1.8)	(8.5)	(-3.4)	(-2.3)	(1.2)		(1.8)			1975		
Economics	.34	.83	-.29	-.31	.11 LFEX3		.46	CORC	.41	1953	.987	.047
LGECO	(0.2)	(5.0)	(-2.1)	(-0.8)	(0.6)		(2.2)		(2.1)	1975		
History	4.34	1.45	-.42	-.69	.15 ENRC3		.02	OLS	DW=1.45	1956	.993	.049
LGHIS	(1.0)	(8.4)	(-2.7)	(-1.1)	(0.4)		(0.1)			1975		
Psychology	.57	1.06	-.23	-.78	.02 LRDA3		.60	CORC	-.39	1953 -	.999	.031
LGPSY	(0.3)	(7.5)	(-2.1)	(2.7)	(0.3)		(4.()		(-2.0)	1975		
Business	2.50	1.00	-.25	-.68	-.01 LIPC3		.47	OLS	DW=1.76	1953	.991	.044
LGBUS	(1.2)	(8.4)	(-3.4)	(-1.3)	(-0.9)		(2.3)			1975		
Huma... es	-1.40	.73	-.20	.06	.39 ENRC3		.20	OLS	DW=1.79	1956 -	[illegible]	.041
LGHUM	(-0.5)	(3.1)	(-1.4)	(0.1)	(1.4)		(0.4)			1975		

results. The number of high school graduates is a significant variable at the 95 percent level for 81 percent of the regressions, while EN3 is appropriate 69 percent of the time.

Two further tests of the model reinforce our confidence in its validity. The first shows that degree fluctuations do tend to follow a cobweb dynamic adjustment path in the sciences. The second applies F-tests to several fields and proves that the exogenous variables significantly improve our explanation of degree variation.

Detailed tests using the engineering model verify our structural equations. They also show that the draft had a marginally significant effect on engineering enrollments, however no effect was found in the reduced form.

7. PhDs

The strongest results derive from our application of a market success variable, the percentage of new PhDs still seeking a job at the time of graduation (SEEK). We are able to show that PhD enrollments for most fields are influenced by this economic variable. Most of the variation in enrollments can be explained by a simple model which incorporates SEEK. Unemployment rates were included to test for an additional effect of general market conditions (as opposed to within-field conditions) on the model. In all cases, this variable proved insignificant. Finally, SEEK was tested as an indicator of the number of enrollees who actually graduate. Again, the results show that economic conditions really do influence students' decisions. Much of the variation of this completion ratio can be explained by the SEEK variable.

Difficulties were encountered in attempts to explain the actual number of PhD graduates. Since a large proportion of PhD recipients hold BA's in the same field, lagged BA graduates was tried as a proxy for enrollments in a graduate completion equation. This specification failed in all fields in which it was tried except for psychology, in which the results were marginal.

Considerable work was done in trying to define a correct demand index for the various fields. Single sector demand indices proved successful for agriculture and chemistry. Composite indices based on both employment and R&D expenditures were tried, with varying results. Employment-based indices were generally unsuccessful, but the R&D-based indices worked fairly well for a number of fields.

Finally, medical school acceptances are tested as a non-price indicator of alternative opportunities for the fields of chemistry, biology, and life sciences. This variable proves quite valuable in explaining the behaviour of these fields.

For the PhD models the recursive term used is usually the endogenous variable lagged five years. This reflects the six year time period which the average PhD student takes in completing his degree. Occasionally, in fields with high dropout rates, a three year lag is tried. The drop-out rate in doctoral programs is higher than that at the undergraduate level. In effect, there is a larger pool of enrollees relative to graduates which acts as a buffer to dampen oscillation. Historically, enrollment levels have not been a limiting factor in PhD supply, as adjustments to changing market conditions occur during the approximate six year lag between enrollment and graduation. In recent years there has been a decline in the PhD completion rate in the biomedical and behavioral sciences -- evidence of just such an adjustment process. Because so much of this adjustment process occurs after the time of enrollment, the appropriate lag in supply response is less than the full six years necessary to complete the degree.

In general, the recursive or cobweb terms in the regressions reported are negative in sign, as the model suggests they should be. In about 56% of the regressions, the coefficient is significantly different from zero. In those cases where the coefficient is positive, it is not significant. This suggests that for most fields the recursive model works quite well. However, it is not as successful for PhDs as it was for BAs.

8. FORECASTING

In order to forecast numbers of gradutes, we first need forecasts of the exogneous variables. For example, the model for BS engineers can be used to predict future enrollments and graduates in terms of four primary exogenous variables: national R&D expenditures, durable goods production, alternative professional salaries, and prices. In order to generate forecasts of enrollments and graduates, it is therefore necessary to provide forecasts for these exogenous variables over the next several years. For forecasting purposes, we assume that prices will continue to increase at 6% per year. Real growth in durable goods production will be 4%. R&D expenditures are assumed to grow by 6% in 1977 and by 4% per year thereafter in real terms. Alternate salaries are pegged at their trend growth rate of 1.8%. We have also included in our forecasts alternatives based on growth rates of 3.5% for R&D and durable goods and 2.1% for alternative salaries (pessimistic forecast) and rates of 5.0%, 5.0% and 1.5% respectively (optimistic forecast). Where total college enrollments or numbers of high school gradutes appear in an equation, we assume them to be a constant fraction of the 18-19 year old cohort.

Figure 2 presents the forecasts for engineering BA enrollments. The upturn which began in 1973 will reach a peak in 1978 and then enrollments will drop off sharply before turning up again around 1982. This behaviour is the same under the entire range of assumptions made for the exogenous variables. Altering the assumptions about the behaviour of the exogenous variables changes only the magnitudes of the forecasted variable. The peak or trough remains essentially unchanged.

irst Year Engineering BS Enrollments

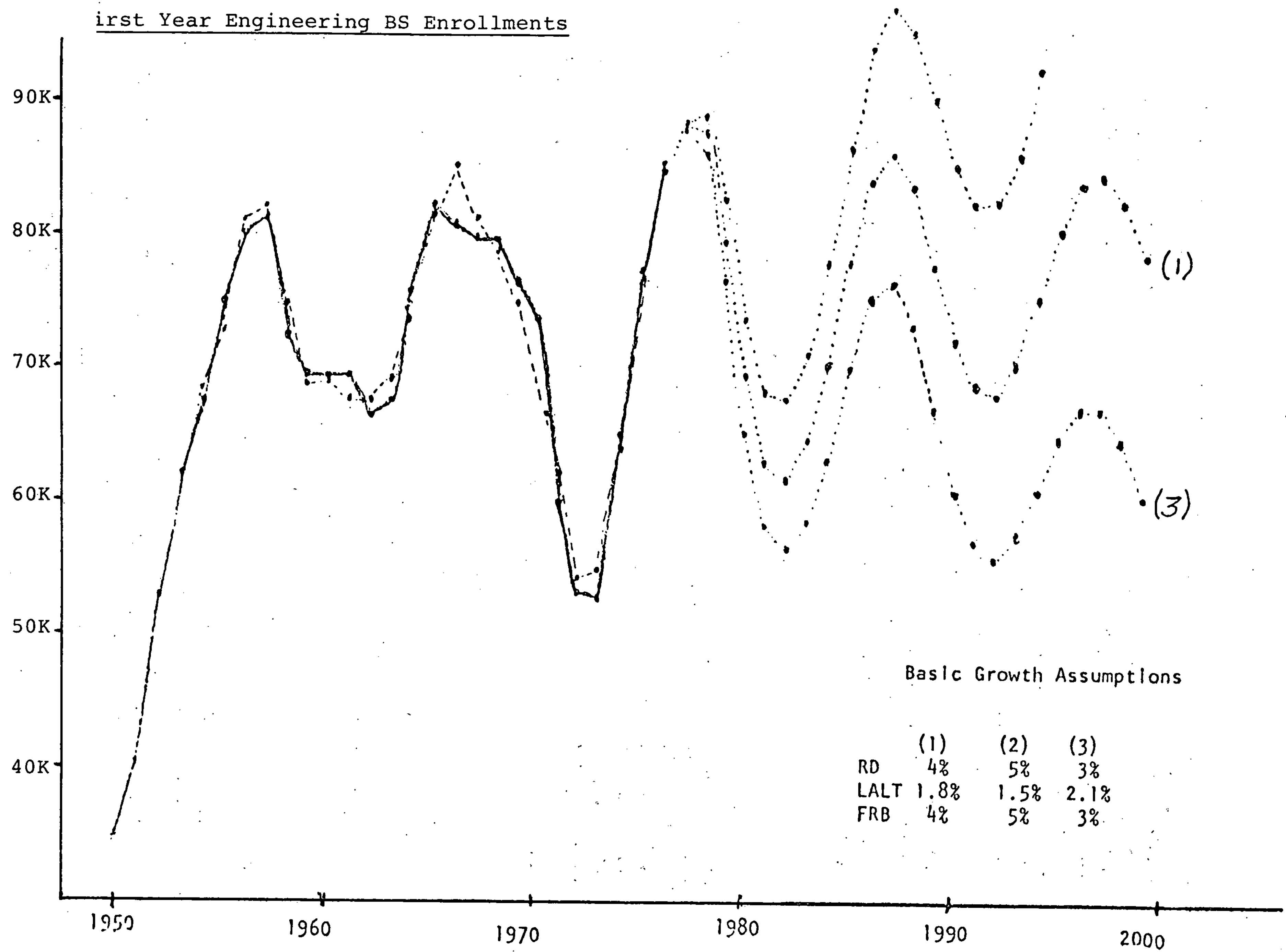

Figure 2

The direction of change in a long term forecast can be approximated by the sum of the growth rates of all exogenous variables multiplied by their respective coefficients. For example, the forecast of enrollments assumes growth rates of 4% for R&D expenditures and durable goods production and 1.8% for alternative salaries. The coefficients of these variables are .49, .17, and -.1.26, respectively. The sum of the exogenous effects is .372%, which implies a small positive long run growth in enrollments. Note that assuming the more pessimistic growth rates of 3.5%, 3.5%, and 2.1% implies a negative movement in trend of -.336%. The forecasts of the exogenous variables are very important in forecasting actual magnitudes of enrollments and graduates. An enrollment forecast is no better than the forecast of the exogenous variables in the enrollment equation. However, in a recursive model, the effect of different forecasts of the exogenous variables (within a reasonable range) is to change the magnitude but not the path of the forecasts. The most we can expect of the forecasts presented is to predict the direction of future changes rather than the specific magnitudes of the changes.

9. TOWARDS THE DEVELOPMENT OF A STOCK MODEL: MOBILITY AND IMMIGRATION

The recursive model measures the flow of new entrants into the science and engineering labor market. Yet, in order to completely project future labor market conditions, we must look at the total stock of available engineers and scientists. Inflows and outflows of manpower will determine the size of the stock of engineers and scientists at one point in time. Thus, in order to determine future stocks, we must know something about all labor flows, in addition to the flow of new entrants from colleges.

One general equation captures the spirit of the stock model:

$$N_t = (1-S)N_{t-1} + CF_t + OF_t$$

where N_t is the total stock of labor at point t in time.
S is retirement, mobility
CF is new entrants
OF is emigrants

The variable S respresents the rate of outflows, due to retirements, or job mobility, for example. In a sense, it is a rate of depreciation.

The complete estimation of the components of the stock model is scheduled for the 1977-1978 year. As a preliminary analysis, two studies have been done. The first looks at the career patterns of scientists and engineers, or their age employment profile. The second considers the stock implications of immigration and emigration.

9.1 Mobility

The Census of the Population, conducted every ten years by the U.S. Bureau of the Census, offers the framework for a career patterns study. In 1950, 1960, and 1970, they tabulated the number of people in the United States who consider themselves scientists and engineers, their specific occupation, and their age group. Given this data, we can follow a field specific age group or cohort over time and measure the outflow. For example, the number of mechanical engineers of age 25-34 in 1950 should be equal to the number of age 35-44 in 1960 and age 45-54 in 1970. If this number declines over time, there is outflow, and if it rises people are entering.

We hypothesize that these changes are a function of changing wages. For example, if wages are particularly low in mechanical engineering in 1970, more people may leave to enter other fields, or may decide to retire early.

To measure changes in career patterns, the most appropriate model regresses the "survival rate" for an occupation, on the rate of change of salaries. The equation is:

9.1 $$\frac{N_{TIJ}}{N_{T-1,I,J-1}} = A + B \frac{W_{TIJ}}{W_{T-1,I,J-1}}$$

where t = 1, 2, 3, for 1950, 1960, 1970

I = 1,..., 10 occupations

J = 1,..., 5 age groups 25-34, 35-44, 45-54, 55-64, 65+

and equivalently,

9.2 $$N_{tij} = A + B\, W_{tij}$$

where t = 1, 2 for 1950-1960, 1960-70

i = 1,..., 10 occupations

j = 1,..., 4 age differences 25-34/35-44,...,55-64/65+

The variable N_{tij} is called the survival rate because it measures cohort survival. For example, it is the number of people in occupation in age group 35-44 in 1960 divided by the people in group 25-34 in 1950. Notice that the survival rate is equal to (1-S), or one minus the depreciation rate, as given in the general stock model above. Wages, W_{tij}, are measured similarly.

Equation 9.2 represent the general form of the model used to study changes in career patterns. A more specific form of the model treats 9.2 as a regression equation. However, it respecifies the equation in order to separate the differential effects which changes in wages may have on each age group and each occupational group. For example, general age employment profiles show that a large number of people enter a professional occupation in their twenties and then begin to leave slowly, at a pace which accelerates by their fifties. Because employment patterns do change with age, we hypothesize that wage changes will affect the general shape of this employment profile, but that a change in wages will not induce an equal proportion of people in the 25-34 age group to leave as in the 55-64 age group. It is only hypothesized that a wage change will have an equal impact in influencing career decisions. In addition, because age employment profiles should differ among different occupations, wage effects are separated for each occupation. Thus, a more exact form of regression 9.2 econometrically separates wage effects for occupational and age groups.

The general, and clearly demonstrated conclusion is that changes in wages do influence the retention rate of employees in an occupation. When changes in wages increase within an occupation, the survival rate increases, or more professionals stay in the occupation, the survival rate increases, or more professionals stay in the occupation. Specifically, regression results show that when changes in wages increase by one percent, the survival rate in the occupation increases by 2/3 of one percent. Thus, wages definitively alter career patterns. Also, as hypothesized, wage changes affect decisions equally across age groups, but the proportion remaining in the occupation does differ for each age group. Likewise, there are occupational differences in age-employment profiles, and wages alter these profiles for each occupation.

Many flows are included in the depreciation rate; immigration, retirement, mobility, etc. are all parts of the rate. Each of these flows is definitely changing over time due to demographic and economic influences. Demographically, the number of new entrants will slow in the future as the number of 25-34 year olds decreases. Retirement levels are changing. Since 1966, the percentage of college employees retiring before age 60 has doubled. The doubling may be because early retirement benefits have increased relative to salaries, or because more people are pushed into early retirement as older workers are becoming a larger proportion of the labor force. These separate flows need to be analyzed in separate models in order to understand the general depreciation rate more fully and to develop a thorough model of changing labor stocks. The work on immigration begins this task.

9.2 Immigration

A large part of the increases and changing patterns of immigration during the post-war period has been due to various amendments to the basic immigration law prior to 1965 and the change that took place in 1965. The basic effect of the pre-1965 laws was to permit displaced persons following the Second World War to begin immigration to the U.S. The increase in immigrant scientists and engineers from 1949-52 came as a result of the Displaced Persons Act of June 25, 1948. The 1953 decline was due to the expiration of this act. The Refugee Relief Act of 1953 caused a renewed increase. Upon the Act's expiration in 1957, there resulted a steady decline in immigrant scientists and engineers through 1961. The Alien Skilled Specialists Act of 1962 was responsible for another spurt of growth.

