



Energy Consulting Services Overview

Advanced Fuel Research, Inc.

2004-2005

Leading Scientists

Leading Research

Focus on Future Energy Concepts

Twenty-Five Years of Experience



Helping to Create the Future of Energy

Advanced Fuel Research, Inc. (AFR) is a privately owned company, founded in 1980, that supplies contract research, product development, analytical services and consulting services. AFR has successfully developed several innovative analytical instruments and software products and has been particularly recognized as a world leader in advanced Fourier transform infrared (FT-IR) spectroscopy for environmental monitoring, process monitoring, and quality assurance applications.

AFR has also developed a number of technologies in the areas of Biomass Conversion, Waste-to-Energy, and Coal Conversion. A fuel characterization instrument known as a TG-FTIR (thermogravimetric analyzer with Fourier transform infrared analysis of the evolved products) was developed in a partnership with a Fortune 500 company.

AFR's FG-DVC (Functional-Group, Depolymerization, Vaporization, Crosslinking) model is a comprehensive code for predicting yields and compositions from coal, biomass and waste pyrolysis. The model has been licensed by more than 50 domestic and international fuels research laboratories. AFR's FG-DVC clients have included ABB Power Plant Laboratories, Foster Wheeler, Babcock & Wilcox, Riley Stoker, U.S. Department of Energy, University of Utah, Brown University, Brigham Young University, University of Leeds (U.K.), DMT (Germany), CSIRO (Australia), Institut Français du Pétrole (France), and Instituto de Carboquímica (Spain).

Advanced FTIR-based fuel combustion monitoring systems have been developed and sold by AFR and its spin-off company, On-Line Technologies, Inc., to industrial and academic clients involved in fuels and combustion R&D. These clients have



Helping to Create the Future of Energy (continued)...

included the Massachusetts Institute of Technology, Oregon State University, ABB Combustion Engineering, Factory Mutual Research Corporation, Dow Chemical U.S.A., Air Liquide, 3M, NASA Glenn Research Center, National Institute of Standards and Technology, and Arizona State University.

Recent research and sponsors on advanced energy applications include:

- Microporous carbons for hydrogen and methane storage in low emission vehicles (NASA)
- Carbon molecular sieve membranes for gas separation in oxygen-enriched combustion (DOE)
- Carbon black from oils derived from scrap tires (EPA)
- Tire-derived activated carbons for mercury control in coal combustion (EPA)
- Pyrolysis of waste materials for fuel gas production (NASA, DOE, USDA)
- High performance carbon materials for ultracapacitors in hybrid vehicles (DOE)

AFR was awarded the coveted Small Business Administration's 2000 Tibbetts Award for commercialization of innovative technologies. Since 1994, AFR has been a four-time winner of the R&D 100 Award for developing one of the 100 most technologically significant new products of the year.

AFR supplies its services to leading industrial, government, and academic clients throughout the world. Its senior management has more than 100 years of combined experience in Energy R&D and more than 200 publications.



President

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Consulting Focus

Distributed Energy Generation
Coal and Biomass Conversion
Waste-to-Energy
Synthetic Fuels

Education

Massachusetts Institute
of Technology
Ph.D., Chemical Engineering,
1984

Cornell University
B.S., Chemical Engineering,
1977
("with distinction")

Michael Serio

Dr. Serio has been a Principal Investigator on experimental and/or modeling studies on the pyrolysis, gasification, liquefaction, and combustion of coal; characterization and development of advanced jet fuel formulations; pyrolysis of biomass and waste materials; synthesis of fullerenes; pollution formation in combustion systems; FT-IR monitoring of combustion systems; advanced fire detection methods; and polymer thermal degradation. For several years, he led the team that developed AFR's widely used FG-DVC model for the pyrolysis of coal, biomass and related materials. He has been employed at AFR since March 1984.

Dr. Serio has been a Principal Investigator or Program Manager on contracts and grants for several government agencies, including NSF, DOE, DOD, EPA, NASA and USDA. He is currently a member of the Industrial Advisory Committee for the Department of Chemical Engineering at the University of Connecticut and the editorial board for the journal, Fuel. Dr. Serio has served as Chair, Program Chair, Program Secretary, and Trustee for the American Chemical Society (ACS) Division of Fuel Chemistry. He also served as a member of the joint CCR/ACS/AIChE task force on the DOE energy research budget in 1996-97 and was a consultant on a five year coal research project sponsored by the Japan Society for the Promotion of Science (1996-2001).

Dr. Serio has three patents and more than 150 publications, including two encyclopedia chapters. He recently was the senior editor of a book titled "Synthesis and Characterization of Advanced Materials," that was published by the ACS in 1998 and which is now available from Oxford University Press. He is a member of the American Institute of Chemical Engineers, the American Chemical Society, the Cornell Society of Engineers and the MIT Chapter of Sigma Xi.