As the 1965 revisions of the basic law began to take effect, there was a noticable shift in both total migration and migration patterns of scientists and engineers. During the adjustment period of 1966-68 the total number of immigrating scientists and engineers jumped to nearly 13,000 from a level of 5400 in 1965. Much of this was due to the shifting of the unused portion of some European countries' quotas to those countries which had long waiting lists. Prior to 1965, Canada, the United Kingdom and Germany were the leading sources of scientists and engineers. By 1969 the lead had shifted to India. The number entering from Asia increased over nine-fold during this period. This resulted by 1970 in an increase to 56% in the fraction of scientists and engineers coming from Asia from only 28% in 1966.

In 1972, scientists and engineers were eliminated from the category of shortage occupations. The large drop in immigrating scientists and engineers in the years since 1972, is in part, an effect of this change. For example, from 1966-72 scientist and engineer immigration averaged 11,500 per year. For 1973-75, it was down to 6500 per year.

Various simple regressions were tried in an attempt to explain in economic terms the numbers of immigrants. Among the right-hand side variables tried were salaries, R&D expenditures and durable goods production. All of these variables represent demand elements in the market for scientists and engineers. An increase in one or more of these would increase the demand for this type of labor and tend to draw more foreigners to the country.

A satisfactory supply-related variable was not found. The number of students graduating with degress in science and engineering was tried, (more graduates increase supply and make migration less attractive) but the variable was never found to have a significant effect. More work needs to be done to model this effect.

Using salaries together with R&D expenditures and durable goods production did not work well. This is probably because salaries are in large part determined by R&D expenditures and production. In fact, the simple regression using only salaries as a right-hand side variable worked well:

$$LSCEN = -4.41 + 2.05\ LSAL$$

$$(-1.94)\quad (5.76)$$

$R^2 = .88$ S.E.E. = .19 Period = 1949–75

Method of Estimation = Cochrane–Orcutt

LSCEN is the log of the number of scientists and engineers who immigrated and LSAL is the log of engineering salaries. The same regression was run adding a dummy variable for the years 1967–72. This was based on the assumption that there was a large backlog of scientists and engineers desiring to enter the U.S. who could not do so under the pre-1965 law and several years were required for this backlog to be taken care of.

$$LSCEN = -1.75 + 1.61\ LSAL + .46\ DUM$$

$$(-1.45)\quad (8.39)\qquad (5.03)$$

$R^2 = .93$ S.E.E. = .14 Period = 1949–75

Method of Estimation = Cochrane–Orcutt

Unfortunately, the late sixties were also a time of unprecedented boom for scientists and engineers, and it is likely that this is partly picked up by the dummy variable. However, during this period much of the immigration was also based on non-economic reasons (note that in 1971 nearly 11,000 immigrants arrived at a time when unemployment for engineers was at an unprecedented 2.8%).

These stock model results are of course preliminary and will be expanded in Phase II of our research.

RECOMMENDED CHARACTERISTICS OF AN ENGINEERING DEMAND/SUPPLY INTELLIGENCE SYSTEM

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Distinguished Professor of Engineering
Virginia Polytechnic Institute and State University

My presentation is going to be based on the 1978 Joint Engineering Manpower Commission/Engineering Foundation Conference this past summer which looked specifically at "Measuring and Forecasting Engineering Personnel Requirements". Therefore, I'm simply going to run thru this so you can realize the lines of reasoning of the studies upon which those reports were based. There is a summary of the conference attached (EXHIBIT 1) and there will be Conference Proceedings available soon. If you want detailed information about these activities see Paul Doigan, who is the Chairman of the Engineering Manpower Commission and my mentor during this particular period.

You have just heard (editor's note: Sirbu), in my opinion, the best modeling that explains the past behavior of engineering enrollments and engineering graduations. The facts beyond that are simply as follows: If you have a model such as this, which explains the past, and you know the factors which are incorporated into the model then, in looking to the future on a short range basis, by keeping track of these factors, you can therefore keep track of future trends. That is probably the best approximation you can do because, in my opinion, none of these models are going to predict the future with accuracy. We'll get into this as we go along.

Secondly, we're going to look at the question of what kinds of data do we need, what kinds of data are missing, and recommendations as to how to go beyond this. Actually, the organization of the prior Conference was to look at current activities, data collection, modeling and current user needs, unsatisfied needs, the state of the art; and then, thru a series of workshops, to determine what kinds of things should be carried out in order to satisfy the unsatisfied needs, and particularly who might pay for it. That is, the goals of the future. (EXHIBIT 2).

For current activity we looked at the data-collecting people. The Engineering Manpower Commission, for example, collects surveys of enrollments and of graduations. Here (EXHIBIT 3) is a set of EMC data which indicates for the last five years the enrollments in engineering and baccalaureate graduations. Collected data is also discipline specific, state specific and university specific. The interesting trends cover from first year to the fourth year. In general, about 10% of the population goes thru a fifth year. The degrees for last June were 46,000,missing from the data table; the Fall enrollment of freshmen was almost 96,000 and the projected number of graduates for this June is 52,000. These are the kinds of data that are available. This happens to be for four-year engineering degrees.

They also have it for four-year engineering technology degrees and data on technicians to some extent, also broken down by ethnic groups etc. etc.. The interesting thing is that there are vast gains being made in women engineers. The gains in the other areas are not so impressive.

We then looked at the Bureau of Labor Statistics Dan Hecker is the one who does this work and if you wish to have details about it you can get them from him. They publish an occupational guidance handbook with potential job openings. They project demand by using a GNP forecast, an input-output model and certain engineering coefficients by industry. They project a supply on EMC-type data and on census data. This is based on economic growth. There are some retirements, transfers in-and-out, and new graduates.

There are some problems with this. Let's look specifically at what was presented at that particular meeting. These data are a little bit out of date, things change in 3-4 months, but these are Dan Hecker's data (EXHIBIT 4) on average annual job openings and supply.

New job openings, he says, will be 100,000 per year for the ten years '76 to '85. This is 31,000 due to economic growth, 25,000 due to deaths and retirements and 44,000 due to transfers-out, which includes transfers into management as well as transfers out of engineering entirely. The new entrants rate, he says, will be 130,000. That suggests a surplus, since job openings (100,000) are equal to only 76% of the sum of those who get degrees in engineering, other recent graduates (some of the ones that didn't go into engineering before but will go in later on), immigrants and transfers-in (people going back into engineering from management and people coming into engineering from peripheral disciplines such as physics, mathematics, chemistry, sometimes law or whatever it happens to be). This is the buffer. That is, in general, those engineers who want to go into engineering can get jobs and the surplus is taken out of these transfers-in and transfers-out, according to Dan Hecker.

We then looked at the census activities. The census activities are fraught with problems. I'm not going into them in detail but this is an occupational survey, not a capability or discipline survey. So if someone says he's an engineer they put him down as an engineer even though he's the stoker out at the boiler factory. So these things are just not very good. They did a resurvey of 16,000 engineers and found that 42% were correctly indicated occupationally, that there were 58% with some sort of error, detail problems, mismatched. So the census data are believed not to be particularly good.

We then looked at two other areas. The NSF is the other principal collector of data. They estimate and analyze current and future supplies of new scientists and engineers, current and future utilization, their characteristics etc.. They estimated 945,000 engineers in the labor force in 1976 (the Bureau of Labor Statistics identified 1,200,000 engineers in 1976). Also, I'm going to wave this report in front of you - the study which Norm Seltzer reported yesterday. This is the energy-related scientists and engineers -- a profile of new entrants in the work force in 1976. There's also a report on experienced scientists and engineers -- you can get this from the National Technical Information Service if you care to -- carried out by Oak Ridge Associated Universities in Oak Ridge, Tennessee. This is the best data, in my opinion, on the energy-related engineering work force.

An added note, there's no such thing as an energy engineer. These are people doing mechanical engineering work, electrical engineering work, civil engineering work, in the energy industry. GE has been in the energy industry for years and I think has no functional job title that says "energy engineer". The fellow who designs a transformer is an electrical engineer.

The Civil Service Commission does not really do studies. They try to balance supply and demand. They do two things: they look at the available supply, they look at government agency needs for the next couple of years and try to make sure that these two match. The Federal government hires 10% of the engineering graduates, about 5700 per year, and now employs 85,000 distributed by disciplines (editor's note: illustrated by chart).

We then took a look at user needs. Now this is one of the basic problems with the available information -- different people want different things. Industry is not interested in demand forecasts. They are interested in supply. And particularly, they are uninterested in long-term demand forecasts, four to eight years. They want to know how many people they're going to be able to hire next year. The basic problem is that you really don't know how many people they want to hire out beyond 6-8 months because this is based on economic conditions, a whole range of indicators, which nobody has been able to forecast. So they really want to be sure that next June they're going to be able to hire the ones they need.

Professional societies are interested in supply and demand. The guidance people would like to know long-range supply and demand so that they can tell 8th graders if they should or should not go into high school science. Women engineers are interested in demand 4-8 years out.

There are some interesting things about this but not particularly pertinent to our subject to-day. Industry has been stimulating entry into the high-school science/math pool because they believe the number of engineers and scientists are related to that pool. Civil Service only wants two-year forecasts to compensate government needs and responses. So that's one of the problems with the data -- there is no consensus as to what data should be used. The methodology, first of all, up until the Sirbu study, is largely input-output. They relate the need for engineers by discipline to a coefficient related to the projection of certain factors such as GNP, such as the growth of various industry areas, labor coefficients, labor distribution coefficients and the like. Again, this is a typical labor economics approach.

The study which we loked at specifically was that done by Hugh Folk, when he was at Illinois. He's now at the University of Hawaii. This was an input/output analysis and I'm going to read to you specifically from my notes while you look at what's on the board. (editor's note: in place of a verbatim transcription of Professor Hibbard's wide-ranging commentary, his written summarization is included, EXHIBIT 5, data tables excluded). This is one of the most complete studies that there are in terms of data. It is probably one of the most erroneous. That is, if you put fairly sharp data thru a large number of factors it makes the study look good even though the data are not inherently great. But there it is, a study worth looking at, and it is detailed in its breakdown.

The other study which I am going to discuss as being the best study that I know about is that which you've just heard. For purposes of review let me describe to you what you heard earlier to-day. Sirbu, working at MIT, has a recursive, cobweb, econometric model. In case you want to know what it is, it's an RCEM. I'm not sure what that means, it sounds like a missile of some sort. The number of current engineering graduates are related to demand four years and two years earlier represented by engineering enrollments influenced by economic indicators of which the enrolling student becomes aware. Engineering salaries comparative to alternative salaries are important inputs, probably as proxy for kinds of information available to the student in his enrollment decision-making process. The result is a cyclic supply, down here, up there (editor's note: illustrated on Sirbu curve) and the problem is there is a lag between the supply decision and the supply reaching the market. It's as if you were growing oranges and selling them four years hence. The supply is committed before the demand and the price are known. That's a poor way to run a business -- it's almost like the turbine business, isn't it, Paul? The charts form an envelope into which the actual numbers are going to fall depending upon the variability of the important factors and the number of actual graduates. The '78 numbers are larger than this would project -- actually 49,000 something — which suggests that current engineering students in college are overenthusiastic.

Part of what came out of this Conference, which is not on the chart, is the fact that engineering is considered to be a good analytical training for other occupations. 25% don't go into engineering. People from industry who were at the Conference said there is not going to be an oversupply of engineering graduates, not because of the demand for engineers but because these kinds of people will be placed in other occupational areas.

The next important thing is mobility. The key man who is doing the mobility work is Robert Dauffenbach. He is at Oklahoma State University. Here is a typical chart of his kind of work (chart illustration). He relates the probability of an occupational change to age. It goes down as a function of age and it goes down as a function of the amount of education. The more years of education you have, the less likely you are to change (i.e., for chemical engineers). (editor's note: chart illustrations of various probabilities of interdisciplinary/interoccupational mobility.)

One caveat, in looking at this mobility data, is that everything we learned in the supply area suggests that the economic conditions in the field have something to do with people changing occupations. This data is compiled for a particular time period and a particular set of economic conditions. To extrapolate it to another set of economic conditions, in my view, might lead you astray. For example, in the '71-'74 period: 33% stayed in their activity, 15% went to another engineering field, 52% went to non-engineering. However, between 1971 and 1974 Boeing laid off two-thirds of its work-force (editor's note: aerospace/defense contracts collapse) and I don't think they plan to do that over the next four years. All I'm saying is that here is a set of data which, if you know the conditions, you can use intelligently, but you can't take these data as coefficients.

Also, this data shows a correlation, which I thought was good, indicating what other kinds of disciplines a certain engineering discipline is more likely to move to. That is, electrical engineers did not move into metallurgy, but into more probable areas.

This is the best study I know of on the subject of interoccupational mobility of engineers and it will appear in the prior Conference proceedings.

We then had workshops and asked the questions "What do we need to do this better?"

Twenty-one recommendations were generated by these workshops (editor's note: rapid commentary) and are included in the summary of the prior Conference, available in the proceedings of this Colloquy (editor's note: see EXHIBIT I, Items A thru U).

That summarizes the proceedings.

(editor's note: wide-ranging discussion following Professor Hibbard's paper was not transcribed.)

EXHIBIT I

MEASURING AND FORECASTING ENGINEERING PERSONNEL REQUIREMENTS - SUMMARY

W. R. Hibbard, Jr.

The conference opened with a welcome from Bryce MacDonald, President of the Engineers Joint Council, who also described the organization and objectives of the Engineering Manpower Commission. Paul Doigan, Chairman of the Engineering Manpower Commission, described the Commission's supply survey of enrollment and degrees in ECPD accredited engineering programs.

Dan Hecker of the Bureau of Labor Statistics described their projection system, which identified $1.2x10^6$ engineers in 1976 and estimated supply and demand for engineers through 1985. This projection suggests there will be no surplus of engineers but less reliance on marginal reentrants.

Lloyd Temme of the U.S. Bureau of the Census described the problems associated with their data. Uncertainties resulting from occupational definitions (work function or skill/capability) may lead to errors (28%), structural differences (34%) or response judgement (38%) in deciding who to include as engineers.

Michael Crowley of the National Science Foundation described the objectives of their surveys and use studies including the 945,000 engineers in the labor force out of a total population of $1.4x10^6$ in 1976.

William Cottingham, President of General Motors Institute, urged that the supply of engineers be stimulated because the engineers are becoming a large fraction of society, they are excellent additions to the work force and there is not a surplus.

A panel representing the users of engineering personnel measures and forecasts included William Robinson of the U.S. Civil Service Commission who suggested that data are useful for general trends; Lindon Saline of General Electric Co., who described their recent study on technology and productivity of engineers; Howard Wakeland of the University of Illinois, who found that the data are useful for the guidance in the 11, 12, 13 and 14 grades; Lewis Blakey of the Army Corp of Engineers, who stated that they did not use the data and John Prados of the University of Tennessee, who described the AICHE's program for getting more accurate and timely data on chemical engineers. The panel identified the following needs:

a) Accelerated enrollment data (3 months)
b) Long range trends of supply and demand
c) Economic factors which affect supply/demand
d) Short range impacts

John Alden of ECPD presented survey data indicating substantial increases in enrollment of women and minorities. Paula Loring, President of the Society of Women Engineers, asked for more consideration for women. David Reyes-Guerra of ECPD, described their positive action programs for minorities. He projected that by 1985 20% of the engineers would be Women, 11% Blacks, 6% Hispanic and 1% Indian.

Hugh Folk of the University of Hawaii described the demand model he had developed and identified the pitfalls of such models including input data, the economic scenario, inconsistencies of forecasts, contingencies and misinterpretation. Robert Dauffenbach of Oklahoma State University described his supply model which focussed on occupational mobility in relation to age and years of college.

Marvin Sirbu of M.I.T. described the "Cobweb" model relating supply, demand and salary, which projects cyclic behavior of supply related to student response to present economic indicators with a lag due to the time between selection and graduation.

Leonard Lecht of the Conference Board discussed the question, "How good are surveys and projections?" He stressed the need to consider labor market forces and changing priorities.

In the context of these presentations, workshops met to generate the following recommendations:

Surveys

A. Make better use of the data available from government surveys and data banks by analyzing the basic data according to characteristics of special interest to engineers, such as graduates compared to non-graduates, etc.

B. Establish the capability within the organized engineering profession to process and analyze the government data for the profession's own purpose.

C. Develop a more sophisticated and disaggregated manpower model in which different indicators of demand would be used to make projections of employment in the different branches and sectors of engineering.

D. Seek a grant from the Engineering Foundation or other source to investigate the use of government data banks and study methods of forecasting supply and demand.

E. Collect and disseminate current information and near future projections of engineering employment for the benefit of individual engineers requiring such information for employment decisions or career development.

F. Establish engineering advisory groups to work with government data collection agencies in categorizing and interpreting data relating to engineers.

Minorities and Women

G. A built-in legal and social demand exists for minorities and women for a reasonably long period. The profession should be concerned about ethical and professional standards in all phases of education, employment, guidance, etc.

H. Include in overall engineering supply/demand forecasts levels of minorities and women, both short and long range. Type of minority and geographical distribution are important for career guidance and college facility planning.

I. Develop parameters for projections both short range and eventual "equilibrium" level for minorities and women. These include:

1. Minorities (male)

   a) salary
   b) jobs - unemployment rates
   c) role models
   d) view of companies, industries
   e) effectiveness of special programs

2. Women

   a) obsolescence problems (part-time work, continuing education, etc.)
   b) reentry problems
   c) dual life objectives (career-family)
   d) other items as under men

3. Eventual "equilibrium" level may be greater than population parity for minorities, unknown for women. This subject is important to industry and education planning.

J. Develop methods to communicate more directly supply/demand projections to those involved in career guidance, students themselves, and engineering college facilities. This is more important than for white males.

Users Workshop

K. Data Development - provide well defined historical demand time series and supply time series by specialty.

L. Monitor of "significant" factors.

M. Monitor of 8th grade math-science pool.

N. Modelling

   1. Trend/Impact and cross impact analysis

      a) semi-quantitative evaluation of significant or catastrophic events on manpower demand or supply.

O. Development of understanding/insights

   1. Restructuring of engineering work

      a) reentry
      b) part-time work
      c) partial retirement
      d) work/study plans
      e) efficiency relationships

   2. Dissemination of technology of work-force analysis

   3. Internationalization of engineering work and work-force

   4. Specification of the "normal" factors affecting supply of and demand for engineers

   5. Academic studies, etc.

      a) why students choose engineering
      b) why engineers leave profession
      c) how new areas of engineering demand arise and grow

Modelling Workshop

P. University/employer mini models are not available - not used.

Q. Real time data are available by telephone, using selected sample data. Short term models could result.

R. Long term models are difficult - problems are conditions and assumptions that are historical. There are few cases for macro models on day to day decisions - except for policy questions.

S. Education and training programs - broad economic control are influenced by forecast - forecasts must be identified as to their precisions. Less precision results in wider range of uncertainties.

T. Occupational coefficients include:

1. Uncertainties in foreign trade

2. Uncertainties in government policy and action

3. Uncertainties in technological policies

R & D and manufacturing coefficient should be separated.

U. There are opportunities for Engineering Societies to study technology future trends for their disciplines. BLS/NSF, etc., should aggretate the results of these societies studies.

EXHIBIT 2

ORGANIZATION SCHEME

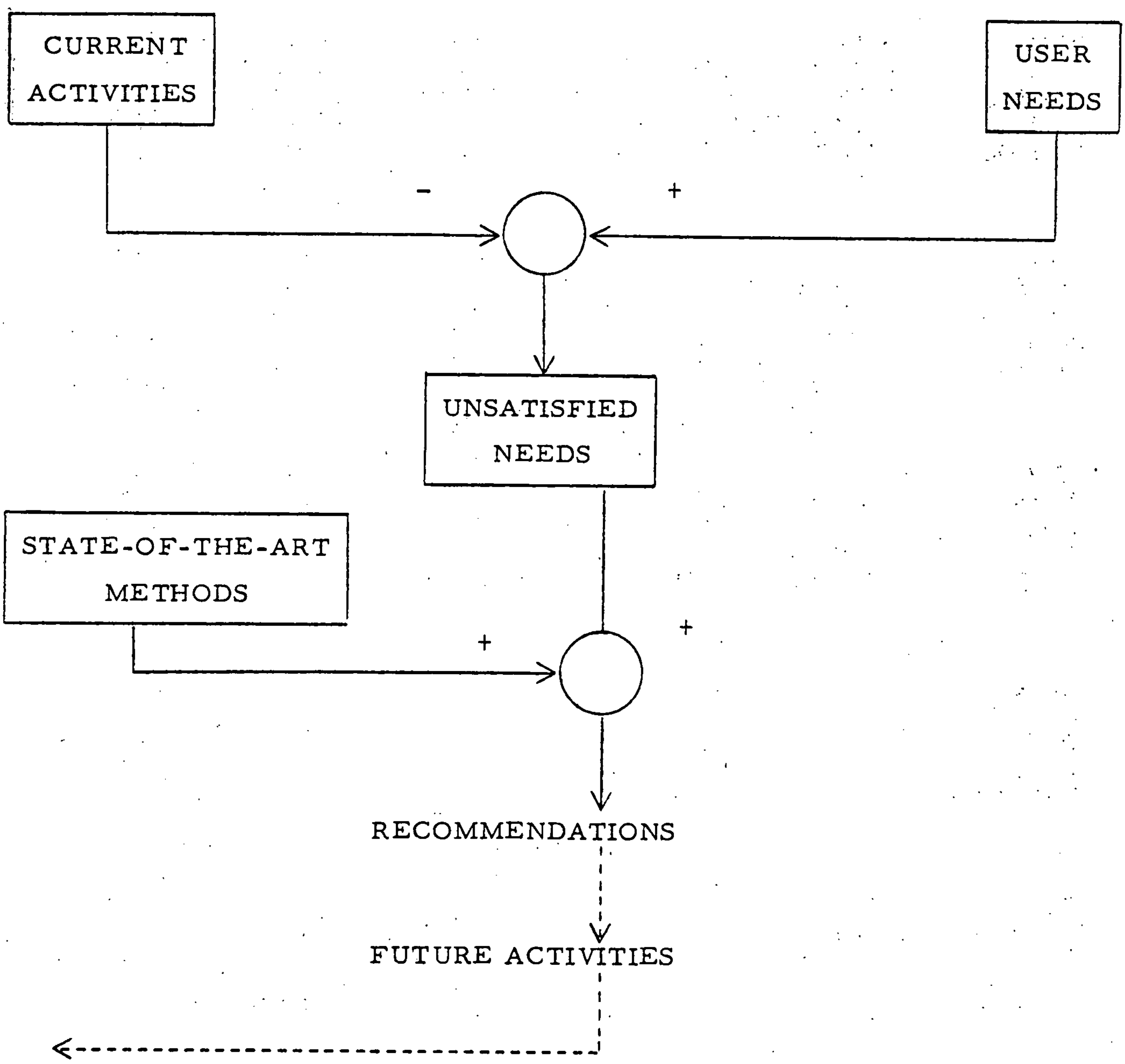

EXHIBIT 3

Engineering Enrollment & Degree Data 1973 - 1978

All U.S. Engrg.

	1st yr	2nd yr	3rd yr	4/5th yr.	Part Time	BS Deg
1973-74	51920	40520	41670	52590	15690	41407
74-75	63440	45940	43010	48710	16690	38210
75-76	75343	55891	49338	50807	17041	37970
76-77	82250	63003	56835	55757	19844	40095
77-78	88780	70326	64721	65421	20634	

Blacks

	1st yr	2nd yr	3rd yr	4/5th yr.	Part Time	BS Deg
1973-74	2130	1324	1056	998	503	756
74-75	2848	1632	1221	1126	549	734
75-76	3840	1980	1366	1203	658	777
76-77	4372	2483	1633	1304	632	844
77-78	4728	2928	2104	1628	613	

Hispanics (W/O UPR)

	1st yr	2nd yr	3rd yr	4/5th yr.	Part Time	BS Deg
1973-74	790	609	629	741	265	640
74-75	1068	750	681	881	387	685
75-76	1384	939	885	903	349	680
76-77	1766	1255	1026	1091	419	702
77-78	2161	1329	1217	1237	331	

American Indians

	1st yr	2nd yr	3rd yr	4/5th yr.	Part Time	BS Deg
1973-74	67	61	65	88	17	31
74-75	102	73	72	76	24	44
75-76	120	73	65	70	27	41
76-77	171	93	93	89	32	36
77-78	244	156	118	100	42	

Women

	1st yr	2nd yr	3rd yr	4/5th yr.	Part Time	BS Deg
1973-74	2417	1487	1140	1020	264	744
74-75	4266	2476	1724	1362	430	878
75-76	6730	4197	2862	2063	1628	1376
76-77	8545	5848	4407	3136	1258	1961
77-78	9921	7537	6193	5122	1192	

EXHIBIT 4

Summary of Average Annual Job Openings and
New Entrants in Engineering
1976 - 1985

	Number
Job Openings	100,000
Growth	31,000
Deaths & Retirements	25,000
Transfers-out	44,500
New Entrants	130,000
Recent Engineering Graduates	53,000
Other Recent Graduates	7,000
Immigrant Engineers	5,000
Transfers-in	65,000

EXHIBIT 5

Inter-Industry Forecasts of Engineering Personnel Demands: Energy Related Private Sector

Hugh Folk
University of Hawaii

(Summarized by W. R. Hibbard, Jr.)

Prof. Hugh Folk of the University of Hawaii described the CAC Micro Computer Systems demand model for scientific and technical personnel (STP) in energy related industries. This model is an input/output study in which the occupational and personnel requirements are related by coefficients to production and facilities construction of the energy related industries. The forecasts depend upon unpredictable events such as the state of the economy, the industry, the firm and the individual. Often these forecasts are based on the hope that errors cancel, trends continue and point estimates are correct. The models used the Bureau of Labor Statistics (BLS) demand by industry, the Bechtel study of Facilities Construction and various oil price scenarios. The BLS model depends on GNP growth, personal consumption expenditures, gross private domestic investment, government purchases of goods and services, exports and imports.

The energy related scientific and personnel study did not use the BLS occupational coefficients. Thirty-five hundred (3500) energy related companies were surveyed and personnel coefficients were computed per unit sales. Variances were uniformly large. Markets are very flexible, with a high degree of choice dependent upon management patterns such as decentralized or centralized decisions, economics of scale and purchased engineering. Coefficients are very uncertain with population variances.

Survey results were used to scale BLS forecasts. The results for 1985 are shown in Table I. The CAG results are generally 8-10% larger than BLS. For the limited imports scenario, total private STP employment rises from 2.3 million in 1974 to 3.2 million in 1985.

The energy related employment of scientific and technical personnel in the private sector is shown in Table II for 1974 when it was 256,000 or 11.2% of the total private STP employment of 2,281,200. Projections for the free imports scenario are shown in Table III for 1980 and Table IV for 1985. Energy related employment of scientific and technical personnel increases to 316,000 in 1980 and 353,000 by 1985, an increase of 97,000 over 1974, but still about 11% of total STP private employment.

The effect of a limited import scenario in 1985 was very small, 345,000 compared to 353,000, or 1 1/4%.

The lessons learned from this study were:

1) Data are frequently misused;
2) Clairvoyance is used where data are missing;
3) Multiple scenarios and forecasts are used to represent sensitivites for poor data;
4) Contingency plans are essential.

The BLS forecasts are probably the best ones available to develop successful forecasting. Inconsistencies and consequences should be identified with contingencies for discontinuities. Trends should be monitored from a technical standpoint and adjustments should be made in the projections and occupational coefficients as the discontinuities arise.

(This study was supported by ERDA).

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CHARGE TO THE WORKSHOPS

Mr. Nathan M. Becker, Vice President
Massachusetts Society of Professional Engineers

It is fitting that the first regional Colloquy and Workshops on energy-related engineering manpower questions is being held in New England; fitting because New England has often displayed innovative leadership and because many of the problems to be addressed will be most acute in New England.

The dialogues enacted here offer no comfort to us. There is no comfort because the form, shape and substance of our national energy program seems still to be elusive. Solutions to be derived from this program appear to be either out of phase with our needs or in a state of gestation not yet ready to come forth.

I think we feel intuitively that there are some problems out there, that a focused, comprehensive plan is wanting. Who shall define these for us? The answer for today is, "we shall". As suggested to me by Ron Frederickson last night, "If Washington won't or can't tell us the extent of the problem or satisfactorily describe it's corrective program to us, then let us do it for them." Therefore, for purposes of our workshops, let us now make some assumptions:

- First: assume the price of oil will reach $20/barrel in one to two years and that this will trigger extensive programming and funding for energy alternatives.

- Second: assume New England, as a recognized high-technology development center, will attract large maounts of R & D money (estimated 2 billion dollars, 1980-1983).

- Third: assume the major output of these programs will be technology instead of hardware. Development, studies, research, consulting and support, etc.

- Fourth: assume required areas of expertise will demand multidisciplined engineers oriented in state-of-the-art alternative energy concepts and techniques.

- Fifth: assume a negative technical manpower delta will exist as follows for New England:

1980 - 1000 Engineers
1981 - 2000 Engineers
1982 - 3000 Engineers

Further, assume these are people with 3 - 5 years or more of experience and are required in relatively commensurate numbers in other regions of the country.

- Sixth: assume defense, the computer and instrumentation industries, and diversity will be competing strongly for additional professional talent at the same time, creating strong pressure on engineers to relocate.

- Seventh: assume support personnel (i.e. technicians) will be equally in short supply on at least a 3:1 ratio.

- Eighth: assume retraining/on-the-job-training programs are viable means for supplying some of these engineers and technicians to New England.

- Ninth: assume anything else which will help you consider the issues in your workshops.

Now, armed with the inputs you received here yesterday and this morning and with these bold assumptions, you are ready to approach the workshop phase of our conference.

To hope that these workshops will provide more than topical responses to the issues addressed therein, is probably too ambitious. Then what is the purpose of these workshops? The purpose is to make a beginning--to begin the exchange of views and ideas with concerned colleagues; to extract a consensus from a consortium of industry, academia and government; to identify developing trends in this elusive and ill-defined field of energy; to reach boldly into our creative selves and identify innovative concepts needed to offer quantum leaps for our problem solving efforts; and, finally, to agree on a mechanism which will continue these joint dialogues and considerations beyond our day-and-a-half meeting.

Gentlemen, history awaits your deliberations.

Good luck!!

COLLOQUY, PART III

WHAT WE NEED TO DO

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WORKSHOP REPORTS

Pairs among four ISSUES were proposed for duplicate consideration by pairs among four WORKSHOPS relative to definition of need; perceptions of responsibility, appropriate sponsorship, initial and continuation funding; and proposal outlines. Responses are reported here in the order of Issue by Workshop.

ISSUE A. A dynamic demand/supply intelligence system that will be interactive with educational, industrial and governmental bodies concerned with the maintenance of a regional energy-related engineering manpower resource of high quality.

Report of Workshop I
Mr. Austin Gillis, Chairman

"1. The issue cannot be reduced to "energy-related" positions only, but must deal with the broader question of total engineering manpower requirements; i.e., there are no "energy engineers", only mechanical, electrical, etc. engineers working on energy-related programs.

2. A regional demand/supply intelligence system is possible, but probably would be redundant to the existing network of demand/supply indicators.