Chief Executive Officer

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Consulting Focus

Instrumentation

Gas Turbines

Process Control

Extreme Conditions

Education

Wesleyan University

M.A. Chemistry, 1984

The University of Hartford

B.S. Chemistry, 1981

James Markham

Mr. Markham's R & D contracts have concentrated on methods and instrumentation for optical-based measurements of process emissions, radiative properties, and temperature. Successful programs sponsored by the U.S. government have resulted in demonstrations and deliveries of new optical instruments that solve vital measurement needs. Often these measurements are needed in extreme environments.

Mr. Markham has more than 50 publications, two patents awarded and three patents pending, and has given presentations to the DOD, DOE, EPA, NASA, industrial/government consortiums, and universities. He has performed field tests at turbine engine test cells, black liquor recovery boilers, a high flux solar furnace, a glass kiln, a coal fired boiler, a chemical incinerator and several government labs and military bases. Mr. Markham is also the Manager of the Combustion Monitoring & Control Research Group ("TurboSense").

He received an R&D 100 Award in 1994, received a U.S. SBA 2000 Tibbetts award on behalf of his company for SBIR commercialization, was recognized in Dec. 2001 by the Connecticut Department of Environmental Protection for implementing energy efficient technology through a U.S. DOE NICE³ grant and, in 2003, received the ISA Major Charles Bassett III Outstanding Paper Award of the 48th International Instrumentation Symposium.

Mr. Markham joined AFR in January of 1983, and holds memberships in the American Institute of Aeronautics and Astronautics (AIAA) and the Instrumentation, Systems and Automation Society (ISA).

**Vice President**

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Consulting Focus

Fuel Science

Coal and Biomass Conversion

Carbon Materials

Air Pollution Control

Solid-Waste Utilization

Education

Brown University

Ph.D., Chemical Engineering,

1988

M.S., Applied Mathematics

1986

Cracow University of

Technology

M.S., Chemical Engineering,

1979

Marek Wójtowicz

Dr. Wójtowicz has pursued experiments and modeling of reactions involved in coal and biomass pyrolysis, gasification, and combustion; diesel processing for use in fuel cells; hydrogen storage by adsorption on carbons with custom-engineered pore structure; the conversion of waste tires to value-added products (activated carbon for mercury sorption, carbon black); and the development of carbon electrodes for ultracapacitors (applications in hybrid and future-generation vehicles). Dr. Wójtowicz has more than 80 publications and 5 patents in these areas.

Before joining AFR in 1993, he worked at the Delft University of Technology under Professor Jacob Moulijn, where he was involved in a large, European Union funded project concerned with the evolution of nitrogen during coal pyrolysis, gasification, and combustion. As a group leader at AFR, Dr. Wójtowicz has directed a number of R&D projects funded by the DOE, NSF, NASA, EPA, and industrial clients.

Dr. Wójtowicz serves on the Advisory Committee for the Chemical Engineering Program at Brown University. He acted as the Program Secretary (1999 – 2003) of the Fuel Chemistry Division of the American Chemical Society, and he was elected the Division Chair for 2005. Dr. Wójtowicz is also a member of the American Institute of Chemical Engineers and the American Carbon Society.

Dr. Wójtowicz has significant expertise in fuel science, carbon materials, air-pollution control (NO_x , N_2O , SO_x , mercury), solid-waste utilization, chemical reaction kinetics, and heterogeneous catalysis.



Chairman

AFR Board of Directors

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Consulting Focus

Coal and Biomass Conversion
Fuel Characterization
FTIR Analysis
Superconductivity

Education

Columbia University

Ph.D., Physics,
1965

M.A., Physics
1963

City College of New York

B.S., Physics,
1960

Peter Solomon

Dr. Solomon has had extensive experience in performing and managing interdisciplinary experimental and theoretical research in several fields including superconductivity, electron spin resonance, solid state physics, and work during the last twenty-five years in energy, radiative properties, FT-IR process monitoring and semiconductor processing. He has guided the development of FT-IR as an on-line in-situ monitor in high temperature reaction systems. He also developed the use of FT-IR as a tool for quantitative functional group determination in coals, jet fuels, and other hydrocarbons.