3. The system currently in-place works reasonably well and should be able to focus on the specific issue of energy-related manpower as this becomes necessary. The current system was viewed as a combination of the following elements:

   - curriculum review boards.
   - faculty/industry/government interfaces on research projects.
   - faculty consultants to industry.
   - the on-campus recruiting system.
   - summer internship programs in industry and government for engineering faculty.
   - NSF, EMC, etc. studies, surveys and reports on engineering manpower requirements
   - state employment service review of supply and demand.

4. The response time of the current system is admittedly limited, but it is doubtful any new system can substantially reduce the cyclical nature of the engineering manpower demand/supply picture..

5. The current intelligence system is diffuse; it is doubtful centralization will improve the situation."

Report of Workshop II
Mr. Leo L. Simms, Chairman

"There is an immediate need for a regional demand/supply intelligence system for purposes of gathering, analyzing and disseminating information to educational, industrial and governmental bodies concerned with the maintenance of a regional energy-related engineering manpower resource of high quality. Further, the demand component in this system must be based on relevant labor markets. The supply component is national in scope, affecting various mobility patterns, but not restricted to regional levels. The intelligence system should develop a complete matrix of energy-related personnel on an industry by industry basis to provide the broadest perspective of manpower requirements and utilization."

ISSUE B. Joint industry/university/government educational and retraining programs for the redirection of mid-career, under- and un-employed engineers into energy-related endeavors.

Report of Workshop III
Mr. Thomas F. Widmer, Chairman

"The workshop considered the question of career switching, both for students and mid-career engineers and technicians, to be an important aspect of energy-related technologies. First of all, the various degree and non-degree institutions should strive to facilitate the transfer of students from technician-type programs to full-degree programs (and vise-versa). The objective is to make sure that each student with a technical orientation finds his way to the highest possible level of training and achievement. At the same time, students unable to fulfill the requirements of a degree program should be given the option of pursuing a technician training course in order to avoid a complete career washout."

Report of Workshop IV
Dr. Paul Doigan, Chairman

"Some of the words Tom used are exactly the words that we're going to be using.

With respect to the under-employed and un-employed engineers, we felt that certainly there should be no change in the basic curriculum, that we should use appropriate techniques for special training as it's needed: on-the-job training; taped courses which could be used to give people background that they did not already have. For instance, if an electrical engineer wanted to get some training in chemical engineering, he could take one or more of the taped courses which are available, currently existing, and he would use those kinds of courses to bring himself up to speed in that other discipline.

For those that need to bring themselves up to date in their own discipline area, state-of-the-art kinds of short courses such as those that are made available through the MIT program, or continuing education departments, or specifically by engineering departments.

We also should take advantage of re-entry programs for those people who are out of the work force, such as women who might have had a degree in chemistry or physics and might very well be the kinds of individuals that we would like in engineering programs. A re-entry program, then, might be aimed at changing their orientation from chemistry to chemical engineering.

Also, we should take into consideration maintenance type courses, vis a vis career growth type courses. There's a continuing need for keeping people up to date on what's going on in their particulr field in addition to courses aimed at providing career growth for them.

It was pointed out by one of our people that there is not enough attention paid to career growth, career development, through the support of employees who are encouraged to take courses at local universities. That is, companies are quite willing to pay for tuition refund programs but with no thought whatsoever to what they're going to do with that individual once he completes that program, or completes an advanced degree course. So something ought to be done with respect to that. Of course, what I'm talking about, in all cases, relates to the discipline areas that the individual is currently in or wants to get into.

In order to do any of these things as it relates to energy we've got to have some leadership from the government. When we address that, we're talking about a policy decision. For example, that we will put all our efforts into coal gasification, or into solar, or whatever. Thus, we must have some policy decisions by the government before we can honestly consider a partnership arrangement between the government, academic institutions and industry. That is, industry won't put its money, or significant amounts of its money, into programs unless it has some assurance from the government that this is the policy that we're going to follow. There might be some tax incentives or other kinds of incentives to do these kinds of things. You also have to look at the government as both a user and a provider -- first, as a provider of the policy and funding and, secondly, as a user of the individuals who are being educated."

ISSUE C. Joint industry/university/government educational and retraining programs for enabling the interoccupational mobility of technicians and non-engineering personnel into energy-related engineering support endeavors.

Report of Workshop I
Mr. Austin Gillis, Chairman

"1. More important than the issue of retraining the technician is the question of adequate inflow into the field as an initial career choice.

2. The current supply of properly trained technicians is low and continues to diminish because:

   - The quality and quantity of technicians trained in the military is falling off.

   - More and more high school grads are opting for 4 year college degrees rather than 2-year vocational training.

   - The technician position suffers from a poor image in the U.S. today.

3. The need for skilled technicians has tended to concentrate on the R&D areas, particularly design, in recent years. This is partly because the products we are producing today frequently call for a changeout of pre-assembled parts as the in-field repair method, thus reducing the need for and utility of the outside technician.

4. Too frequently, degreed engineers are doing technician work.

5. The need for skilled technicians is real and requires
   a) more activity on the part of high schools and 2 year vocational schools in promoting this career choice, and
   b) better leadership by government in providing funding and awareness.

6. A good but untapped source of technicians might be the growing female workforce. Women seem to have the skills to make good technicians and should be encouraged to pursue this field on a full time or part time basis."

Report of Workshop II
Mr. Leo L. Simms, Chairman

"The primary responsibility for retraining technicans and non-engineering personnel into energy-related engineering support endeavors should reside with the vocational schools and community colleges. Joint ventures of industry and government with these educational institutions should be dictated by market demand and supply conditions."

ISSUE D. Improvements for incorporation in energy-related engineering degree curricula.

Report of Workshop III
Mr. Thomas F. Widmer, Chairman

"With respect to engineering course content, the workshop concluded that more emphasis must be placed on basic programs for thermodynamics, mechanics, chemistry, physics, etc. There seems to be a distressing trend among engineering schools to create special programs (e.g., nuclear, environment, space, solar energy) in response to the latest fads. For example, the recent wave of enthusiasm over solar energy on various campuses (by students and certain faculty members) may distract emphasis away from basic technology. This is not in the best interest of either the students or their future employers. Excessive advocacy of any particular energy system, especially by those not necessarily knowledgeable in the practical constraints of market, finance, economics, manufacturing, etc., has lead to inflated and unrealistic expectations by recent graduates who find the climate in industry less than receptive to concepts whose economic feasibility remain highly questionable. Engineering graduates in the energy disciplines must be prepared to work a variety of technologies and should not be "brainwashed" towards excessive advocacy of any particular system or concept.

One of the basic technical disciplines that seems to need substantial strengthening in the schools is thermodynamics, particularly with respect to providing better understanding of the Second Law and its implications. Another important subject although non-technical, is economics...not macro-economics, but rather the detailed financial study of capital projects to determine rate of return and payback. This know-how is crucial to any engineer expecting to practice in the energy field, because all energy facilities and technologies ultimately succeed or fail on the issue of economic feasibility."

Report of Workshop IV
Dr. Paul Doigan, Chairman

"Addressing the second subject--that is, curriculum development--we first want to point out that there are no energy engineers, but there are mechanical, chemical, electrical engineers, etc. etc.. So the curriculum should be pretty much the basic curricula as they now exist, with some options which are energy-related.

Most important would be the awareness courses, so that people in chemical engineering, for instance, could have a broad picture of the kinds of options that might be available to them as chemical engineers if they wish to work in energy-related areas. This means that they might, in the course, be exposed to solar power, to nuclear power, to coal gasification, or any of the other power sources, or energy sources, and how they might apply what they have learned in chemical engineering, to those particular areas. It's important to infuse into the courses, as they now exist, specific examples which are energy-related. Therefore, you don't have to change the courses so much as you use up-to-date-examples which are related to various energy forms.

We must also include in the curricula courses that are devoted to the cost effectiveness of energy options, economics-oriented kinds of courses, so that informed decisions can be made."

PERIPHERAL COMMENTS

Report of Workshop I
Mr. Austin Gillis, Chairman

"Regional manpower issues, although important, are overshadowed by the pressing need a) to get a concensus on the nature and scope of the so-called "energy crisis", and b) to formulate a clear, goal-oriented national policy for alternative energy source development, the most important impact area for engineering manpower."

Report of Workshop III
Mr. Thomas F. Widmer, Chairman

"Our workshop had some initial discussion of the ground rules and assumptions. In particular, we questioned the projections of R&D spending for energy programs in New England, and the attendant forecast of a substantial shortage of engineers (running into the thousands). There seemed to be a concensus that a shortage of this magnitude would not, in fact, develop because no massive infusion of energy research funding could be foreseen from the Federal Government, or from any other source for that matter.

A peripheral issue considered by our workshop was the problem of poor technical understanding on the part of the general public, especially those possessing college degrees in non-technical subjects. Energy policy is ultimately decided by the political process, and to the extent that policy makers and the electorate remain ignorant of the key engineering and economic factors surrounding various energy systems, the outlook for formulating constructive legislation and administrative policies will indeed be dismal. At the very least, there should be a requirement that all university graduates be exposed to a few survey-type courses in technical subjects. It is no less reasonable, given the technical orientation of today's society, that all "educated" persons have some familiarity with technology than to require science and engineering graduates to be "well-rounded" through some exposure to history, literature, social sciences, etc."

Report of Workshop IV
Dr. Paul Doigan, Chairman

"Lastly, for non-engineers, courses to make them more aware of energy problems and energy options because those are the individuals who will be involved in government and policy-making positions. The more we can do to make them more aware of what's going on the better off we will be."

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SUMMATION

WHAT WE HAVE HEARD YOU SAY

Professor Israel Katz
College of Engineering
Northeastern University

I am charged with the responsibility of winding things up here, telling you what I think we've heard, but with the privilege of doing a little editorializing in the process. So I'm going to try to tell you what I heard, within the framework of my own conceptions.

I'd like to give you some background as I see the present situation facing us as a society, in a civilization in which the energy problem is only one of many. The amazing thing is that they're all related. I'd like to draw a couple of curves on the board and focus primarily on the technological aspects of these. Then we'll relate these to the manpower crunch that we think we may be facing at the moment.

The first curve I'll draw is one of my favorites. (By the way, I have a one-hour lecture on this subject but I'm going to tie this up in about 15 minutes). This curve represents yield versus time (Figure 1).

You could draw such a curve for a subcritical mass of U235 and, if you don't assemble it, it can last for some 2 billion years before it deteriorates. You still don't get a sudden release of energy. But when you bring it together you get a fission reaction and a tremendous yield of energy which is also destructive. Other than being used as a bomb, there's no practicality to it excepting that you could harness it by mitigating the rate of reaction and get roughly ten or more times the yield out of the process. That's what a fission power plant does. It mitigates this bomb reaction so that we get more power or, at least, we utilize the energy which is being liberated at a slower rate and use it for constructive purposes.

This curve is really a model of what's happened to mankind. Let me take you back 50,000 years. The reason for picking 50,000 years is that some of our paleontologists, and others who deal with human history, say that man 50,000 years ago may have looked a little different--perhaps like our students looked 5 years ago--but they had the same intellectual equipment that we have today. In other words, if you were to pick up someone who lived 50,000 years ago and put him into our society, give him the same education, chances are he would be viably functional in our group.

If we clock the speed of human travel of 50,000 years ago we find that man was more or less tied down to 3 miles an hour, which is the speed at which we walk today on a continuing basis. We can run faster, and so could they, but the speed of human transportation over long distances was 3 miles an hour up to the time of about 10,000 years ago. (Now don't forget, on Figure 1, 1/8 inch represents 1000 years). About 10,000 years ago man got on top of a horse. The horse wasn't domesticated and the speed of human travel on top of a horse didn't change much until the poney express. You could go from St. Louis to somewhere south of San Francisco in the scheduled time of 11 days, via pony express. This was only 130 years ago and was a sensation. The record in those days was 8 days.

You could send a letter or message by pony express from St. Louis to San Francisco. Then along came the telegraph which displaced the pony express and we got very rapid speed of communication, but travel crept up slowly. Realize, this was all in the past one hundred years. We're talking about a tiny fraction of an inch on our Time axis, Figure 1. During that period we have gone from something on the average of 8 miles an hour into orbital velocity, and you know the kinds of technology that has gone into that sort of thing.

You can plot not only the speed of human travel, but the speed of human communication. We can now communicate almost instantly from outer space over tremendous distances. We can communicate with enormous groups of people where only a few years ago you could only talk to groups this size or maybe a little larger. Many things have changed along this curve: roads under construction, pavement, dwellings, newspapers, publications, everything.

Population data has the same curve. When we talk about how many people are alive today we don't focus on the idea that there are more people alive today than ever lived in the aggregate. Hence, quite a concept: more people walking the surface of earth today than ever lived before in total. The rate of population growth is such that it doubles every 30 years. So we'll have to do something about that because it'll be kind of crowded in a few years. Some of us may find it very difficult to drive a car even if we have some fuel.

Mankind has gone critical, just like a bomb, only in the past 100 years. In that short time we've consumed approximately 50% of the known fossil fuels deposited by nature over about 2 1/2 billion years. Now, if we continue to do this at the present rate of consumption we will probably run out of fossil fuel in a very short period of time. We keep discovering new deposits--I recall about 25 years ago it was estimated we had 10 years to go. I recall putting in a request to include the internal combustion engine in my laboratory's research program. They laughed at me, saying "Who needs to improve the internal combustion engine?" I got $200.00.

Naturally, I gave it up because it was obvious that nobody wanted to do anything about it. Today the internal combustion engine is a hot subject, but who is working on it? Very few people know much about it.

I went to a transportation conference in Cambridge, just two weeks ago and listened to the speakers. There was only one individual who seemed to know what he was talking about. He was talking about the physical limitations, the laws of science and nature that inhibit the achievement of some of the imaginery, harebrained efficiencies that some people are talking about. They're not in the cards. Some of the people in government are just beginning to recognize this.

One of the problems that confronts us, in the energy field, is the lack of understanding that power plants don't always operate at the design points and there are severe penalties in deviating from design point operation. The internal combustion engine, as it is today, is a very mature device which was developed by the great thinkers in that area some 75 years ago. Then there was a cut and the schools stopped teaching it. We got rid of most of our laboratories involving internal combustion engines. Instead, we replaced it with little toys that really don't teach much. And much of engineering has gone in the direction of toy development instead of real machinery and processes. We need more of that. We need more of the practical aspects of engineering put back into our engineering curriculum. I'll come back to that in a moment--this is one of the things that bugs me when I think along the lines of our discussions here.

Another thing is the growth curve of systematic change. There are roughly three kinds of change: catastrophic, non-systematic and systematic change. Systematic change, which most systems adhere to, is described by this curve (Figure 2) -- in economic systems, in engineering systems, in the physical world, and what have you. Just let me explain it briefly.

Let's take you, as an organism. Call the vertical axis your physical height or progress versus the horizontal axis which we can call investment. At one time you start off as an idea, a point of conception. The embryo grows very slowly at first, during Period A. During the gestation, about 9 months for a human, there's a period of cell specialization, a period of organization. Nobody yet understands what makes the cells specialize but it has something to do with genetics. Period B, from sometime after infancy to about age 17, is a period of very rapid growth which slows down in the late 'teens. Then follows Period C and at about age 24 you completely stop growing, that is, vertically, (you can still grow horizontally!) no matter how much you eat.

Engineering developments follow this curve. For example, you send out a proposal for an advanced development. You've written it and sometimes if you're unfortunate enough to get the contract you say "Good heavens, what are we going to do?" In virtually every development you have a fog period. Everybody who has worked on or directed an advanced technical development knows this. You kind of figure out what you're going to do. Even though you wrote the proposal and told the customer what you're going to do, you don't do it. After the fog there comes a technological breakthrough. You begin to see the light. There's a period of great activity and rapid progress. Then things are going to slow down and, finally, there is the delivery date when you have to deliver the product, the study or what have you.

An engineering manager has his hands full in Period C trying to figure out what to do with the people who have contributed during Period B. He has to have another job or he has to fire these people. So naturally an engineering manager not only has to direct the work in progress but he has to think in terms of utilizing the resources, both human and physical, subsequently if he doesn't want to fire them.

Okay, what is going on in our energy-related engineering area. Most of our developments are pretty mature: the steam engine, the gas turbine, the internal combustion engine, etc. etc.. These are all pretty highly developed devices, including the magnetohydrodynamic devices, which are primarily going to be copying kinds of devices if they are ever really developed to a practical point. The point is this: if we're talking about improving the existing devices so that they are more energy efficient we're talking about very high technology which pays off at a very slow rate, high on the curve where Period B passes into Period C.

Here the investments are enormous per unit of output. Consequently you have to look for seasoned people, not recent graduates. They don't have the new knowledge and you'll be wasting your time. We have to nurture, as Dr. Bisplinghoff said at the very beginning, nurture our seasoned engineers because that's where the knowledge lies.

New knowledge doesn't grow on trees. It no longer comes from academia as it used to. Only 20% of the new knowledge is coming from academic institutions. In fact, 19% by actual count of papers, developments, funded programs, etc. etc.. Who keeps score of that? Battelle Memorial Institute does a wonderful job--the NSF utilizes much of that information. BMI puts out an annual report on this--the latest is entitled "Probable Levels of R&D Expenditures in 1979--Forecast and Analysis," published in December, 1978.

Some of that information is contained in this document. This is a report put out in December, 1977 by the National Science Foundation, available thru the U.S. Government Printing Office. It's called "Continuing Education of Scientists and Engineers".

Another source is the annual statistical issue of the Journal of Engineering Education, published by the American Society For Engineering Education, "Engineering College Resarch and Graduate Study." It covers all the ECPD accredited engineering schools in the country and gives in great detail who's doing what. You get a complete breakdown of the various areas in which work is going on and there are some activities in every area of the energy sciences and technology. On a percentage basis my estimate is that it's something like 10 or 15%.

Now, where are you going to get the people to do this advanced work (editor's note: upper curve in Period B), which is very expensive per unit of output and requires a high skill?

Also, when you're beginning something very new (editor's note: Period A into lower curve in Period B), as we are in some instances, we also need highly skilled people because, even tho' they're in the fog area, the cost differential involved is relatively negligible. In other words, no matter how we man the work, the return is going to be marginal for a long time. We're not going to come up with answers even tho' we're going to spend a lot of money.

It's when we really know something about the subject, but don't know all that's needed, that we make a lot of progress (editor's note: central curve in Period B). You know, most companies like to work in that part of the curve because it's very profitable. For a relatively little bit of expenditure you make a lot of progress. Up here (editor's note: upper curve in Period B) you spend a lot but don't make much progess.

Okay, where are these people coming from? I would point out that they're the people who have the knowledge <u>and keep updated</u>. How do they keep updated? The key to keeping updated is not to go to universities and take a course. The key to keeping updated is to be on a tough job and learn on the job. Then, if you need supplementary education you go to the university, or bring in the university, or you run a course in-house. How many people are doing that now?

There's research on that--3% of our engineering population. We have approximately 12 million engineers at the present time, working as engineers, not just those who call themselves engineers but engineers with degrees. 3% of those are actually taking formal education courses outside of their companies. 10% of that population, making a total of 13%, are doing something about taking additional courses to supplement learning on the job.

How many people are really learning on the job? Approximately 20%. This seems to be the body of engineering talent that's alive, alert and trying to push back the frontiers of knowledge in science, applied science and technology -- 20%.

One of the things that you'll discover when you get into this business of continuing education is that when an engineer has allowed him-or herself to slip behind, nothing really helps. The notion of stockpiling engineers (editor's note: against cyclic lows in supply) was mentioned earlier and I advise against that. I heard it, you heard it. The reason for not stockpiling engineers is that the shelf-life of the engineer is very poor.

When you stockpile them its like putting tomatoes in the refrigerator and forgetting about them. In about two weeks they rot, so you throw them out. Stockpiling engineers, and not using them while they're stockpiled, will give you a lot of rotten tomatoes. So you have got to use them!

What's wrong with industry? The jobs are poorly designed. How are they poorly designed? You're operating your engineers at part load. When we send an engineer out from an educational institution presumably we've trained him to operate at an optimal load. Not full load because that is very taxing. If you overload them they are not efficient, if you underload them they're not efficient. If we're going to utilize our engineers in either an over-or underloaded capacity we're going to have trouble. The challenging job is to operate in the optimal part of the spectrum, an extremely challenging job.

If a job is full of fire drills, where the individual has to put in an awful lot of casual overtime, where things have to be done in a great hurry and they are very difficult, that person doesn't have time to really think through the problem of keeping updated in the way a professional person should. On the other hand, people learn primarily in response to a need. If you run the engineer underloaded there's no need for him to push himself. "Come on, I get my salary, my coffee klatch in the morning, the coffee's always percolating, what do I have to update for?" So they don't update and they begin to rot, you see. Pretty soon you have to get rid of them.

So, how do you keep them up-dated? You give them a tough job which doesn't overload them. Then, provide plenty of opportunity, and incentives if you will, to pay for their courses. Bring them in to company courses. You have to bear in mind that continuing education is full of ruts and snags. As the subject matter becomes increasingly difficult there are less and less people in any one company who can comprehend the subject matter. You don't want to run classes for two or three people. Universities therefore can provide an even ground where you can bring very able people together from different companies in the area, and bring in an expert. The university is providing this even ground so you don't need to worry about proprietary information. You have to explain that you don't want to divulge company secrets or give away classified information.

We have had many of these programs and they have been highly successful. For example, I had a program in advanced infrared techniques. It was well known that Honeywell had the best team so we went to Honeywell and said, "How about you running a course for us?"

"What? Educate all these people, all of our competitors, on how to do these things?"

I said, "If you don't do this nobody else can. I'm speaking of the national interest rather than Honeywell's."

"Well, I'm thinking of Honeywell. Can you give me a good reason why our team should be giving this advanced course?"

I said, "Sure, we're going to have people there from NASA." (This was when NASA was still located in the Boston area, in Cambridge, and they were very much interested in infrared techniques as a means for getting platform stabilization for space vehicles). "Who do you think is going to get the contracts when the NASA people, who are going to be monitoring those contracts and handing them out, see who's teaching the course."

"Fine, plan on the course, I'll check with Minneapolis."

He gave it not only once but several times. Each time we got the same students to come back because each time it was more and more advanced.

So the nature of the beast is such that we have to nurture our most competent people now to handle the opportunities and the emergencies of the future.

Now, what do we have to do about the educational plan for the energy future? What I have heard is that great expectations are simply not in the cards. It's time now to take another look at our curricula and the structural environment of our professional engineering schools. We have to bring in people who can teach the subject matter in areas that we shouldn't expect the fulltime faculty to be able to handle.

For instance, we now have tenured faculty who are, for the main part, younger people who have no industrial experience whatever. It's an inbreeding kind of thing. They even have their own language in some fields. Students go out and they ask for a two-port electric motor. The dealer says, "What are you talking about, two-port motor?" "Well, you know, the output port and the input port." The dealer will say, "you mean a shaft and a couple of leads?" "Yeah." Okay, they have their own language.

At any rate, to make a long story short, the model we might need, might have to go to, is one where there is a core of very competent fulltime faculty, tenured or otherwise, with adjunct people. There's going to be tremendous resistance to this. Everytime I talk about it I'm shot down.

We need professional people in fields of practice who are fully competent to teach. Some of them are former professors, or professors who do a great deal of consulting work with industry and have kept themselves up to speed, so to speak. Those are the people who should be giving the applied courses.

Now, you can do a much better job of teaching theory, once you get all the fundamentals, by teaching the theory as you teach the aplied subject matter. Bring in the theory as you need it. I find you can compress curricula, get more subject matter in there, at the same time make room for some of the humanities that ECPD requires.

These days it's increasingly difficult to get across the proper preparation for our engineering graduates. There's much more to learn. They find there's a gap when they get out on the job between their academic preparation and what they really need to know to be productive in a creative sense in industry. There's a gap and the gap has widened.

Why? Because the targets are moving very fast, so that the student has to learn an awful lot of fundamentals, a great deal of theory, and some of the humanities to make him a little more rounded. In order to bridge this gap we have to move the burden to industry to do that job. Industry has been doing the job fairly well, but more of it needs to be done in cooperative conjunction with our educational institutions.

That's my way of saying what I have heard.

FIGURE 1

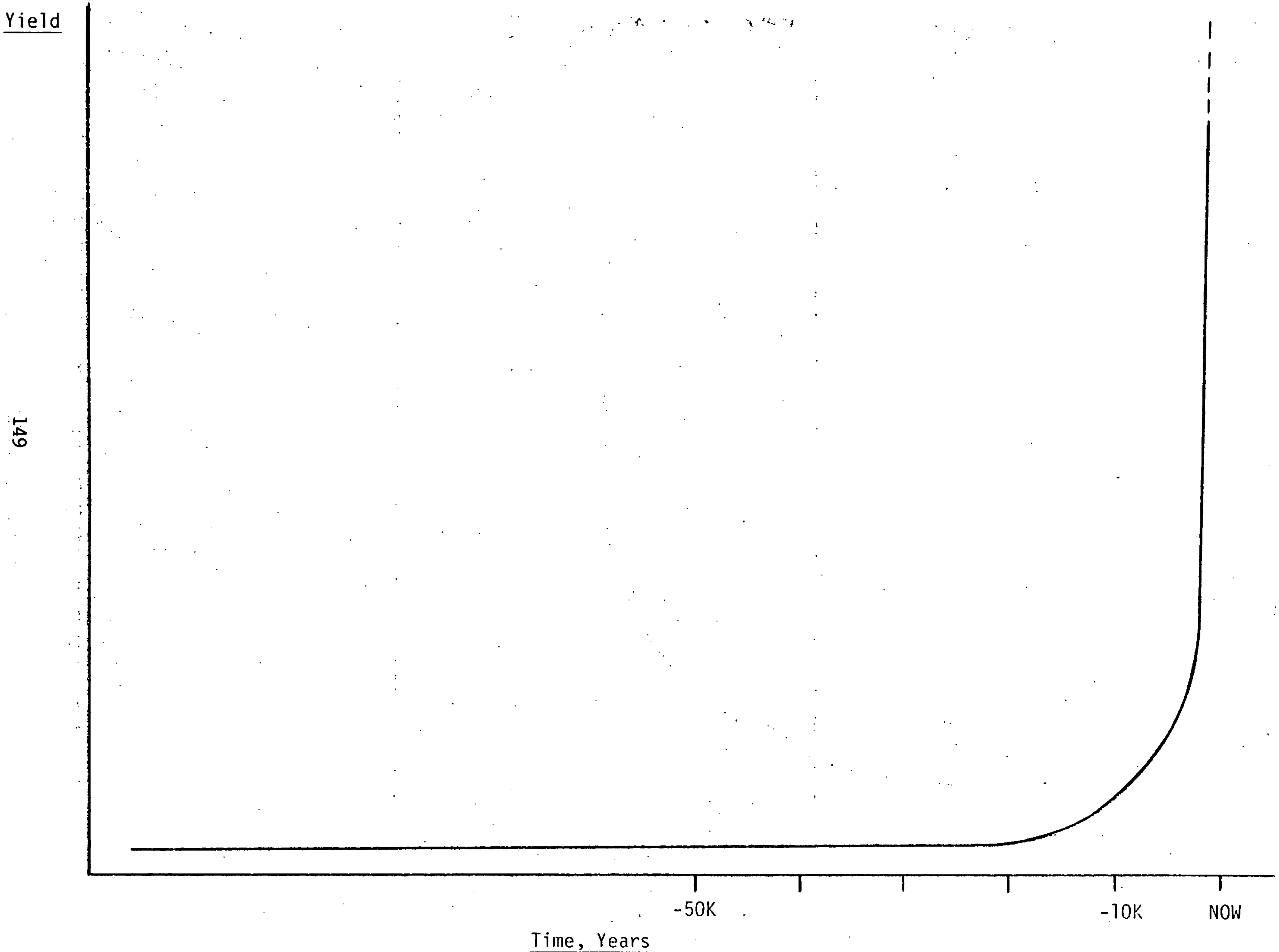
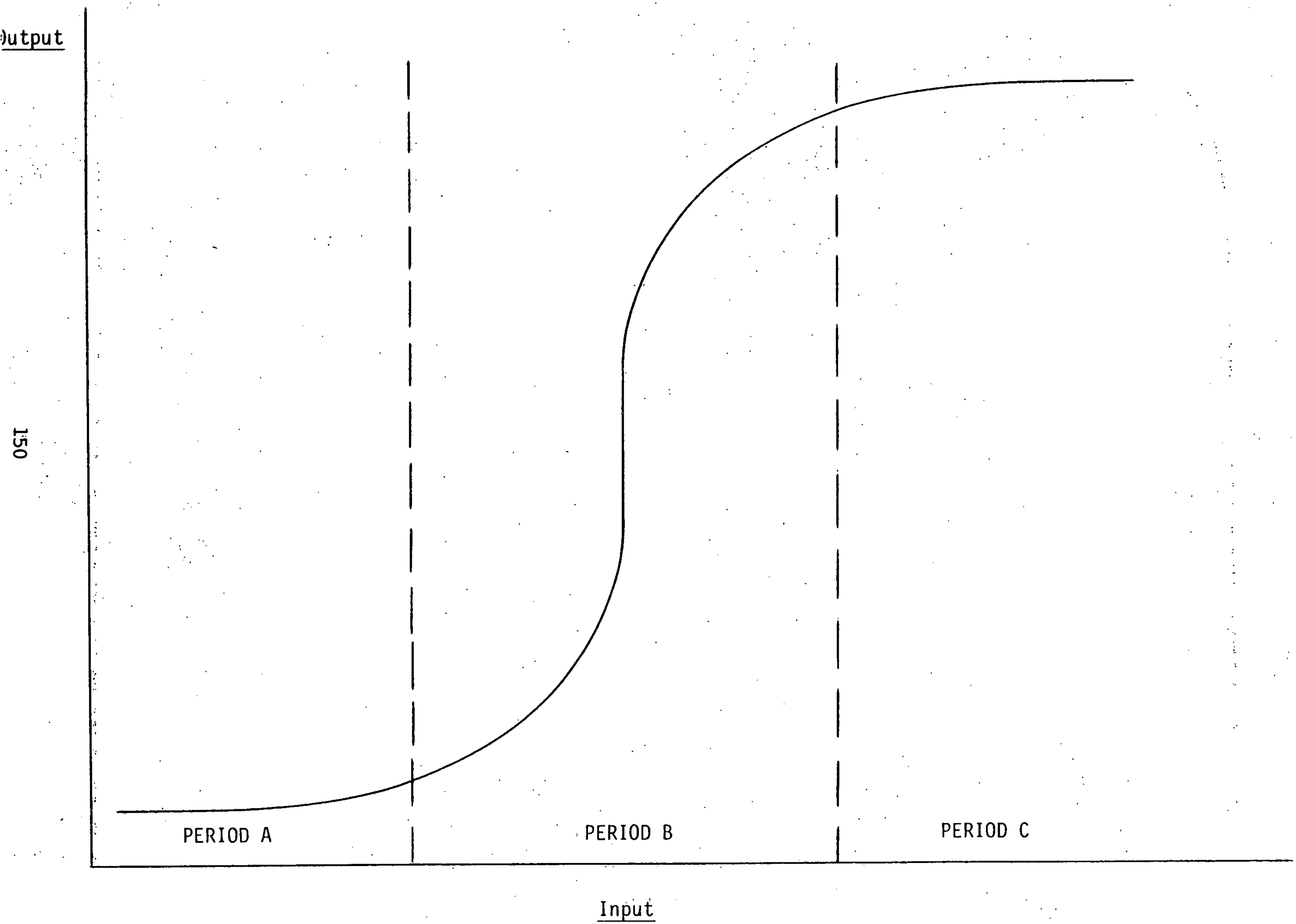


FIGURE 2



EVALUATION REPORT

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EVALUATION REPORT OF COLLOQUY AND WORKSHOPS

Relative to the Southern New England Region:
Connecticut, Massachusetts, Rhode Island

A COLLOQUY AND WORKSHOPS: REGIONAL IMPLICATIONS OF THE ENGINEERING MANPOWER REQUIREMENTS OF THE NATIONAL ENERGY PROGRAM

March 1-2, 1979
Campus Center, University of Massachusetts
Amherst, Masssachusetts

by

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April 12, 1979

Introduction

The University of Massachusetts and the Massachusetts Society of Professional Engineers sponsored a colloquy and workshops to assess the regional energy-related engineering manpower prospectus relative to the national energy program. Forty-four professionals from industry, engineering, education and government met on the Amherst Campus for the two day conference.