He was a member of the staff and management of United Technologies Research Center from 1965 until 1980, when he left to start Advanced Fuel Research, Inc. Dr. Solomon is the author of over twelve publications and three patents on superconductivity, nine publications and one book on solid state devices, and more than 140 publications on the application of FT-IR spectroscopy for fuel analysis, combustion monitoring, and semiconductor processing. Dr. Solomon was elected the 1991 winner of the American Chemical Society Henry H. Storch Award in Fuel Chemistry, was the Keynote Speaker at the Fourth Annual Australian Coal Science Conference (1991), and was also a Keynote Speaker for the International Coal Science Conference (1991). He has managed research contracts totaling over \$20,000,000.

Dr. Solomon served as CEO and President of AFR from 1980 to 1991 and presided over its growth from 3 to 40 employees. In 1991, he started a second company called On-Line Technologies, Inc. (OLT) and served as President and CEO of that company until 2001 when it was sold to MKS Instruments, Inc. (Wilmington, MA). OLT grew from 3 to 35 employees and reached \$5 million in sales of advanced FT-IR instrumentation for process and environmental monitoring.



Senior Engineer

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Consulting Focus

Instrumentation

Heat transfer

Sensitivity and error analyses

Image processing

Education

Princeton University

Ph.D., Mechanical and

Aerospace Engineering, 2002

M.A., Mechanical and

Aerospace Engineering, 1997

The Cooper Union for the

Advancement of Science and

Art

B.Eng., Mechanical

Engineering, 1995

James Scire

Dr. Scire, a Senior Engineer in the Combustion Monitoring & Control Group at AFR, has experience in the development of optical diagnostic techniques for the measurement of gas-phase species, surface properties, and gas and surface temperatures. The diagnostic systems that Dr. Scire has designed and implemented have included single-point and imaging measurements, and these systems have utilized wavelengths from the far ultraviolet to the long-wavelength infrared. He also has considerable experience in spectral simulation, modeling of instrument behavior, sensitivity and error analyses, and image processing.

Dr. Scire has been a key investigator on Air Force, NASA, NIST, and NSF-sponsored programs and has been the principal investigator on a NASA-sponsored program. He has performed numerous field tests at engine test cells and stationary gas turbine locations. He has 6 publications and one patent pending, and has presented project results and analyses to engine manufacturers, Air Force personnel, and NASA personnel.

Dr. Scire joined AFR in October 2001. He holds memberships in the American Institute of Aeronautics and Astronautics (AIAA), the American Society of Mechanical Engineers (ASME), and the Instrumentation, Systems and Automation Society (ISA).



Senior Physicist

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Consulting Focus

Image analysis
Ultracapacitors

Education

Yale University
Ph.D., Astrophysics,
1997

Columbia University
B.S., Astrophysics,
1987

Eric Rubenstein

Dr. Rubenstein has extensive experience in image analysis, high-energy astrophysical outbursts and related phenomena, Monte Carlo simulations, and numerical modeling. He has studied and taught graduate-level radiative transfer and concentrated on the high-energy outbursts of stars, including their X-ray radiation. He has also worked on a variety of laboratory projects including a particle accelerator and superconductivity experiments.

Dr. Rubenstein is currently managing a DOE sponsored program on the development of high performance carbon materials for ultracapacitors that can be used in hybrid vehicles. In addition, he has been involved in the development of AFR's FG-DVC model for biomass pyrolysis. Dr. Rubenstein has 40 publications and has managed several NSF and NASA sponsored projects using modeling, analysis, and simulation techniques.

Dr. Rubenstein is a member of the International Astronomical Union (Bio-Astronomy Commission), American Astronomical Society (High Energy Astrophysics Division), and Astronomical Society of the Pacific. Dr. Rubenstein is currently undergoing a background check for security clearance due to his commissioning as an officer in the U.S. Naval Reserve (Naval Air Systems Command). The honors include the following: (1) U.S. National Science Foundation International Research Fellow 1999-2001 (taken in Chile and at Yale Univ.); (2) JW Gibbs Lecturer at Yale Univ. 2000-2001; and (3) Lunar-Planetary Institute Intern, 1987.

SELECTED RESEARCH PAPERS AND PUBLICATIONS

- "Very Rapid Coal Pyrolysis," **Fuel**, **65**, 182 (1986).
- "Vapor Phase Cracking of Newly-Formed Coal Tars," **IEC Process Des. Dev.**, **26**, 1831 (1987).
- "A General Model of Coal Devolatilization," **Energy and Fuel**, **2**, 405 (1988).
- "A Study of Thermal Stability of JP-5 Using FT-IR and FIMS," **ACS Div. of Petroleum Chemistry**, **34**, 4, 816 (1989).
- "FT-IR Spectroscopy in Process Monitoring Part II: Applications," **Sensors**, **8**, 13, (1991).
- "Pyrolysis of Phenol-Formaldehyde Resin: Experiments and Modeling," **ACS Div. of Fuel Chemistry Preprints**, **36**, 2, 664 (1991).
- "Studies of Retrogressive Reactions in Direct Liquefaction," **1991 Int. Conf. on Coal Science**, New Castle, England, (1991).
- "Modeling of Mild Gasification Processes," **8th Annual Int. Pittsburgh Coal Conference**, Pittsburgh, PA, 183-188 (1991).
- "The Application of FT-IR Methods to the Characterization of Coal Liquefaction Process Streams," **ACS Div. of Fuel Chem. Preprints**, **37**, 4, 1903 (1992).
- "Review of Coal Pyrolysis: Experiments, Kinetic Rates, and Mechanisms," **Progress in Energy and Combustion Science**, **18**, 133 (1992).
- "The Prediction of Coal Char Reactivity Under Combustion Conditions," **Proceedings of the Twenty-Fourth Symposium International on Combustion/The Combustion Institute**, pp. 1189-1197 (1992).
- "A Novel Test Instrument for Fuel Thermal Stability," **Proc. SPIE-Int. Soc. Opt. Eng.**, 2069, 20-31 (1993).
- "A Characterization Method and Model for Predicting Coal Conversion Behavior," **Fuel**, **72**, 4, 469-488 (1993).
- "On-Line FT-IR Analysis of Fossil-Fuel Fired Power Plants," **Proc. of the Air and Waste Management Int. Symp. on Optical Sensing for Environmental Monitoring**, Atlanta, GA (1993).
- "Measurement and Modeling of Lignin Pyrolysis," **Journal of Biomass & Bioenergy** **7**, 107 (1994).
- "An Instrument for Characterization of the Thermal and Optical Properties of Charring Polymeric Materials," **25th Int. Symposium on Combustion**, (1994).
- "Pyrolysis," in **Encyclopedia of Energy Technology and the Environment**

(A.Bisio and S.G. Boots, Eds.), John Wiley & Sons, New York, pp. 2281-2308 (1995).

- "Reprocessing of Used Tires into Activated Carbon and Other Products," **Industrial & Engineering Chemistry Research**, 34, 3102-3111 (1995).
- "A Coal Fired Heat Exchanger for an Externally Fired Gas Turbine," **ASME Transactions of the Journal of Eng. for Gas Turbine & Power**, 118, (1996).
- "Mercury SO₂ and NO Removal from Flue Gas by Adsorption on Activated Carbons," **Proc. Twenty-Third Biennial Conference on Carbon**, The Pennsylvania State University, II, 130-131 (1997, July 13-18).
- "Modeling of Biomass Pyrolysis Kinetics," **Twenty-Seventh Symposium (International) on Combustion /The Combustion Institute**, pp. 1327-1334 (1998).
- "Pyrolysis Kinetics of the Waste-Tire Constituents: Extender Oil, Natural Rubber, and Styrene-Butadiene Rubber," **ACS Div. of Fuel Chem. Preprints**, 43(1), 185-191 (1998).
- "Sensor for Performance Monitoring of Advanced Gas Turbines," **SPIE Conference on Advanced Sensors**, Process Industries and the Environment, Boston, MA, (November 1998).
- "Microporous Carbon Adsorbents for Hydrogen Storage," **International Journal of the Society of Material Eng. for Resources**, 7, 253-266 (1999)
- "Pyrolysis processing of mixed solid waste streams," **ACS Div. of Fuel Chem. Prepr.**, 45 (3), 466-474, 2000.
- "A Prototype Pyrolyzer for Solid Waste Resource Recovery in Space," **SAE 2001-01-2349**, presented at the 31st International Conference on Environmental Systems, July 9-12, 2001, Orlando, Florida).
- "Pyrolysis-Based Processing of Diesel Fuel," **ACS Division of Fuel Chemistry Preprints**, 46(2), 481 (2001).
- "Simultaneous Short and Long Wavelength Infrared Pyrometer Measurements in a Heavy-Duty Gas Turbine," **Transactions of the ASME**, 528, Vol 124 (July 2002).
- "Biomass Pyrolysis for Distributed Energy Generation," **ACS Division of Fuel Chemistry Preprints**, 48(2), 584 (2003).
- "Pyrolysis of Miscanthus Giganteus and wood pellets: TG-FTIR analysis and reaction kinetics," **Fuel**, 82, 1139-1147 (2003).
- "Carbon Black Derived from Waste Tire Pyrolysis Oil," **Proc. Carbon 2004 Conf.**, Brown University, Providence, RI (July 11-15, 2004) in press.



Advanced Fuel Research, Inc. Energy Consulting Services

For additional information on how Advanced Fuel Research, Inc. consultants may assist you, please contact the pertinent staff member directly.

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