A questionnaire (Exhibit 1) was administered to the participants to evaluate its overall effectiveness and to determine if the colloquy and workshops met the goals and intents described within the proposal. The questionnaire was divided into four major sections: identifying information, adequacy of physical facilities, relevance and quality of the colloquy presentations and, finally, workshop processes and products.

This report analyzes the results from each section of the questionnaire and provides a summary and recommendations.

Identifying Information

This section of the questionnaire included information on occupations and previous experience with conferences of this nature. Out of the forty-four participants, twenty-eight completed the questionnaire, a return of 65%. Ommissions were due almost entirely to partial attendance. Fifty-four percent of the respondents indicated that they had previously participated in conferences of this nature. Forty-six percent indicated they had not. The participants represented the following sectors:

Engineering	13%	Government	10%
Education	23%	Other	8%
Industry	26%	Unspecified	20%

There seemed to be a representative sample of responding professionals with the exception of government which was not as equitably represented among the respondents as the other sectors. Occupational titles included:

Architect
National Professional Society Staff
Professor/Consultant
Manager
Manager/Technical Recruiting
Manager/Engineer
Economist
Energy Economist
Director of Personnel
Personnel Administration

Director of Energy Management
University Professors (6)
Vice President - Engineering
Manpower Planner
Industrial Relations Manager
Educator
Marketing Engineer
Director of a Corporation
Energy Executive
Executive
Employment Counselor
Consultant

All of the participants were highly sophisticated and knowledgeable about the subject matter. One hundred percent of the audience recommended further programs of this nature.

Physical Accomodations

Participants were housed at the Campus Center. The physical facilities were rated very good to excellent by seventy-nine percent of the participants. However, several participants suggested that the meeting rooms be cooler and better ventilated.

Preliminary Materials

Each invitee was sent material prior to the colloquy in preparation for the speakers/panelists. Only one person indicated he had not received the preliminary packet. Out of twenty-seven people, eleven indicated that they had read all of the material; fifteen indicated that they read approximately one-half of the material and only one did not read any of it. When asked if the preliminary material stimulated/provoked thought pertinent to the colloquy/workshop, twenty-six replied "Yes", one replied "No"; twenty-three participants were satisfied that they were appropriately prepared for the program. Four participants indicated they were not satisfied with the preliminary materials.

With programs as highly specialized as this, it is extremely valuable to prepare the audience in a way that increases its knowledge base and stimulates thinking on the subject matters. The dissemination of preliminary materials prior to the colloquy and workshops was successful in that it encouraged the audience to think about upcoming issues, thus accomplishing its purpose.

Colloquy and Workshops

The colloquy and workshops were designed to accomplish several purposes:

1) to assess the energy-related engineering manpower prospectus relative to the emerging national energy program.

2) to focus the assignment (#1) on the Connecticut, Massachusetts and Rhode Island region.

3) to consider vehicles for the monitoring, maintenance and replenishment of an engineering manpower resource consonant with a vigorous regional role in the national program.

4) to offer proposals for energy-related engineering manpower monitoring, development and redevelopment programs.

A series of questions were generated to address the first two purposes. Additionally, the degree of participant satisfaction and their perception of the relevance of each presentation was evaluated. Each question and the evaluation results are as follows:

Did the colloquy direct your focus to the Connecticut, Massachusetts and Rhode Island region?

22 (76%) Yes	7 (24%) No

To what extend did the Colloquy assess the regional energy-related engineering manpower demand/supply prospectus?

1 (to a large extent)	2	3	4	5 (minimally)
0	8	12	5	3

The mean rating was 2.89.

How consistent was the regional assessment (above) with the magnitude of the emerging national energy program and the potential regional participation in it?

extremely	adequately	minimally	not at all
3 (11%)	16 (59%)	7 (26%)	1 (4%)

To what extent did the Colloquy indicate a need for improved vehicles for the monitoring, maintenance and replenishment of an energy engineering manpower resource?

5/1	11/2	4/3	4/4	3/5
to a large extent				minimally

The mean rating was 3.04.

How were those indications (above) consonant with a vigorous regional role in the national energy program?

1 (4%)	extremely	16 (64%)	adequately	8 (32%)	minimally	______	not at all

Participant satisfaction with each presentation in the background Colloquy, Part I, was rated on a four-point scale, key:

1 = to a large extent
2 = to my satisfaction
3 = minimally
4 = not at all.

In addition, each participant was asked to indicate his perception of the relevance of the presentations on a scale: Highly Relevant, Of General Interest, Irrelevant

Exhibit 2 graphically reports this measure of the presentations in rank order of perceived relevance.

Of the four presentations considered by more than half the participants to be highly relevant (54-59%), the degree of satisfaction reported (sum of scales 1 and 2) ranged from 57% to 89%, on the average 74.5%. Of the five presentations considered by less than half the participants to be highly relevant (33-49%), the degree of satisfaction reported (sum of scales 1 and 2) ranged from 52% to 79%, on the average of 68.4%. A relationship seems to be suggested between the degree of satisfaction experienced with a presentation and its perceived relevance. With the possible exception of two presentations (Perceptions of the Regional Role in the National Energy Program; and Federal Imitiatives For The Commercialization of Emerging Energy Technologies), the sponsors of the Colloquy should be pleased with the registrations of satisfaction with the presentations.

Overall rating of the Colloquy was:

5 excellent   15 very good   5 adequate
1 less than adequate   0 poor

The workshops were designed to address purposes three and four. Each workshop was evaluated in terms of the participatory process and the final product.

All workshop participants rated the process positively. Excepting one person, all others felt the colloquy prepared them for the workshop. The workshops sustained interest and each chairman was rated very good to excellent in terms of his presentation of the task, organization and summarization of the session.

Product evaluation results of each proposal are as follows:

Workshop #1	5 Excellent	4 Very Good	3 Average	2 Poor	1 Very Poor	Mean Rating
CREATIVITY	1	4	3			4.0
FEASIBILTY						
TIME	2	3	3			4.1
COST	2	1	2			4.2
MANPOWER	2	1	2			4.2

Everyone indicated that the proposal generated was worthy of further pursuit. Overall ratings of the workshop included:

15% excellent 57% very good 28% adequate
0% less than adequate 0% poor

Workshop #2	5 Excellent	4 Very Good	3 Average	2 Poor	1 Very Poor	Mean Rating
CREATIVITY		1	3	1		3.0
FEASIBILTY						
TIME		1	1	3		2.6
COST		1	1	3		2.6
MANPOWER		1	1	3		2.6

Workshop number two was not as successful as the other workshops. Three participants felt that the proposal was worthy of further pursuit, two persons did not and one person felt that, with modification, the proposal could be worthwhile. Overall workshop ratings included:

____ excellent   50% very good   50% adequate
____ less than adequate   ____ poor

Workshop #3	5 Excellent	4 Very Good	3 Average	2 Poor	1 Very Poor	Mean Rating
CREATIVITY	1	1	3			3.6
FEASIBILTY						
TIME	1	3	1			4.0
COST	1	3	1			4.0
MANPOWER	1	3	1			4.0

Workshop number three was positively received. Of the participants, one-half indicated that they felt the proposal was worthy of further pursuit. The remaining half felt, with modification, the proposal would be worthwhile. Overall workshop ratings included:

____ excellent   100% very good   ____ adequate
____ less than adequate   ____ poor

Workshop #4	5 Excellent	4 Very Good	3 Average	2 Poor	1 Very Poor	Mean Rating
CREATIVITY	1	4	3			3.8
FEASIBILTY						
TIME	1	4	2			3.9
COST	1	4	2			3.9
MANPOWER	1	4	2			3.9

Workshop number four was also rated positively. Seven out of eight participants indicated that they felt the proposal was worthy of further pursuit. One participant felt, with modification, the proposal would be worthwhile. Overall workshop ratings included:

25% excellent 25% very good 50% adequate
____ less than adequate ____ poor

Summary

The Colloquy and Workshops sponsored by the University of Massachusetts and the Massachusetts Society of Professional Engineers was a successful endeavor. The conference was well planned and implemented. Audience perceptions of its effectiveness were very good to excellent. Overall Colloquy presentations were considered relevant and met the needs of the the audience while accomplishing the purposes it set forth to accomplish.

Each workshop was defined and organized productively. In three out of four workshops, the resulting proposal was rated favorably.

It is obvious that considerable time, effort and expertise was put into making the Colloquy and Workshops a successful endeavor. Its organizers should be commended for its success.

Recommendations

One recommendation emerged out of the evaluation:

1. Whenever possible, funding should be allocated to pursue endeavors similar to this project. The process of collaboration as well as the resultant products demonstrated within this project should be encouraged.

Exhibit 1

No. ____________

Evaluation Questionnaire

A COLLOQUY AND WORKSHOPS: REGIONAL IMPLICATIONS OF THE ENGINEERING MANPOWER REQUIREMENTS OF THE NATIONAL ENERGY PROGRAM

In order to evaluate the effectiveness and impact of this program, we need your co-operation in completing the following questionnaire. Please take a few minutes as, the program proceeds to complete the form and return it to Dr. Segool before you leave. Your signature is not requested. Your candid opinions and ideas for future programs are welcomed. Thank you.

Identifying Information

1. What is your current occupation? ______________________________

2. Please check one or more of the sectors you represent.

   ______ Engineering ______ Government

   ______ Education ______ Other (please specify)

   ______ Industry ____________________

3. Is this your first experience in a Colloquy/Workshop of this nature?

   ______ Yes ______ No

4. Would you recommend future programs of this nature?

   ______ Yes ______ No

Physical Accomodations

5. The physical facilities (space, lighting, atmosphere) of the Colloquy were:

   ______ excellent ______ very good ______ adequate

   ______ less than adequate ______ poor

6. The physical facilities of the Workshop meeting room were:

   ______ excellent ______ very good ______ adequate

   ______ less than adequate ______ poor

7. The housing accommodations (room, heat, lighting, food) were:

   ______ excellent ______ very good ______ adequate

   ______ less than adequate ______ poor

8. What improvements, if any, would you suggest for better physical accomodations?

Preliminary Materials

9. Did you receive the preliminary materials?

_____ Yes _____ No

10. How much of the material were you able to read prior to the Colloquy/Workshop?

_____ all of the material _____ about 1/2 _____ none of the material

11. Did the preliminary material stimulate/provoke thought pertinent to this Colloquy/Workshop?

_____ Yes _____ No

12. To what extent did the preliminary material prepare you for the program?

_____ to a large extent _____ to my satisfaction _____ minimally

Colloquy: Part I

13. Did the Colloquy direct your focus to the Connecticut, Massachusetts and Rhode Island region?

_____ Yes _____ No

14. To what extend did the Colloquy assess the regional energy-related engineering-manpower demand/supply prospectus? (please circle your rating)

1 2 3 4 5
to a large extent minimally

15. How consistent was the regional assessment (above) with the magnitude of the emerging national energy program and the potential regional participation in it?

_____ extremely _____ adequately _____ minimally _____ not at all

16. To what extent did the Colloquy indicate a need for improved vehicles for the monitoring, maintenance and replenishment of an energy engineering manpower resource?

1 2 3 4 5
to a large extent minimally

17. How were those indications (above) consonant with a vigorous regional role in the national energy program?

_____ extremeley _____ adequately _____ minimally _____ not at all

13. The following topics were addressed within the Colloquy. Please rate your degree of satisfaction with each presentation and indicate its relevance to you personally.

PRESENTATION	DEGREE OF SATISFACTION				RELEVANCE		
	to a large extent	to my satisfaction	minimally	not at all	highly relevant	of general interest	irrelevant
TWO CRUCIAL ITEMS: ENGINEERING MANPOWER AND CAPITAL RE-FORMATION							
INTERRELATIONSHIPS OF ENERGY POLICY AND NEW ENGLAND ECONOMY							
REGIONAL ROLE IN NATIONAL ENERGY PROGRAM							
THE COMMERCIALIZATION OF SOLAR ENERGY							
INITIATIVES FOR COMMERCIALIZATION OF EMERGING ENERGY TECHNOLOGIES							
DEMAND/SUPPLY PROSPECTUS FOR ENERGY-RELATED ENGINEERING MANPOWER							
TRENDS IN U.S. ENGINEERING DOCTORAL PROD'N.							
REGIONAL DEMAND/SUPPLY PERCEPTIONS							
SUMMARY FOR REGIONAL DEMAND/SUPPLY DELTA							

19. My overall rating of the Colloquy was:

______ excellent ______ very good ______ adequate

______ less than adequate ______ poor

20. Please list any other related topics of interest to you.

21. Additional comments and recommendations.

Workshop Sessions Number (circle): I II III IV

22. Did the Colloquy adequately prepare you for the workshop?

______ Yes ______ No

23. To what extent were you given the chance to openly express your ideas and opinons?

______ to a large extent ______ to my satisfaction ______ minimally ______ not at all

24. To what extent did you participate in the group's conclusions?

______ to a large extent ______ to my satisfaction ______ minimally ______ not at all

25. To what extent did you agree with the group's conclusions?

______ to a large extent ______ to my satisfaction ______ minimally ______ not at all

26. Did the discussion/dialogue sustain your interest and motivation?

______ generally ______ about 1/2 the time ______ minimally

27. Please rate the Chairman's presentation of the task, and the organization and summarization that occurred throughout the workshop.

______ excellent ______ very good ______ adequate

______ less than adequate ______ poor

28. Did your workshop generate a proposal(s)?

______ Yes ______ No

29. In your opinion, will the proposal(s) your group generated be a valuable model input for national program planning and implementation?

______ Yes ______ No

30. In your opinion, will the proposal(s) your group generated be a valuable model input for regional planning and implementations?

_______ Yes _______ No

31. Please evaluate your own workshop's proposal(s) according to the following criteria:

	Excellent	Very Good	Average	Poor	Very Poor
CREATIVITY					
FEASIBILTY					
TIME					
COST					
MANPOWER					

32. Is the proposal(s) worthy of further pursuit?

_______ Yes _______ No _______ With Modification

33. Please choose another workshop and evaluate its proposal(s) according to the following criteria:

Number (circle): I II III IV

	Excellent	Very Good	Average	Poor	Very Poor
CREATIVITY					
FEASIBILTY					
TIME					
COST					
MANPOWER					

34. Is the proposal(s) worthy of further pursuit?

_______ Yes _______ No _______ With Modification

35. My overall rating for the workshop session was:

_______ excellent _______ very good _______ adequate

_______ less than adequate _______ poor

36. Please add your personal comments.

STRENGHTHS OF THE COLLOQUY AND WORKSHOP

WEAKNESSES OF THE COLLOQUY AND WORKSHOP

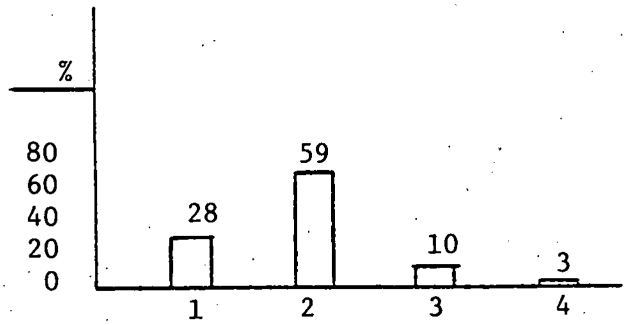
RECOMMENDATIONS

Thank you for your time and effort!

Exhibit 2

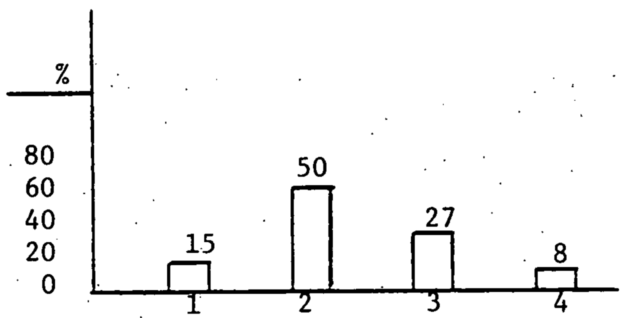
PRESENTATION | **DEGREE OF SATISFACTION** | **RELEVANCE**

Demand/Supply Prospectus for Energy-Related Engineering Manpower (Seltzer)



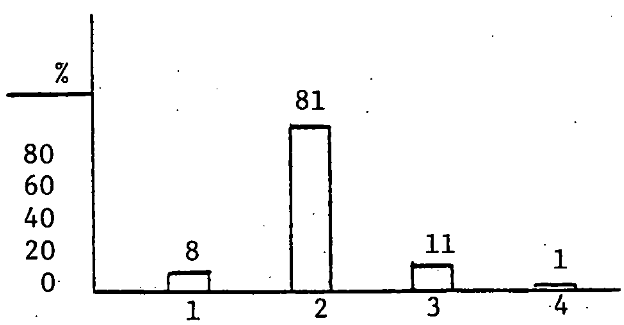
Highly relevant 59%
Of general interest 41%

Interrelationships of Energy Policy and New England Economy (Zeitz)



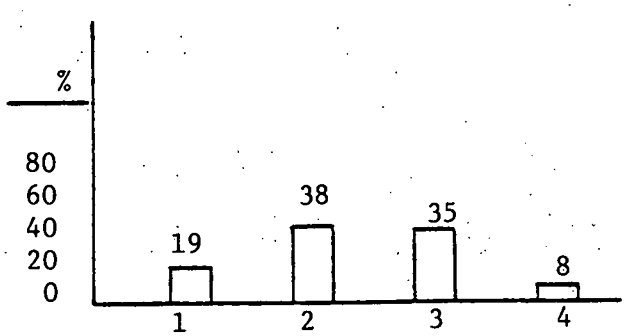
Highly relevant 57%
Of general interest 40%
Irrelevant 3%

Two Crucial Items: Engineering Manpower and Capital Re-Formation (Bisplinghoff)



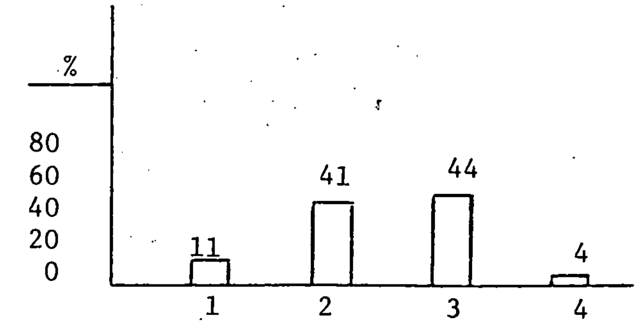
Highly relevant 54%
Of general interest 46%

Initiatives for Commercialization of Emerging Energy Technologies (Gouaud/McElroy)



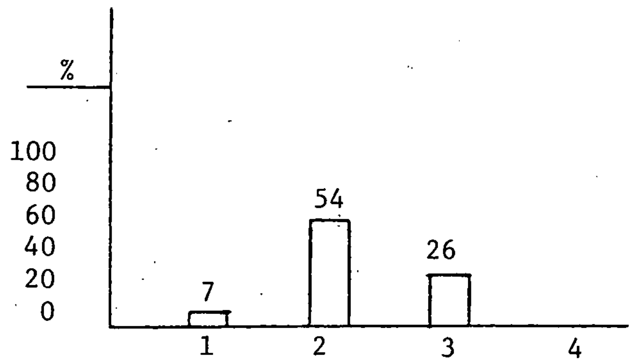
Highly relevant 54%
Of general interest 42%
Irrelevant –

Regional Role
in National Energy
Program
(Panel)



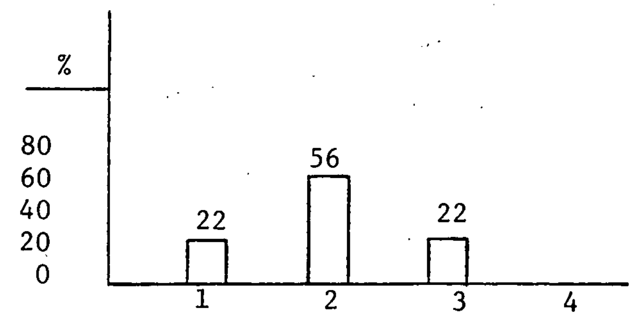
Highly relevant 49%
Of general interest 51%

Regional Demand/
Supply Perceptions
(Panel)



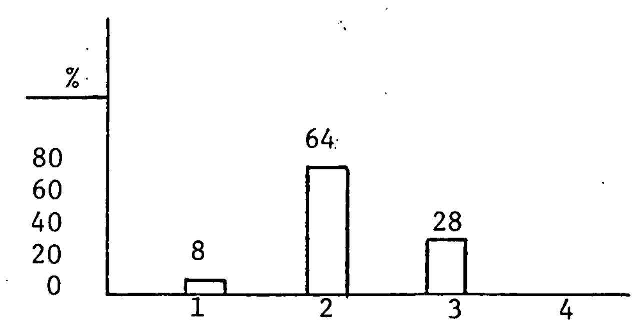
Highly relevant 41%
Of general interest 59%

Trends in U.S.
Engineering Doc-
toral Production
(Picha/Marcus)



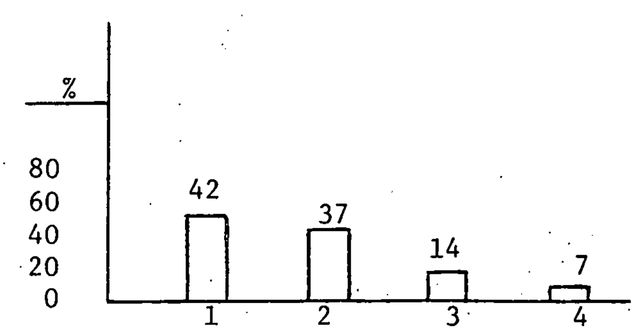
Highly relevant 41%
Of general interest 52%
Irrelevant 7%

Summary Pros-
pectus for Regional
Demand/Supply
Delta
(Frederickson)



Highly relevant 40%
Of general interest 60%

The Commercial-
ization of Solar
Energy
renner)



Highly relevant 33%
Of general interest 63%
Irrelevant 4%

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APPENDIX

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(herein is reported the transcribed conversational presentation for its interesting insights and for participant interaction)

A MARKET MODEL OF ENGINEERING MANPOWER DEMAND AND SUPPLY

Dr. Marvin A. Sirbu, Jr., Resarch Associate
Center for Policy Alternatives
Massachusetts Institute of Technology

In considering the supply of engineers or, indeed, any scientific or professional occupation, the first thing you have to start with is some idea of what the behavior has been, over time, in those degree fields. So, what I'd like to do is quickly run through a number of figures showing the behavior in several fields in terms of the supply, the number of new entrants, at the bachelors degree level in a variety of disciplines. Past data shows clearly identifiable trends in fields ranging from psychology, history, government, mathematics, chemistry, physics, etc.. What's clear is that the pattern is not a steady growth trend, the pattern shows substantial fluctuations in the numbers of graduates.

Here, (editor's note: table omitted) for example, are 1st year engineering enrollments between 1950 and 1975, with fluctuations of as much as 50% up and down. Take a field like geology, the number of graduates, tremendous fluctuations, a factor of three up and down in the period between 1950 and 1975.

Now, some fields haven't fluctuated quite so much. If we look at a field like biology we see almost an exponential growth pattern for the last 20 years. If we look at PhD degrees the trends show an upturn, then a peaking and a downturn, the peak occurring around 1971-1972.

All right. The first thing we observe is that you're not going to explain this behavior with simple trend extrapolation models. There's something more going on here and, if you begin asking yourself what's going on, the first thing you observe is that, for a lot of fields, there's a downturn around 1970-71-72. And you say, "Gee, if I can begin to understand that phenomenon, then maybe I can start building a model for the larger behavior."

So, if you're an economist, the first thing you think of when you see a change in supply is "Gee, maybe there's a change in demand and a change in the equilibrium implementation of price." You say the price must have gone down and therefore it drew out less supply. And so, if you plot in constant dollars the starting salaries for various occupations, what you find is, indeed, between 1960 and 1974, that the price being paid to the starting B.S. electrical engineering, physics, accounting, business administration, humanities graduate turned down substantially beginning in about 1969-70, in almost all of these fields. That is, from a market point of view, the price the market was willing to pay for these people declined and that coincides or leads appropriately to the drop in supply.

Another way of looking at it is to look at the % change, in real terms, for starting B.S. candidates in a variety of fields. In the period '60-'69, accountants' real salaries went up 35%; civil engineers' 32%; chemical engineers' 30%; mechanical engineers' 26%; electrical engineers' 24%; whereas in the period '70-'74 the changes are all negative: mathematicians, - 16% in real terms; chemistry, - 12%; electrical engineering, - 9%; aeronautical engineering, - 8%; civil engineering, - 8%; mechanical engineering, - 8%.

So, indeed, there was a change in the price being paid for bachelors in these disciplines. That might lead you to say, "Well, maybe I can explain the behavior in economic terms, in terms of the salaries that are being offered and the interaction of supply and demand."

Taking that approach, a model was developed for explaining supply and demand in the professions by Richard Freeman at Harvard which we've elaborated and tested in 18 different disciplines. The basic model has the following equations. Now let me see if I can explain this gobbledegook here for you. (editor's note: see formal paper, p. 99 etc.)

The first equation says that the enrollment in a field, first year enrollment, is a function of the student's expectation of the salary he's going to receive when he graduates, and it's negatively related, minus sign here, to his expectation of the alternative salaries available in other occupations. That says, if the salaries of doctors go up relative to the salaries of engineers, the number of people enrolling in engineering goes down, even if nothing happens to change the demand for engineers.

The second statement says that <u>actual</u> salaries awarded to first-year graduates are a function of some demand index and negatively related to the supply the previous year, the number of graduates the previous year. So that, again, if demand increases then salaries will increase, and if supply increases salaries will drop.

The third equation relates graduates to the enrollments four years earlier. Now its not just a straightforward 'graduates are a constant fraction of enrollments four years earlier'. In fact, we know from experience that generally no more than half of the students who enroll as first year students in engineering graduate four or five years later. There's an enormous amount of switching in and out. And that switching in and out is not totally unrelated to changes in the economic situation during the period while they are students in school. So that, for example, if salaries increase between their freshman year when they made a decision and their junior year, which is about the last year you can switch in or out of a field and still graduate on time, if salaries increase in that period then we can expect the fraction who graduate to increase. And conversely, if salaries, alternative salaries, increase between the freshman year and the junior year, we can expect people to move out and the number of graduates to be proportionally less than the average fraction of first year enrollments who graduate four years later.

Finally, the last statement is critical. It says that, regarding a student's expectation of what the salary will be when he graduates, because, after all, as a good salary maximizer what the student should do is make his enrollment decision based on what the salary is going to be when he gets out, it turns out that students don't have a very good forecasting mechanism. What they use for estimating what the salaries will be when they get out is essentially an adaptive model based on what the salary is to-day. So, it says that when students make their enrollment decisions they are primarily looking at to-day's salaries. So, when a student enrolls as a freshman in 1979 he looks at the salaries being paid to graduates in 1979 and he says "That's what I'll get in 1983," and so he makes his enrollment decision. And if salaries are up in 1979 he says, "Oh, boy" and he goes into the field.

Now, you might say, "Well, wait a minute. Students don't look at salaries. I know a lot of students and if I walk up to a random freshman and ask him what the starting salary is in his chosen field he won't have the vaguest idea." You're right. Okay. And the second thing that will also be true is that a lot of students will say, "Well, I'm going into this because my father went into it, so I don't care what the economics are." Okay. You're right there too. Now, let me tell you why it is that a model like this can still work.

It can still work because it's only sufficient that <u>some</u> students at the margin make a decision based on economic criteria. Not that they all do, but that enough students make a decision at the margin to account for fluctuations. And, secondly, we can use salary here as a proxy for a number of other variables which are highly correlated with salary and which are more easily observable by the student.

A recent study that appeared in Chemical Engineering magazine in January of this year shows that salaries are very closely correlated with the number of job offers per student. Now, your average freshman may not know what the starting salaries are, but he knows whether the senior down the hall is getting any job offers or not. So that the salary could be seen here as a proxy for a measure of the tightness of the market which is observable to the student in a number of ways. It's observable thru the number of job offers being given to graduates, it's observable in the number of advertising lines in the student newspaper for recruiting visits, and a variety of other measures, plus stories in the newspaper about how there's a shortage of whatever, and the student need not be aware of actual dollar salary amounts.

So, when given a model like this we can hypothesize it and we can test it. Now, in testing it -- I won't spend a lot of time going thru the actual regression results here -- let me just say that one of the things that we do is we take the model and we actually can eliminate salary from it directly, salaries being a notoriously difficult thing to measure, starting salaries for graduates. We can create a reduced form set of equations by just taking the equation for salary and plugging it into the equation for enrollments, here, and you get an equation that depends upon demand and supply and doesn't have salary terms in it directly. Similarly, by plugging in the equation for graduates relating to enrollment four years earlier, you can get a single equation that is recursive in enrollments and doesn't have graduates in it at all.

So, here's an equation, this last one, which is recursive in enrollments and could be used to forecast future enrollments, 1st year enrollments, in engineering. We have done a lot of work with equations of this form which gets around the problem of measuring salaries, and there is some indication that, in fact, students are aware of demand and supply directly and not just thru the intermediary of salaries, which is consistent with the notion that salaries are a proxy for a lot of variables that measure the tightness of the market.

You can do a similar thing to construct an equation for graduates, a reduced form equation for graduates, in which the graduates depends on the number of graduates earlier and the demand terms earlier. The numbers in parenthesis indicate lags, if you're familiar with the notation for regression analysis.

Okay. Now, when we actually run these regressions we can have data, for example in the case of engineers, for some 20 years, actually thirty years, 1947-1977, and we get a tremendously good R-squared, a tremendously good fit and significant results. For the demand terms what we have used here, and what we use in different fields, are a variety of indices that we think are correlated with, in some sense, the "demand for the profession." For engineers we have found that what works best is a measure of total R&D spending in the economy, both public and private, and also a measure from the Federal Reserve Board of the index of durable goods production, since the durable goods industries are major employers of engineers. These are the indices that seem to be good proxies for the demand for engineers.

In other fields we use other indices. For example, in agriculture we use an index of food production; in petroleum engineering we use an index of oil exploration; in biology what turns out to be a good index is the admission rate into medical school -- if chances of getting into medical school are good, more people go into biology and when the chances of getting in are bad fewer people go in because they don't think they're going to have as good a shot at becoming doctors.

So, you can use a variety of demand indices in different disciplines -- these are the ones that have worked best for us in engineering.

When you produce a model like that, what kind of behavior does it lead to? Here (editor's note: see formal paper, p. 106 etc.) is our prediction, based on data thru 1977 I believe, of the enrollments, first year enrollments in engineering. The dark line is the actual data for the period 1950-1977; the dotted line is the model reproduction of the past, you can see the quality of the fit, and the forecast.

Now, a model like this really isn't telling you the future, precisely. What it's doing is it's converting statements about what you think R&D expenditures are going to be, and what you think alternative salaries are going to be, and what you think durable goods production is going to be, into statements about what enrollments might be. What it says is, enrollments depend upon those things and if you tell me what your forecast is for R&D and for durable goods production, I'll tell you what our forecast is for enrollments.

Obviously, that's only as good as your ability to forecast R&D, or to forecast durable goods production. We all know that business cycle economists aren't terribly good at forecasting durable goods production. Nevertheless, we can still learn something from this, even without being able to make an absolute forecast.

One of the things, probably the most important thing, we can learn is that even for a range of assumptions about what R&D will do, about what alternative salaries will do etc. etc., we find that there is a cyclical behavior in enrollment independent of the assumptions we make about those exogenous variables. What that says is that the cyclical behavior is not a property of your absolute prediction for these exogenous variables but is a property of the internal structure of the supply system for engineers. It has nothing to do with R&D spending per se, but it has to do with the process by which people make decisions.

Let's go back and think about that process again. The process says that students make their enrollment decisions based on current salaries, but they don't graduate currently, they graduate 4 or 5 years later. There's a lag, and any of you who have studied control theory know that when you have a second order system with a lag you get instabilities. That's precisely what we have here. Students make an enrollment decision in 1979 on the basis of high salaries. By 1983 or '84, when they graduate, they are a surplus on the market and they drive salaries down. In that environment fewer people will enroll and so, as a result, 4 or 5 years after that there will be fewer graduates coming on the market and salaries will be bid up. Precisely the explanation of the previously experienced cycles.

Now, we have some exogenous movements in R&D spending which contributed to these cycles. In the early '60s we had a tremendous growth in R&D spending due to the Apollo program and increasing health expenditures in society. That prompted many students to enroll in science and engineering. These expenditures leveled off or peaked in 1966. When they did, the salaries began leveling off, which we saw earlier, and the number of people enrolling dropped, reaching a nadir in 1972.

Now, in 1972 a lot of people were screaming that there were going to be terrible shortages of engineers for the foreseeable future, because they extrapolated this curve, sort of forever. Of course, that's not what happened because by 1973, the number of graduates had turned down and so the salaries were beginning to be bid up again and we saw tremendous increase in enrollments in this period. Now, some of this increase, certainly in the period 1974, is explainable not by an increase in the salaries of engineers. Remember, 1974 was a recession year. Engineers' salaries certainly weren't going up tremendously either, but everyone else's salaries were declining in real terms.

For the first time in 20 years the average salary of non-agricultural production workers declined in real terms. So relatively, relative to the opportunities available to engineers, engineering looked quite good, and you remember in our equation for enrollments we had not only salaries but we had alternative salaries. So that you can't understand this tremendous surge without looking at the options, the alternatives available. Given the alternatives available, then this tremendous growth, even in the period 1974 when engineering salaries were not growing particularly, is easy to understand.

Well, we're reaching a tremendous peak, and you all know how high salaries have been in the last 6-12 months, causing huge enrollments, and it's our prediction that those enrollments, which began as early as 1973 when the turnaround began, are going to level off. They are going to level off because this June's supply of graduates is much larger than last June's or the year before, and that is actually going to have a slightly depressing effect on starting salary offers.

As a consequence, the enrollment picture will not look quite so large next Fall and by 1983, when to-day's high enrollments lead to high numbers of graduates, the market will be saturated and there'll again be stories of how people with engineering degrees can't get a job. It will sound a lot like 1973. Students will respond accordingly by staying away in droves.

I want to present the forecast for graduates, which shows substantially fewer fluctuations than the forecast for enrollments. That's because of the part of the model which I showed you which says that the fraction of people who complete the program adjusts according to changes in economic circumstances between the freshman and junior years. So, therefore, the lag is much shorter for graduates because effectively there's only a two-year lag really, and as a result there's a dampening in the fluctuations. Students see it getting bad, they just don't stick it out, so you don't get the same overshoot, and conversely you don't get the same undershoot because, as things get better, more people stay in the program and the number of people finishing is higher than it would otherwise have been. One of the things this says is that much of the known shortage of engineers is about to be relieved substantially by a large increase in the number of graduates.

Now, let me just note about the three different forecasts. The middle forecast is our best estimate. It's based on a 4% real growth in R&D expenditures, a 4% real growth in durable goods production annually and an increase in alternative salaries. Here we're using the salary increase of all non-agricultural workers of 1.8% per year which is the 25-year trend. The high forecast represents an R&D growth rate of 5% and an alternative salary growth rate of only 1.5%. The low forecast corresponds to an R&D growth rate of 3%, a durable goods growth rate of 3% and a somewhat higher growth in alternative salaries. You may consider 3 & 4% real growth in production to be optimistic. If you do then you'll take the lower value of that curve. But in any case, you're going to see a cyclical behavior as part of the structure of the way students make decisions.

I'm going to run quickly thru some forecasts for some other disciplines just to give you an idea. Here is the forecast, for example, for physics graduates. In the '70s they were talking about terrible surpluses of physicists. The market for physicists was self-correcting. The number of people in the field just simply declined precipitously. The surpluses didn't materialize, in fact what materialized were shortages. And now we're beginning to see an increase again in enrollments in physics and in physic graduates because the drop was an overshoot, and now salary surpluses are back up again. Here is a trend forecast for chemistry graduates. That is, if you just extrapolated the trend line here, the growth curve, that's what you would get. In fact, we believe that the behavior in chemistry is more likely to look like this, that there's going to be a tremendous overshoot in the mid '80s and an eventual decline.

Now, someone asked about physicists. We tried to apply the same techniques to modeling physicists. The results were not nearly as satisfactory. We cannot construct a model which explains, with the same degree of confidence, the behavior. We can, however, assert that even PhD's, who are presumably more dedicated and doing it more out of love, are in fact very conscious of the financial implications of the particular degree choice. One way to measure the tightness of the market for PhD's is to use the value of the variable that's collected annually by the National Academy of Sciences. Each year the National Academy sends a questionnaire to all PhD graduates that year and asks them, at the time of graduation, do you have a job or are you still looking for a job? In other words, they measure the number seeking employment. In some sense this is a measure of unemployment, not quite, because these people haven't been employed previously necessarily, but obviously if the number seeking employment is higher that says that the market is not very good. If the number of those seeking employment is smaller, then the market is very good. If we look at the completion rate for PhD's, that is the ratio of PhD degrees to enrollment for advanced degrees 6 years earlier, as a function of the percentage of PhD recipients still seeking an appointment, and here we look at the value of Seek three years into the PhD program, that is a guy has taken his courses, passed his generals, the question is, is he going to stick it out and write his thesis or not. He looks around and sees how many of his friends are getting jobs when they finish. If the number of people getting jobs is not very good, that is if the number seeking employment is high, then the number who are going to stick it out and complete the program goes down. So that, as the value of the Seek variable goes up, the fraction completing the program goes down, in engineering. This occurs in a number of fields and indicates the very significant effect of this Seek variable. So, we are able to show that even PhD's are not completely immune to economic conditions.

What we weren't able to identify is what precisely are the demand variables to use to predict, for example, the value of Seek. In other words, what is the model for predicting this tightness of the market against some measure of demand and supply. The structure of the demand for the PhD is quite different, of course, than the structure of demand for bachelors level people and we're not able to construct as good a model for that side of the equation.

Well, that really sums up what I wanted to say. I think the conclusions that you want to draw from this are, first of all, that if you want to affect the supply, you can't affect it this year for next year's graduates, because there's a delay in the process.

Secondly, that if you are terribly concerned about shortages, wait a few years. They're going to disappear and you're going to have a different problem on your hands.

Thirdly, from the point of view of the students, these alternating periods of shortage and surplus are fine for the students in the shortage years but pretty awful for the students in the surplus years.

It would behoove us to think about ways of stabilizing this behavior thru providing better information to students. Motivated in part by problems with vocational schools, which would promise the students that when you graduate you'll get a great job, and it really wasn't so, HEW recently promulgated a regulation requiring all educational institutions, not only vocational schools but bachelor's degree and graduate institutions, to make available to entering students the starting salaries of last year's graduates and the number that got jobs.

I can't think of worse information to give to students. What you're doing is encouraging them to make a decision to-day based on to-day's salary data, instead of thinking about what it's going to be like when they graduate. Better they should have given him five-year old data and then he would have been a full cycle out of phase, and that would have matched.

So, I think from the point of view of our educational institutions we have to supply students with a projection of what the opportunities will be, not with the current salary or employment information.

DISCUSSION/COMMENTS/QUESTIONS

Comment: Yes, but that law also says that they have to provide information with respect to what might be available also, and give them an opportunity to opt out of the system without losing money, things like that, there are several things.....

Response: Yes, there are lots of things in the law, I don't want to criticize it entirely. But the fact of the matter is, giving people salary information for last year's graduates is not the most helpful thing for deciding this year's enrollments.

Question: There are other things to do to the system, what would you propose to dampen the cycles?

Response: Well, in any business where there's cyclical behavior, the stockpiler is a virtuous person. Not only does he make money because he buys cheap and sells dear, but he helps to smooth out the fluctuations in the system by providing demand in periods of surplus when things are cheap and providing supply by selling off in periods of shortage when things are dear. From industry's point of view, the best thing is to hire like crazy in the early '70s and the early '80s, and not try and hire right in the peak of the boom. That is, to stockpile your manpower. Now, that's a hard thing to do -- manpower is very costly. But the companies that did hire a lot of engineers in the early '70s are finding themselves in a very good competitive position to-day. I think of Hewlett Packard as one, in the electronics industry.

Comment: But then most of those people move because of the high demand situation, which has caused higher salaries, and a great deal of mobility. Many of these same companies have experienced a very severe compression as a result of higher salary offers to new graduates.

Comment: The answer is to behave like a cartel. If you look at how cartels behave to smooth out supply and demand, if you could do the same thing....

Response: What I'm saying is that I don't think you can. Bidding higher to-day isn't going to produce more graduates to-day.

Comment: No, I fully understand what you're saying and I think in principle, or even in theory, it is correct, but as practice I don't think you can do it. Most of us, at least those of us who are at the hiring end, are finding that to be the case. We've had to make adjustments in salaries of our people we already have because we're having to pay higher salaries to incoming graduates.

Response: I don't doubt that. I'm just saying that the companies that in the early '70s tried to save money by cutting out engineers are in really bad shape to-day.

Comment: But there are companies -- I don't want to belabor the point, but there are companies who are in bad shape to-day who did do some stockpiling and who because of simply, let us say, normal salary increases for those people, have not been able to keep those salaries abreast of the salaries of the incoming graduates. That's their key problem now.

Response: I've been talking about what could be done on the demand side. Let's talk a minute about what could be done on the supply side. Not only can you provide information but you can provide financial support for students in periods in which the hiring looks bad. MIT, looking at results like this, took some of its own internal funds to support PhD candidates in the early '70s who otherwise would have opted out. And those candidates, graduating now, are finding that the market is terrific and that indeed they are thankful that they were able to keep up their education and didn't opt out, because MIT provided support in a crucial period.

Industry can supply support for new students in the early '80s when its not going to look very attractive. They may be insuring continued availability of supply in the late '80s when there would otherwise be a shortage.

Comment: You're talking about PhDs though, aren't you?

Response: Or even potential undergraduates -- thru co-op, part-time jobs, summer jobs, any other kinds of support that would encourage people to stay in the program.

Comment: I'm just not sure that your modeling is an accurate or even good description of what the real phenomena is that's taking place. I think this mobility thing is a real, real factor...

Response: Look, this is just a model for graduates, okay, it's not a model for the mobility of the experienced engineer. I make no claims in that regard.

Comment: But that effects the data to a very dramatic...

Response: It doesn't. It doesn't because we know... Again, here is our model tracking the behavior of the past. Now, whatever it is we're leaving out, it isn't very important. At least it wasn't in the past and that was thru some very substantial cyclical fluctuations. I don't know if any of you have made regression models, but to try to match a turnaround like that with a regression model, you've got to have a damned good model.

Comment: I think that the idea that we're going to dampen those cycles, and are going to do what we did to the economy while trying to dampen the cycles which are natural in the marketplace, we'll end up with really going out of line. We have roughly the right amount of engineers in this country for the right amount of jobs. To try to say we don't ever want to have a year where graduates can't find jobs and we don't ever want to have a year where the price goes up pretty high because we all go scratching for them, I'm sure will make things worse. I think that you can give this information to students, that they somehow can get that information and this might make the dampening, the feedback a little better. But the concept that, somehow, that's bad, or a bad response to the marketplace, it isn't.

Response: If you're worried, these oscillations are damped, okay, if you calculate the dampening coefficient, it's about 0.7. The oscillations don't get worse and worse when you put a shock into the system.

Question: Marvin, you're describing a system in which the students are the supply and the students decide what the supply is going to be. You've observed the behavior of the system and you have inferred information flows which apparently caused that behavior. Now, what is the counseling content of the finding? What would you advise the students to do? For example, if you're presently concerned, with some assurance, that there are going to be too many electrical engineers in 1983, would you stand up before the assembled enrollments of electrical engineers and counsel them to change to something else and, if so, to what?

Response: Well, first of all, one would like to be able to do this for all disciplines, so that you can see which things are on an up cycle and which things are on a down cycle. Right now, for example, chemists and biologists are going to be still on an up cycle in the mid '80s by our calculations. So, from what I forecast, that might be something to switch into. Yes, I would get up in front of a student and tell him that he ought to think seriously about whether he wants to stick with it, okay? And yes, I will tell him what I think the professions are that are going to be in an up cycle in that period, or that are going to be countercyclical with respect to engineering.

Comment: Except that the engineering starting rates are still probably going to be higher than for those other fields.

Response: If you can get a job!

Question: Another thing, the periodicity of your model for the future years seems to be much more regular than for the regressive years. How far out would you put any credence on your prediction? 1 cycle? 2 cycles?

Response: Not more than 1985, 1990. I give no credence beyond 1990, none at all. All right, not none. I think there are still going to be fluctuations, I don't think we will succeed in dampening the system, but the fact of the matter is much of the behavior in here has been accentuated by the Apolo program, by the cutback in spending after the Apollo program. If we have a recession this Fall that continues for a year it's going to reinforce this downturn tremendously. And the downturn may be even lower than what I forecast, and it may also make it last longer.

Question: What if the economy goes the other way?

Response: If we suddenly decide to get really serious about energy and double the Federal R&D budget by spending another $15 billion on energy research, then this forecast, which is based on 4% growth of R&D is wrong and I'll have to plug it in again with a 20% growth in R&D and see what it predicts.

Comment: But even beyond that, the assumption that you have the same growth in R&D for all those years is wrong.

Response: Yes, that's correct.

Comment: It's going to be 3,4,5 up, down.

Response: Yes, that's right, it's going to be up and down. We've done some sensitivity analysis. That is, we've said suppose you put in a 10% pulse in R&D or a 10% pulse in durable goods. We find that the oscillations die out in about a cycle and a half. That gives you some idea of the duration. We find also that the most sensitive is the fluctuation in alternative salaries. That is, if you get a big spurt of inflation, which causes real alternative salaries to go down, then that may contribute greatly to an increase in enrollments in engineering.

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